University of Nevada, Reno

Population Variation in Dental Development and Its Effect on Forensic Age Estimation

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Anthropology

by

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Abstract

Dental development is considered the most accurate method of age estimation in subadults, as this process is less subject to external and internal influences than skeletal development. However, dental development can be affected by secular change, socioeconomic status, sex, and ancestry. Therefore, it is problematic that the established methods for subadult dental age estimation in the United States are based on foreign samples or are outdated. This dissertation has two goals: 1) to create age estimation methods based on dental development from a modern sample of U.S. children; and 2) to analyze the effects of sex and/or ancestry differences in dental development on age estimation.

Dental development was evaluated from 1,757 orthopantomograms of individuals ages 5-20 taken between 1972 and 2017, using widely employed scoring systems (Demirjian et al. 1973; Moorrees et al. 1963). Values for intraobserver error suggest that the Demirjian et al. (1973) system is more consistently applied; therefore, these scores are used in subsequent tests.

The overall trend is that no significant differences in developmental scores exist between groups. When there are significant differences ($\alpha < 0.05$), dental development in females is more advanced than males, and Hispanic dental development is more advanced relative to European Americans. There are fewer significant differences between the other ancestry groups, likely as a product of small sample size.

Age estimation methods that do and do not account for sex and/or ancestry differences are created from a training subset of the total sample, to evaluate whether group-specific methods of age estimation perform significantly better than general

methods. Confidence intervals (CIs) are created for each developmental score for every tooth in the training sample. CIs based on all individuals are comparably accurate to and more precise than CIs based on group-specific subsets. Therefore, the use of CIs based on the whole sample is recommended for age estimation from a single tooth.

Linear models are created to estimate age from multiple teeth. Models based on all individuals exhibit comparable accuracy and precision to those based on subsets of sex and ancestry. Estimating sex and ancestry in juveniles can be difficult; therefore, the models based on all individuals are recommended for skeletonized juvenile remains. However, in living individuals, models based on females, males, European Americans, and Hispanics are slightly more accurate and precise than models based on all individuals and are therefore recommended.

There are currently no age estimation methods using dental development that are derived from a modern American population. The methods presented here fill that void. Since the analysis of dental development is non-invasive and non-destructive, these age estimation methods can be applied to both the living and the deceased, potentially increasing the accuracy of age estimations in the forensic context in the U.S.

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Chapter 1: Introduction

The analysis of dental development through radiographs is considered the most accurate method to estimate chronological age in subadults, due to the high heritability of tooth formation and the resistance of this process to extrinsic and intrinsic factors (Cameriere et al. 2012; Cunningham et al. 2016; Garn et al. 1973a; Garvin et al. 2012; Jernvall and Jung 2000; Liversidge 2016a; Liversidge et al. 2006; Schmidt 2016; Smith 1991). Age estimation methods based on the dentition currently in use in forensic contexts in the United States are either based on foreign samples (e.g., AlQahtani et al. 2010; Demirjian et al. 1973) or are outdated (e.g., Moorrees et al. 1963; Schour and Massler 1941). The conclusions drawn by forensic scientists are only as valid as the methods being employed; therefore, it is imperative that age estimation techniques are derived from the most applicable sample. To this end, the primary purpose of this dissertation is to create a method for age estimation from dental development that is based on a modern sample from the United States.

1.1: The Creation of Age Estimation Methods

The radiographs comprising the current sample come from modern children living in the United States, which should mitigate the potential effects of secular change on the process of dental development (e.g., Cardoso et al. 2010; Heuzé and Cardoso 2008; Nadler 1998; O'Neill 2012; Rautman and Edgar 2013; Sasso et al. 2012). Additionally, radiographs originate from three different states, New Mexico, Texas, and Oregon, to prevent the age estimation methods from being regionally specific. Finally, a comparatively large sample (n = 1,757) is analyzed in this project, which should increase the amount of normal human variation represented. These aspects of the research design

should improve the accuracy of the methods created for subadult age estimation from dental development. The accuracy and precision of age estimation methods are evaluated on a holdout sample of randomly selected individuals. This ensures the methods are not tested on the individuals used to inform them, a practice that could lead to a false sense of accuracy.

1.2: Testing for Sex and Ancestry Differences in Dental Development

The primary goal of this dissertation is the creation of a more appropriate method for age estimation from dental development in the forensic context in the United States. One component of an accurate method is utilizing a training sample that most closely approximates the individuals on whom the method will be utilized. Therefore, the secondary goal of this dissertation is to evaluate the effects of sex and ancestry on dental development. If significant differences exist between groups, methods for age estimation should account for these variables.

Sex differences in the rate of dental development are well-documented; females reach developmental stages at earlier ages than males, except for the third molar (e.g., Blankenship et al. 2007; Caldas et al. 2010; Cameriere et al. 2006; Daito et al. 1992; Demirjian and Levesque 1980; Gleiser and Hunt 1955; Harris 2007; Harris and McKee 1990; Knell et al. 2009; Levesque et al. 1981; Liversidge 2010; Prince and Ubelaker 2002). Age estimation methods should therefore take sex into account.

Regarding ancestry, the literature is divided on whether this factor has a significant effect on dental development. Some authors argue that variation in the rates of development between ancestry groups is significant enough to warrant the creation of population-specific age estimation formulae (e.g., Caldas et al. 2010; Demirjian et al.

1973; Gunst et al. 2003; Kasper et al. 2009; Lewis and Senn 2010; Moorrees et al. 1963; Orhan et al. 2007; Prieto et al. 2005; Sisman et al. 2007; Solari and Abramovitch 2002; Te Moananui et al. 2008; Willems et al. 2001). Others contend that population differences are the product of different analyses among researchers (e.g., Cunningham et al. 2016; Davis and Hägg 1993; Liversidge 2010; Smith 1991). Finally, there is the possibility that ancestry differences in the rates of dental development do exist, but these differences are not great enough to affect age estimation methods (e.g., Konigsberg et al. 2008; Liversidge 2010).

1.2.1: Hypothesis Testing

Two hypotheses are tested regarding sex and ancestry differences in dental development. These tests take place prior to the creation of linear models for age estimation; this ensures that the most appropriate sample(s) can be used in the production of the final method.

Hypothesis 1: Sex and ancestry groups undergo dental development at different rates.

Many researchers have found differences in the rates of dental development between the sexes and across ancestry groups. In the case of ancestry specifically, it may be that the research design of conducting comparative studies has inflated the importance of these differences. Therefore, with a large sample and a single researcher, these potential statistical errors should be mitigated. If the first hypothesis holds true, then the sex and ancestry groups analyzed in this project will exhibit statistically significant differences in rates of dental development.

Hypothesis 2: Sex- and/or ancestry-specific models of dental development will provide more accurate age estimates.

Even if dental development occurs at significantly different rates between sexes and ancestry groups, it is possible that a general model for age estimation will exhibit comparable accuracy and precision when compared to sex- and/or ancestry-specific models. This second hypothesis is concerned with the practicality of population-specific age estimation methods. Are they necessary, or will a general method be more utilitarian? If the second hypothesis holds true, then sex- and/or ancestry-specific models derived in this study will more accurately estimate age than the general model derived from the same material. Confidence intervals are created for the entire training sample, as well as for subsets divided by sex, ancestry, and sex/ancestry. Additionally, linear models are created from the entire training set, while sex- and ancestry-specific linear models are created from the appropriate subset of the training set. The accuracy and precision of the age estimation methods based on the entire training set are compared to those values produced by the methods based on subsets of the data, to determine whether sex- and/or ancestry-specific methods of age estimation outperform general models.

1.3: Project Significance

The analysis of dental development is unique among age estimation techniques. Since this method is non-invasive and non-destructive, dental age estimation methods can be applied to living individuals as well as the deceased. Inaccuracy in age estimates can carry legal consequences, particularly among the living (e.g., Cameriere et al. 2012;

Cunha et al. 2009). Methods for age estimation are most effective on populations whose composition is similar to the sample from which the method was derived (e.g., Davis and Hägg 1993; Willems et al. 2001), a conclusion that applies to methods across the field of biological anthropology (e.g., Garvin 2012; Garvin et al. 2012; Hefner and Ousley 2014; Jantz and Ousley 2013; Milner and Boldsen 2012; Ousley 2012; Snow et al. 1979; Spradley et al. 2015; Spradley and Jantz 2011; Spradley et al. 2008, 2015; SWGAnth 2013; Tise et al. 2013; Trotter and Gleser 1958; Ubelaker 2006; Wilson et al. 2010). For these reasons, the use of an appropriate reference sample is of the utmost importance in the forensic sciences. This research evaluates whether a modern sample from the United States produces accurate and precise age estimates, and whether sex- and/or ancestry-specific models prove more successful than a general age estimation model.

Chapter 2: Introduction to Dental Development

Teeth develop in a predictable sequence and at relatively consistent rates (Antoine and Hillson 2016; Guatelli-Steinberg and Huffman 2011; Harris 1998; Hillson 1992, 1996; Nanci 2013). The predictable nature of dental development, or odontogenesis, allows this process to be used in age estimation techniques (Nanci 2013). In fact, dental development is considered the most reliable age indicator for subadults, because this process is less subject to external influences than skeletal development (Garn et al. 1973a; Garvin et al. 2012; Jernvall and Jung 2000; Liversidge et al. 2006; Scheuer and Black 2000; Schmidt 2016). However, it is important to understand the process of odontogenesis at the cellular level. Without knowledge of the embryological stages of odontogenesis, researchers cannot know the most appropriate way to analyze this phenomenon and quantify its progression to estimate age.

It is important to clarify the terminology used to describe odontogenesis. While the distinctions between enamel mineralization, maturation, and development may be semantic, these terms have different implications and should not be used interchangeably. There are age estimation techniques that claim to analyze dental "mineralization" (e.g., Anderson et al. 1976; Harris 2007; Harris and McKee 1990; Olze et al. 2005; Olze et al. 2003), but do not clearly define the process in question. The application of these techniques may therefore be subject to interpretive errors, in turn reducing their replicability. Subadult age estimation methods, with focus on the dentition, are reviewed in the next chapter. Before age estimation can be discussed, the process of odontogenesis is summarized to contextualize developmental terminology. The use of these terms is then reviewed, with the goal of distinguishing between enamel mineralization,

maturation, and overall development in methods using dental radiographs. This discussion ensures that the appropriate terminology is used.

2.1: Dental Development

2.1.1: Early Stages of Embryological Development

After fertilization, the zygote goes through a series of cell divisions, creating a ball of cells called a morula. As fluid accumulates in the morula, the cells realign to create a border; this fluid-filled ball is the blastocyst. Around day eight of gestation, the blastocyst begins to differentiate into two separate layers, called the bilaminar germ disk. During the third week of gestation, the bilaminar germ disk separates into three layers: the amniotic cavity on top, the ectoderm and endoderm in the middle, and the yolk sac on the bottom. The cells in the ectoderm divide and spread, filling the space between the ectoderm and endoderm, creating the mesoderm layer (Nanci 2013; Schoenwolf et al. 2015).

During the next three to four weeks of gestation, major tissues and organs begin to differentiate from the three-layered embryo. During the fourth week of gestation, the embryo begins to fold in two directions, rostrocaudally (i.e., head to tail) and laterally. The head fold creates the oral cavity in which the dentition eventually develops, and the lateral fold causes the ectoderm to envelope the rest of the embryo and form the surface epithelium. When considering dental development, two differentiated components of the embryo are most important. Neural crest cells come from the neural tube (a thickening of the ectoderm created during development of the nervous system), eventually differentiating into most tissues of the tooth. Cells in the surface epithelium differentiate into the enamel of the tooth (Nanci 2013; Schoenwolf et al. 2015).

2.1.2: Development of the Tooth Germ

Around day 37 of gestation, the surface epithelium thickens to form primary epithelial bands corresponding to what eventually become the maxilla and mandible. Proliferative activity in the dental lamina causes epithelial growth into the underlying mesenchyme. These outcroppings of dental lamina, or tooth germs, are the sites of future teeth (Antoine and Hillson 2016; Liversidge 2016a; Nanci 2013; Schoenwolf et al. 2015).

Tooth germs form in three stages: bud, cap, and bell. For more information on the timing of tooth germ development, see Table 5-2 in Nanci (2013: 88). The bud stage is defined as the first time the epithelium extends into the underlying mesenchyme. During the bud stage, the mesenchymal cells underneath the tooth germ begin to condense. Though the mesenchymal cells are condensing at this point, there is not yet any change in the epithelial cells of the tooth germ (Harris 2016; Nanci 2013).

The next stage of tooth germ development is the cap stage. The tooth germs begin to increase in size during the transition from the bud to the cap stage. Because of this increase, the epithelium now looks like a cap on top of the condensed mesenchymal cells (Jernvall and Jung 2000). The condensed mesenchymal cells underneath the tooth germ are referred to as the dental papilla, which later forms the dentine and pulp cavity of the tooth. The epithelium of the tooth germ is now referred to as the enamel organ, as this tissue later differentiates into the enamel. The upper and lower borders of the enamel organ are the outer and inner enamel epithelia, respectively. Where these two epithelial layers meet is called the cervical loop. Surrounding the enamel organ and the dental papilla is a layer of ectomesenchyme called the dental follicle or sac. This tissue layer eventually gives rise to supporting structures of the tooth, such as the periodontal

ligament that anchors the tooth into the alveolar bone (Antoine and Hillson 2016; Harris 2016; Liversidge 2016a; Nanci 2013; Tang et al. 2016; Thesleff et al. 2001).

The cap stage is characterized by the appearance of primary enamel knots, dense clusters of epithelial cells that correspond to the location of future cusps. Primary enamel knots provide the chemical signals that trigger histodifferentiation to begin during the transition from the cap stage to the bell stage. Histodifferentiation is the process during which non-specialized cells differentiate into morphologically and functionally distinct cells. Epithelial cells in the enamel organ differentiate into ameloblasts (i.e., enamel forming cells), and mesenchymal cells in the dental papilla differentiate into odontoblasts (i.e., dentine forming cells). At the end of the cap stage, signals from the primary enamel knot initiate growth of the tooth germ around itself, causing the epithelium to grow downward (Antoine and Hillson 2016; Hillson 2000; Jernvall and Jung 2000; Jernvall et al. 1994; Nanci 2013; Salazar-Ciudad and Jernvall 2002; Tang et al. 2016; Thesleff et al. 2001).

The final stage of tooth germ development is the bell stage (Harris 2016). The growth of the epithelium causes the enamel organ to surround the dental papilla, creating a bell shape in cross-section (Jernvall and Jung 2000; Nanci 2013). The bell stage is characterized by further histodifferentiation and a process called morphodifferentiation, in which the tooth crown takes on its final shape.

Histodifferentiation begins at the enamel-dentine junction corresponding to the location of future cusps (Antoine and Hillson 2016; Hillson 1992, 2000; Jernvall and Jung 2000; Nanci 2013; Tang et al. 2016). Morphodifferentiation takes place as the inner and outer epithelial layers of the enamel organ fold in conjunction with the formation of

secondary enamel knots. In single-cusped teeth (i.e., incisors and canines), the primary enamel knot formed during the cap stage is the only chemical signaling center to form. However, in multi-cusped teeth (i.e., premolars and molars), secondary enamel knots begin to form in the bell stage, each corresponding to a cusp on the final tooth. These chemical signaling centers guide the morphodifferentiation of the enamel organ, dictating the final shape of the tooth crown (Jernvall et al. 1994; Nanci 2013).

2.1.3: Formation of the Hard Tissues of the Tooth

Hard tissue formation begins at the dentine horn where the enamel knots signal histodifferentiation of ameloblasts and odontoblasts. Dentine is the first tissue to be laid down, but the odontoblasts require signals from the differentiating ameloblasts in the enamel organ to begin laying down hard tissue. Therefore, the formation of dentine and enamel are linked. Histodifferentiation travels along the enamel-dentine border until it reaches the cervical loop; ameloblasts and odontoblasts follow this progression, laying down enamel and dentine until the full crown is formed (Antoine and Hillson 2016; Guatelli-Steinberg and Huffman 2011; Hillson 1992; Nanci 2013; Tang et al. 2016). For more information on the timing of hard tissue development in the permanent dentition, see Tables 6-5 and 6-6 in Liversidge (2016a).

Enamel is formed by ameloblasts on top of the newly formed dentine at the enamel-dentine junction. Enamel formation is referred to as amelogenesis, and this process consists of two stages: matrix formation (alternately referred to as secretion) and maturation. During the first stage of amelogenesis, the enamel matrix is deposited in layers. Ameloblasts travel from the enamel-dentine junction toward the outer epithelial layer of the enamel organ, which corresponds to the crown surface. Ameloblasts first

secrete a protein template; then, the enamel matrix consisting of small hydroxyapatite crystals is deposited within this template. Enamel is initially deposited in domes on top of the dentine horn, but after the ameloblasts reach the crown surface, enamel is laid down in "sleeve-like" layers instead (Hillson 1992: 7). Layers of enamel continue to be deposited from the cusp tip down the crown surface, finally ending at the cervical loop. After the ameloblasts reach the cervical loop, enamel matrix formation is complete, and the tooth crown is visible in its final shape (Antoine and Hillson 2016; Guatelli-Steinberg and Huffman 2011; Hillson 1992; Nanci 2013; Suga 1989).

During the second phase of amelogenesis, enamel maturation, the enamel is further mineralized. After the ameloblasts have deposited the protein matrix and the initial hydroxyapatite crystals, their function is to remove organic components and water from the enamel matrix while increasing the size of the existing hydroxyapatite crystals. Enamel maturation, or the process of further mineralization, seems to happen in the same pattern as enamel deposition, starting at the dentine horn, traveling up to the crown's surface, and continuing down the sides of the tooth to the cementoenamel junction (Antoine and Hillson 2016; Guatelli-Steinberg and Huffman 2011; Hillson 1992; Nanci 2013), although, this may not accurately represent the entire process of enamel maturation (Suga 1969, 1982, 1989).

Dentine is formed in the same manner as enamel. After receiving the signal from the inner epithelial layer of the enamel organ, odontoblasts begin dentine formation at the dentine horn. There are two phases to this process: predentine deposition and further mineralization. During the first phase of dentinogenesis, odontoblasts lay down an organic layer of predentine, which is a matrix to guide the second stage. At this point,

odontoblasts are also depositing inorganic crystallites within the predentine matrix, just as ameloblasts did (Antoine and Hillson 2016; Guatelli-Steinberg and Huffman 2011; Hillson 1992; Nanci 2013; Tang et al. 2016). Odontoblasts start predentine deposition at the enamel-dentine junction and travel toward the pulp cavity. As with enamel, dentine is also formed in domes until the odontoblasts reach the pulp cavity, after which dentine is laid down in "sleeve-like" layers to finish the tooth crown (Hillson 1992: 7). During the second stage of dentinogenesis, the inorganic crystallites placed in the predentine matrix expand and fuse with one another. This expansion of the inorganic crystallites forms the mineralized portion of dentine (Nanci 2013; Tang et al. 2016).

After the odontoblasts reach the cervical loop, the dentine of the crown is complete; next, the dentine of the roots must be formed. Enamel formation is complete at this point, but odontoblasts still require the signals from the epithelial layers of the enamel organ to differentiate. Therefore, the inner and outer epithelial layers at the cervical loop proliferate to create a layer of cells called Hertwig's epithelial root sheath. Hertwig's epithelial root sheath travels from the cervical loop down the length of the root, providing the signal for odontoblast differentiation. For teeth with multiple roots, "tongues" of the root sheath grow toward one another, meeting in the middle and dividing the pulp cavity into multiple chambers (Nanci 2013: 89). Odontoblasts follow Hertwig's epithelial root sheath, laying down layers of dentine to form the root of the tooth (Nanci 2013; Schoenwolf et al. 2015; Tang et al. 2016).

Cementum forms in conjunction with the dentine of the roots, a process referred to as cementogenesis. Cementum initiation is first limited to the location of Hertwig's epithelial root sheath. The differentiation of cementoblasts follows the formation of

dentine at the apical edge of the root. Once cementoblasts differentiate, they deposit collagen fibrils into the predentine matrix. As the odontoblasts go through the second phase of dentine mineralization, these cells effectively secure the fibers from the cementum into the dentine, establishing a connection between the two layers (Guatelli-Steinberg and Huffman 2011; Nanci 2013).

The hard tissues of the tooth differ in their capacity for developmental change after odontogenesis is complete. While dentine and enamel form in a similar manner, dentine differs from enamel in that odontoblasts continue to function throughout life. Once enamel maturation is complete, this layer of tissue no longer experiences any developmental changes, since ameloblasts alternately undergo preprogrammed cell death (i.e., apoptosis) after serving their function or are incorporated into the surface epithelium to protect the enamel until eruption (Antoine and Hillson 2016; Guatelli-Steinberg and Huffman 2011; Hillson 1992; Nanci 2013; Tang et al. 2016). In contrast, new dentine can form later in life. Within the pulp cavity, new layers are called secondary dentine, while reparative dentine at the crown surface is called tertiary dentine. Dentine also experiences further mineralization throughout life, since hydroxyapatite crystals within the predentine matrix continue to expand over time (Bang and Ramm 1970; Guatelli-Steinberg and Huffman 2011; Nanci 2013; Tang et al. 2016).

As with dentine, cementum continues to undergo developmental changes throughout the individual's life, though only one type of cementum is capable of these changes. Primary cementum covers the two-thirds of the root closest to the occlusal surface and is acellular. Secondary cementum covers the two-thirds of the root closest to the apical foramen. Secondary cementum is deposited more rapidly than primary

cementum, which leads to cementoblasts becoming trapped. Since secondary cementum is cellular, cementoblasts continue deposition throughout life (Guatelli-Steinberg and Huffman 2011; Nanci 2013; Tang et al. 2016).

2.1.4: Dental Eruption

Eruption is defined as the migration process of a tooth from inside the maxilla or mandible into its final occlusal position (Liversidge 2016b; Nanci 2013). In age estimation studies, eruption is sometimes conflated with clinical eruption (e.g., Chagula 1960; Garn and Lewis 1957; Krumholt et al. 1971), but the two are distinct. Clinical eruption is also referred to as gingival emergence. This phase represents the moment when the tooth erupts into the oral cavity through the gingiva, which is only a brief event in the continuous eruption process (Gleiser and Hunt 1955; Liversidge 2016b; Nanci 2013). For more information about the timing of eruption in the permanent dentition, see Table 6-2 in Liversidge (2016a).

Eruption has been divided into stages based on the direction of movement and level of activity observed in the developing tooth: pre-eruptive tooth movements, active eruption, and passive eruption. Pre-eruptive tooth movements take place within the dental follicle and serve to orient the tooth in preparation for the second stage. During active eruption, the tooth physically moves in an axial direction, i.e., toward the gingivae. Active eruption begins when the tooth crown is completely formed and a few millimeters of root formation has occurred. This phase continues until the apical half of the root length has formed (Liversidge 2016b; Nanci 2013).

During active eruption, the developing tooth migrates from within the alveolar bone through the gingivae until the occlusal surface is able to interact with the teeth in the

opposing jaw. To erupt through the alveolar bone, the dental follicle surrounding the developing tooth initiates osteoclastic activity, creating a canal through which the tooth can erupt. For deciduous teeth and permanent molars, resorption only occurs in the alveolar bone, but successional teeth require resorption of the deciduous roots. Root formation is completed during the third phase, passive eruption. During passive eruption, the tooth itself no longer moves. Instead, the gingivae retract as the jaws mature after the growth period in adolescence; this retraction increases the clinical crown height of the tooth (Liversidge 2016b; Nanci 2013).

2.2: Dental Hard Tissues – Clarifying Developmental Terminology

For the purposes of age estimation, the formation of the hard tissues is typically scored radiographically, and many age estimation techniques specify dental "mineralization" as the subject of analysis (e.g., Anderson et al. 1976; Harris 2007; Harris and McKee 1990; Olze et al. 2005; Olze et al. 2003). However, mineralization occurs during both phases of the development of the enamel and the dentine (Antoine and Hillson 2016; Hillson 1992; Nanci 2013; Tang et al. 2016). Since dentine is cellular, mineralization continues throughout the individual's life and is only used in adult age estimation (Bang and Ramm 1970; Guatelli-Steinberg and Huffman 2011; Lamendin et al. 1992; Nanci 2013; Tang et al. 2016). Nevertheless, since enamel is acellular, no developmental changes can be made to this dental hard tissue after the maturation phase (Antoine and Hillson 2016; Guatelli-Steinberg and Huffman 2011; Hillson 1992; Nanci 2013). Since enamel mineralization only happens during the process of dental development, it is of interest to those who analyze the dentition for subadult age estimation. For the remainder of this research, it is necessary to define and utilize the

appropriate terminology. Therefore, the following discussion focuses on enamel development, with the goal of distinguishing between the terms "mineralization" and "maturation."

Rather than the two phases of amelogenesis previously mentioned (Antoine and Hillson 2016; Hillson 1992), mineralization occurs in four phases (Nanci 2013; Suga 1969, 1982, 1989). The first phase is termed primary mineralization; this includes the formation of the enamel matrix and the initial deposition of hydroxyapatite crystals. At this point, the enamel is approximately 30% inorganic material (Nanci 2013: 154). The second phase is secondary mineralization (Nanci 2013; Suga 1982, 1989). Radiographically, an increase in mineralization is visible starting at the occlusal surface and moving toward the enamel-dentine junction. This phase of mineralization happens relatively quickly and produces a slight increase in inorganic content. Secondary mineralization is only visible in microradiographs obtained by "long exposure to soft X-ray" (Suga 1989: 191). The third phase of amelogenesis is tertiary mineralization (Nanci 2013; Suga 1982, 1989). During this phase, an increase in mineralization travels from the enamel-dentine junction back up toward the occlusal surface. Tertiary mineralization appears to increase the mineral content of enamel by a higher degree than secondary mineralization; consequently, this phase of enamel production takes longer to complete. It is during this stage that the enamel begins to be more highly mineralized than the dentine (Suga 1989). The final phase of enamel production is quaternary mineralization (Nanci 2013; Suga 1982, 1989). During this phase, the outermost layer of enamel, the "subsurface layer" (Suga 1982: 1533), at the crown surface starts to experience fast, heavy mineralization. Eventually, the outermost surface of the tooth crown is the most

highly mineralized of all the enamel, with a gradual decrease in mineralization moving toward the enamel-dentine junction and a slight increase again at the innermost layer of enamel on the surface of the dentine. During quaternary mineralization, the rest of the enamel stops increasing its inorganic content (Suga 1982, 1989).

The first and third phases defined by Suga (1969, 1982, 1989), primary and tertiary mineralization, correspond with the previously discussed secretion and maturation phases of amelogenesis (Antoine and Hillson 2016; Hillson 1992; Nanci 2013). The other two phases are more difficult to detect through radiography (Beynon et al. 1998; Suga 1989), which may explain why secondary and quaternary mineralization are not typically discussed in summaries of amelogenesis. Secondary and quaternary mineralization are shorter phases (Suga 1982, 1989), and dental radiographs may simply not be taken often enough to detect these changes. Additionally, radiographs of average quality, such as those produced during a routine dental check-up, are not of the appropriate sensitivity to distinguish enamel of a lower mineralization level or minute changes in inorganic composition. This presents a potential problem with age estimation techniques based on dental radiographs. Radiographs from dental offices are easy to obtain, but this imaging technology may not be capturing the entire process of enamel formation (Beynon et al. 1998).

During enamel matrix formation, the tissue is approximately 30% inorganic material (Nanci 2013: 154). This means that at the initiation of hard tissue formation, the enamel may not be radiopaque enough to stand out against the alveolar bone. If the radiation has less energy, it cannot penetrate the subject matter as deeply or as quickly, but the minimum thickness of the items that it can detect is much smaller. With

increasing energy, the penetration power increases, but so does the minimum size of the item detected (Beynon et al. 1998). As Suga (1989) suggests, X-rays of lower energy detect smaller mineralized objects, which allows researchers to distinguish developing teeth more clearly. However, since the penetrating power is lower with lower radiation energy, the exposure time must be increased (Beynon et al. 1998; Suga 1982, 1989).

As long radiation exposure is not safe in living subjects, traditional radiographs are more commonly utilized to analyze the process of odontogenesis, from hard tissue formation through eruption; additionally, these radiographs are easier to obtain and are more useful for comparative purposes. However, because traditional radiographs have a minimum thickness detection size of 1 mm (Beynon et al. 1998: 359), they are less effective at detecting the earliest and latest stages of hard tissue formation in the crown. Researchers have long recognized there is a delay between the initiation of crown formation and its detection in traditional radiographs; Hess and colleagues (1932) suggest there is approximately a six-month difference in these two events. Therefore, radiographs tend to overestimate the age at initiation of hard tissue formation in humans (Beynon et al. 1998; Liversidge 1995, 2016a). At the other end of crown formation, enamel thins as it travels down the crown surface; this hard tissue is at its thinnest, and subsequently is hardest to distinguish from the dentine, at the cementoenamel junction. Therefore, radiographic age estimations at the later crown development stages tend to underestimate age by up to three years, as compared to gross or histological examination of isolated teeth in which differences in physical appearance and cellular structure can help distinguish enamel from other dental hard tissues (Beynon et al. 1991: 202, 1998).

To ensure the appropriate terminology can be applied, the question remains: are dental age estimation techniques using radiographs based on enamel mineralization, as many suggest, or are these techniques instead focused on the larger process of dental development? Suga (1982, 1989) refers to the entire process of amelogenesis as mineralization, since there are hydroxyapatite crystals being deposited within the organic matrix during the initial secretory phase of enamel production as well as during the secondary, maturation phase. Used in this broad sense, radiographs are capturing the mineralization process of enamel, which would mean that age estimation techniques are evaluating the earliest stages of dental mineralization (e.g., Anderson et al. 1976; Harris 2007; Harris and McKee 1990; Olze et al. 2005; Olze et al. 2003; Scheuer and Black 2000; Suga 1969, 1982, 1989).

If mineralization is used in a narrower sense to refer to the maturation phase of enamel production (e.g., Antoine and Hillson 2016; Hillson 1992; Nanci 2013; Salazar-Ciudad and Jernvall 2002, 2010; Thesleff and Sharpe 1997), age estimation methods from radiographs are not measuring mineralization of the dentition. During amelogenesis, ameloblasts travel from the enamel-dentine junction toward the outer epithelial layer of the enamel organ (Antoine and Hillson 2016; Hillson 1992; Nanci 2013). Once ameloblasts reach the crown surface, the function of creating the enamel matrix is complete. The cells now have a new function: increasing the inorganic content of enamel. Once ameloblasts reach the crown surface, they immediately transition into the function of enamel maturation (Antoine and Hillson 2016; Nanci 2013). Therefore, maturation, or further mineralization, does not begin until the full depth of the tooth crown has formed at any given spot (Antoine and Hillson 2016; Hillson 1992; Nanci

2013). Developing teeth are visible in radiographs before the full tooth crown is formed; otherwise, age estimation methods from the developing dentition would be wholly ineffective during early dental development.

Why do semantic differences matter? The term "mineralization" is alternately used to indicate the entire process of amelogenesis (e.g., Anderson et al. 1976; Harris 2007; Harris and McKee 1990; Olze et al. 2005; Olze et al. 2003; Scheuer and Black 2000; Suga 1969, 1982, 1989) or simply the enamel maturation phase (e.g., Antoine and Hillson 2016; Hillson 1992; Nanci 2013; Salazar-Ciudad and Jernvall 2002, 2010; Thesleff and Sharpe 1997). To effectively convey the material that has been analyzed, it is up to researchers to define the terminology they are using. Without clearly defining terms, researchers have no way to ensure their results are accurately portrayed. Terminology that is not well defined affects the replicability of a method. If it is unclear whether an age estimation method is analyzing "mineralization" as the entire process of amelogenesis or specifically enamel maturation, then the results of other studies utilizing this method may be inconsistent.

2.2.1: Developmental Terms Defined

The purpose of this project is to create an age estimation method based on dental development for use in the forensic context in the United States. With this goal in mind, and having established that consistent terminology is important, the following terms are used and defined as such:

Dental development – This term will be taken literally for the remainder of this project. In other words, "dental development" refers to the formation of the hard tissues of the tooth, i.e., the development of the tooth itself. Only once hard tissue

formation begins can the developing tooth be seen radiographically. Therefore, "dental development," i.e., hard tissue formation, is the process on which age estimation is based. Neither the embryological stages preceding hard tissue formation nor the eruption process are considered in this research.

Odontogenesis – This term refers to the entire process through which teeth must progress to serve their ultimate masticatory function, from embryological stages through hard tissue formation and eruption (Nanci 2013). "Odontogenesis" is the broadest descriptor available.

Mineralization – This term is used in the broad sense that Suga (1982, 1989) applies. Inorganic crystals are deposited in the organic matrix during the initial, secretory phases of both enamel and dentine production, and the inorganic content continues to increase during the secondary, maturation phases. Therefore, "mineralization" is occurring throughout the process of dental development.

Secretion – This term refers to both the enamel matrix formation phase of amelogenesis and the predentine deposition phase of dentinogenesis (Antoine and Hillson 2016; Nanci 2013; Tang et al. 2016).

Maturation – This term refers to both the enamel maturation stage of amelogenesis and the further mineralization phase of dentinogenesis (Antoine and Hillson 2016; Nanci 2013; Tang et al. 2016). In enamel, this phase begins after the full depth of the tooth crown is formed, while in dentine, this phase starts after the hard tissue matrix has been created and continues throughout adult life (Antoine and Hillson 2016; Bang and Ramm 1970; Guatelli-Steinberg and Huffman 2011; Hillson

1992; Nanci 2013; Tang et al. 2016). Therefore, the maturation phases are not considered, as these processes are of no utility for subadult age estimation.

2.3: Conclusions

Odontogenesis is a complex process, from the early stages of embryological development through the formation of the hard tissues and the eruption of the tooth into its final occlusal position. Despite the complex nature of dental development, it is still considered the most reliable age indicator in subadults (Garn et al. 1973a; Garvin et al. 2012; Jernvall and Jung 2000; Liversidge et al. 2006; Scheuer and Black 2000; Schmidt 2016). However, without utilizing consistent terminology, the likelihood of producing replicable results in subsequent age estimation studies decreases. Therefore, researchers utilizing dental development in age estimation methods should be mindful of appropriate terminology to ensure their results are reproduced in the most consistent way possible.

Chapter 3: Subadult Age Estimation

Subadult age estimation techniques are based on development (Cunningham et al. 2016; Garvin et al. 2012; Ritz-Timme et al. 2000). Once an individual is skeletally mature, age estimation depends on the inexorable process of degeneration (Garvin et al. 2012; Milner and Boldsen 2012). The teeth and skeleton form at relatively consistent rates, but degeneration is a less predictable process than development. Many factors influence the rate at which an individual experiences skeletal deterioration including sex, ancestry, socioeconomic status, physical activity, disease load, and malnutrition (e.g., Aykroyd et al. 1999; Buikstra and Ubelaker 1994; Cho et al. 2002; Cho et al. 2006; Garvin et al. 2012; İşcan and Loth 1987; Milner and Boldsen 2012; Nawrocki 2010; Paine and Brenton 2006; Ritz-Timme et al. 2000; Robling and Stout 2008; Schmeling et al. 2000). For these reasons, age estimation in subadults is more accurate than in adults (Cunningham et al. 2016; Garvin et al. 2012; Milner and Boldsen 2012; Ritz-Timme et al. 2000).

Despite its advantages relative to adult age estimation, methods for aging subadults are not without flaws. Although skeletal and dental development are both a reflection of genes, environment, and culture, the development of the skeleton is more subject to external influences than dental development. This difference in environmental sensitivity led many researchers to suggest subadult age estimation from the dentition is more accurate (Cunningham et al. 2016; Garvin et al. 2012; Milner and Boldsen 2012; Schmidt 2016). Even within the dentition, secular variation has been observed (e.g., Heuzé and Cardoso 2008; Rautman and Edgar 2013) as well as differences between socioeconomic groups (e.g., Cardoso 2007; Garn et al. 1973a), sexes (e.g., Liversidge

2010; Mincer et al. 1993), and populations or ancestry groups (e.g., Garn et al. 1973b; Lewis and Senn 2010).

This chapter reviews subadult age estimation with a focus on methods that employ the dentition. Variation within the process of odontogenesis is also addressed. While external and internal factors are more influential on the process of skeletal development, the impact of these variables on odontogenesis must be considered to ensure the highest accuracy possible.

3.1: Age Estimation from Skeletal Development

Skeletal development occurs in a well-documented sequence. Primary centers of ossification form, followed by secondary centers of ossification where applicable. After epiphyseal union connects these ossification centers, skeletal development is complete. This predictable pattern allows skeletal development to be used in age estimation studies. Primary centers of ossification are the first to form, beginning to appear during fetal development (Cunningham et al. 2016; White et al. 2012). Balancing selection operates on fetal size to prevent babies from being too small to survive or too large to pass through the pelvic inlet. Since fetal growth is tightly genetically controlled, age estimations during the fetal period typically involve measurements of the diaphyses of long bones (e.g., Fazekas and Kósa 1978; Stewart 1979).

Most secondary centers of ossification begin to form after birth (Cunningham et al. 2016; White et al. 2012). Post-natal age estimation again involves measurements of the long bone diaphyses (e.g., Hoffman 1979; Johnston 1962; Stull et al. 2014; Ubelaker 1978), along with the identification of secondary centers with recognizable morphology, since secondary centers of ossification begin to form at known times during development.

The final phase of skeletal development involves fusion of the primary and secondary centers of ossification that happens at various times during adolescence and early adulthood (Cunningham et al. 2016; White et al. 2012). Ages of epiphyseal union have been extensively studied for age estimation (e.g., Cunningham et al. 2016; Fazekas and Kósa 1978; McKern and Stewart 1957; Stewart 1979; Ubelaker 1978).

Since primary and secondary centers of ossification form in a predictable pattern, an age estimate should be possible through comparison of the ossification centers present in a subadult skeleton to an atlas of known ages of development (e.g., Cunningham et al. 2016; Ubelaker 1978). As with any age estimation technique, there are methodological issues with estimating age solely on the appearance of ossification centers. Early in formation, some primary centers (e.g., bones of the hands and feet) and many secondary centers do not possess distinctive morphology (Cunningham et al. 2016). Age estimation techniques also assume that ossification centers appear in a designated order, though there is individual variation in this timing (Acheson 1954, 1957; Scheuer and Black 2000).

Once ossification centers begin to take on their distinct morphological appearances, measurements can be taken and compared to known standards to create an age estimation (e.g., Cunningham et al. 2016; Fazekas and Kósa 1978; Stewart 1979). For example, the volume by Cunningham and colleagues (2016) features great details on each skeletal element amassed from the work of other authors. Methodological issues from previous works may carry over, and the authors acknowledge there are known problems with estimating age from measurements of primary ossification centers (Scheuer and Black 2000). The first has to do with study design, using the work of

Fazekas and Kósa (1978) as an example. The subject material for that work was derived from a forensic context, and Scheuer and Black (2000: 9) state that the individuals are "essentially of uncertain age." For prenatal remains, fetuses were first organized based on full body length, and these individuals were then split into age groups of two-week intervals. However, since grouping and subsequent assignment of age were based on full body length, the high correlation between long bone lengths and age found by these authors was inevitable (Cunningham et al. 2016; Fazekas and Kósa 1978). The techniques for estimating age from measurements of ossification centers also rely on being able to recognize these centers as belonging to specific bones. The ages at which ossification centers take on their distinct morphology are highly variable, ranging from before birth for most primary centers through the teenage years for a few secondary centers (Cunningham et al. 2016; White et al. 2012).

A final problem with age estimation methods based on diaphyseal lengths is the lack of appropriate measures of statistical error. A recent study by Stull and colleagues (2014) notes that previous work on diaphyseal lengths in biological anthropology has failed to include prediction intervals and is therefore inappropriate for use in forensic casework (per Daubert v. Merrell Dow Pharmaceuticals, Inc. 1993). Standard errors may be presented (e.g., Cardoso et al. 2013; López-Costas et al. 2012), but based on the nature of the developmental process, it is not valid to assume that a standard error alone can describe the variation in measurements throughout childhood and adolescence. For example, a standard error describing the average range of variation in diaphyseal lengths would simultaneously be too wide for the youngest individuals and too narrow for the oldest individuals (Stull et al. 2014). As development progresses, children are exposed to

an increasing number of external influences, which in turn increases the variation observed in the measurements contributing to age estimates (Cunningham et al. 2016). This trend is referred to as the "trajectory effect" and can be observed through development and later into degeneration. Minute changes early in childhood, such as exposure to different environments, are magnified over time, resulting in large amounts of variation in both skeletal growth and deterioration (Nawrocki 2010: 88). Since variation is acknowledged to increase over time, the standard error alone cannot adequately address the entire developmental process (Nawrocki 2010; Stull et al. 2014).

To make diaphyseal dimensions usable in the forensic context, Stull and colleagues (2014) incorporated both length and breadth measurements of the long bones and applied univariate and multivariate models to create 95% prediction intervals for the purposes of age estimation. Standard errors were provided for each model, along with multiple 95% prediction intervals. The combination of the standard error and many prediction intervals ensured that increasing levels of variation throughout the age range were adequately described. The authors found that univariate models, particularly those based on diaphyseal lengths, created the smallest prediction interval for younger individuals. For older children, multivariate models performed best, since including measurements from different bones helps account for the variation in limb proportions observed in adolescence. The work of Stull and colleagues (Stull 2013; Stull et al. 2014) demonstrates that diaphyseal dimensions can be used to accurately estimate age during this stage of skeletal development, though the authors suggest supplementing these variables with other age estimation methods, particularly when the upper bound of the prediction interval exceeds 12.99 years.

Researchers can also estimate age based on the fusion of primary and secondary ossification centers. Timing of fusion varies depending on the part of the body and its function. Some bones of the skull and those of the vertebrae fuse early due to the fast growth of the central nervous system, while ossification centers in the long bones fuse later to accommodate growth spurts during adolescence (Cunningham et al. 2016). This variation in the timing of epiphyseal union means that, between birth and early adulthood, an individual's age can be estimated based on which epiphyses have or have not fused (Cunningham et al. 2016; McKern and Stewart 1957; Stevenson 1924; Todd 1930; Ubelaker 1978).

As with the appearance of ossification centers, the age at which these centers fuse is variable. Not only does variation naturally increase with age, but epiphyseal union is also triggered by hormones released at the onset of puberty, which means the relative speed of sexual maturation affects the timing of skeletal development (Cunningham et al. 2016; Cutler 1997; Grumbach 2000; Shapland and Lewis 2014; Ubelaker 1978). Additionally, the stages of fusion of the ossification centers may be difficult to identify, depending on the means of visualization (e.g., radiograph versus dry bone). Therefore, Cunningham and colleagues (2016) suggest that inter- and intraobserver error may be higher in these age estimations, depending on the method of analysis.

With all methods that estimate age from skeletal development, researchers must be aware of biases involved in different methods of visualization (Milner and Boldsen 2012). Gross metric and morphological observations on dry bone can be used for age estimation in forensic anthropology, but in living subjects, this is not feasible. Since age estimation for living individuals is increasingly necessary in the judicial sphere

(Cameriere et al. 2012; Cunha et al. 2009), research on subadult age estimation often relies on imaging technology. Bones are three-dimensional objects, which means traditional radiographs that produce a two-dimensional image may cause warping of the subject matter, potentially affecting the intra- and interobserver error associated with metric assessments of skeletal growth (Cunningham et al. 2016; Stull et al. 2014).

3.2: Age Estimation from Odontogenesis

The process of odontogenesis is predictable, under genetic control, and more buffered against external factors than skeletal development (Cardoso 2007; Cunningham et al. 2016; Garn et al. 1973a; Hillson 1992; Jernvall and Jung 2000; Nanci 2013; Ritz-Timme et al. 2000). Cunningham and colleagues (2016) suggest this difference in sensitivity to external factors may be related to the amount of development that takes place in the intrauterine environment. All deciduous teeth and a portion of the permanent dentition begin development before birth when the tissues are relatively protected from external influence. Enamel specifically cannot make developmental changes after it is formed (Antoine and Hillson 2016; Liversidge 2016a). Skeletal development also begins in the intrauterine environment, but through the processes of modeling and remodeling, bones are highly adaptable in the presence of external and internal stimuli, such as injury or malnutrition (e.g., Cunningham et al. 2016; White et al. 2012).

While protection within the intrauterine environment could explain dental buffering from external factors (Cunningham et al. 2016), maternal health has conversely been demonstrated to influence both tooth crown dimensions and the prevalence of

fluctuating asymmetry[1] in the dentition (e.g., Garn et al. 1979, 1980; Heikkinen et al. 1992, 1994; Kieser et al. 1997; Pilloud and Kenyhercz 2016). For example, Kieser and colleagues (1997) find that maxillary central incisor dimensions are significantly more likely to be asymmetrical in the presence of maternal obesity. Although the reason for resistance is unclear, the fact remains that odontogenesis is a more stable process than skeletal development (Cardoso 2007; Cunningham et al. 2016; Garn et al. 1973a; Jernvall and Jung 2000; Nanci 2013; Ritz-Timme et al. 2000). Therefore, for its predictability and relative resistance to external influence, odontogenesis is considered the best indicator of age in subadults (Cunningham et al. 2016; Garvin et al. 2012; Schmidt 2016). Age estimation techniques are based on two aspects of odontogenesis, eruption and dental development (Cunningham et al. 2016).

Metric methods have been created to estimate age from the developing dentition. These methods typically include length and width measurements, often expressed as a ratio to account for variation in tooth size (e.g., Cameriere et al. 2006; Deutsch et al. 1985; Liversidge et al. 2003; Thevissen et al. 2012). Thevissen and colleagues (2011, 2012) created univariate and multivariate models for age estimation using stages of dental development and measurements of developing teeth as independent variables. However, the multivariate models that combined both forms of data did not increase the accuracy of the age estimations when compared to the univariate model based solely on stages of development. As these measurements are time-consuming and require high quality

[1] Fluctuating asymmetry is defined as apparently random differences in either size or expression of dental morphological features between the same tooth in different sides of the jaw, e.g., the left and right mandibular first molar (Townsend et al. 2016).

radiographs, the authors suggest that analyzing dental development through stages is preferable over measurements for subadult age estimation (Thevissen et al. 2011, 2012).

3.2.1: Age Estimation from Dental Eruption

Techniques for age estimation from eruption often examine clinical eruption or gingival emergence, rather than the entire process of eruption (Liversidge 2016b). Eruption can be scored skeletally, visually, or radiographically (Chagula 1960), though these scoring methods may capture different aspects of the eruption process. Teeth must first emerge from the alveolar bone, and alveolar eruption can be scored either skeletally or radiographically (e.g., AlQahtani et al. 2010; Muller-Bolla et al. 2003). Next, gingival eruption occurs when the tooth emerges from the gingival tissue, and this stage can be scored visually (e.g., Chagula 1960; Garn et al. 1973a). Recent methods for age estimation from eruption are typically based on dental radiographs; mean or median ages of eruption are calculated along with standard deviations to produce age estimates (e.g., AlQahtani et al. 2010; Liversidge 2016a; Muller-Bolla et al. 2003; Wilmott et al. 2013).

Age estimation from dental eruption is based on the idea that since teeth develop at a predictable rate, they should theoretically erupt at a predictable rate. Many authors have examined eruption of the teeth to estimate age in subadults (e.g., Chagula 1960; Hassanali 1985; Krumholt et al. 1971; Muller-Bolla et al. 2003; Olze et al. 2007; Wilmott et al. 2013), often in conjunction with development (e.g., AlQahtani et al. 2010; Gleiser and Hunt 1955; Gustafson and Koch 1974; Schour and Massler 1941). However, this is not the most accurate age estimation technique from the dentition for several reasons (Liversidge 2016a). Eruption is one phase in the larger process of odontogenesis, which means that only a small portion of the process is being captured (Demirjian et al. 1973;

Gleiser and Hunt 1955; Gustafson and Koch 1974; Nolla 1960). During a study on the accuracy of eruption as an age estimation technique, Wilmott and colleagues (2013) confirmed that permanent teeth, excluding the third molar, erupt in two phases. Early erupting teeth (i.e., M1, I1, and I2) emerge between the ages of 5 and 7.3, while late erupting teeth (C, P1, P2, and M2)[2] emerge between the ages of 8.8 and 12.2 (Wilmott et al. 2013: 57). This lull between the emergence of the early and late erupting teeth means that age cannot be estimated reliably from clinical eruption during this latent period. Additionally, eruption of the third molar happens significantly later and has a very wide age range, from as early as 13 (Chagula 1960: 79) to as late as 25 (Liversidge 2016b: 166).

The final problem with utilizing eruption in age estimation is that it is perhaps the least consistent stage of odontogenesis. Impaction occurs when a tooth does not erupt into its proper anatomical position within the expected time frame (Hattab and Abu Alhaija 1999; Heim and Pilloud 2018; Saker et al. 2009). If a tooth is impacted, the age estimation from the eruption of that tooth will be affected, in that the tooth may not erupt at all. Additionally, eruption is more likely to be affected by internal and external factors than the process of dental development, such as the early exfoliation of a deciduous precursor or a lack of space in the jaw (Cunningham et al. 2016; Demirjian et al. 1973). Despite the high replicability of eruption scores (Wilmott et al. 2013), the aforementioned problems mean that dental eruption is not an ideal method for subadult age estimation.

[2] Abbreviations are used in place of full tooth names. I stands for incisor, C stands for canine, P stands for premolar, and M stands for molar. If a number follows, this indicates the tooth's position, e.g., M1 is the first molar.

3.2.2: Age Estimation from Dental Development

Dental development is considered the most accurate method for estimating age from the dentition, since this process is under genetic control and is least likely to be influenced by external factors (Cunningham et al. 2016; Garn et al. 1973a; Jernvall and Jung 2000; Liversidge et al. 2006; Smith 1991). Dental development is typically scored radiographically, though some exceptions exist. For example, AlQahtani and colleagues (2010) assigned developmental scores to isolated teeth if radiographs of an individual were not available; however, these authors suggest the internal structure of the tooth can help the researcher differentiate between developmental stages. Therefore, radiographs should be utilized in the assessment of dental development whenever possible (AlQahtani et al. 2010).

There are many methods for obtaining an age estimate from dental development. Some authors utilize atlases to describe the developmental process (e.g., AlQahtani et al. 2010; Schour and Massler 1941; Ubelaker 1978). Atlases are generally popular methods for age estimation because they are simple to use, requiring only a dental radiograph and the ability to compare to the chart (Liversidge 1994, 2016a). However, atlases have potential problems, not the least of which is a lack of statistical support (Adams et al. 2016).

In their original publication, Schour and Massler (1941) do not specify which sample they use, nor do they provide a sample size on which their observations are based (AlQahtani et al. 2014; Smith 1991; Ubelaker 1987). Ubelaker (1987) mentions that the atlas created by Schour and Massler (1941) is based on a small sample of unhealthy American white children. Additionally, the age ranges associated with the dental

development and eruption phases are not wide enough to cover the range of variation, particularly in the late stages of odontogenesis (AlQahtani et al. 2014; Schour and Massler 1941). This atlas is more accurate for age estimation in males than females, suggesting that the sample composition may not have been balanced by sex (Byers 2011; Schour and Massler 1941).

A subsequent atlas for estimating age from development and eruption was created by Ubelaker (1978). This atlas combined data from American white and Native American individuals and provided age ranges that better accommodate normal human variation. While the sample includes more ancestry groups than the atlas created by Schour and Massler (1941), the distribution is uneven. The data for the deciduous teeth are entirely from American white children, since only data for permanent teeth were available from Native American samples (Ubelaker 1978). Ubelaker (1978) also pooled the data for males and females, a potential problem since females reach developmental stages earlier than males in all permanent teeth except the third molar (e.g., Anderson et al. 1976; Arany et al. 2004; Engström et al. 1983; Garn et al. 1962; Gleiser and Hunt 1955; Gunst et al. 2003; Kasper et al. 2009; Knell et al. 2009; Kullman et al. 1992; McGettigan et al. 2011; Mesotten et al. 2002; Mincer et al. 1993; Moorrees and Kent 1978; Nolla 1960; Prieto et al. 2005; Schour and Massler 1941; Sisman et al. 2007; Solari and Abramovitch 2002).

The London Atlas created by AlQahtani and colleagues (2010) uses a larger sample (n = 704) and includes individuals of both English and Bangladeshi origins, although data for males and females are pooled (AlQahtani et al. 2010: 481). Another positive aspect of the London Atlas is the inclusion of statistical measures of reliability

and subsequent reports on accuracy rates (e.g., Adams et al. 2016; AlQahtani et al. 2014; Alshihri et al. 2015). Intra-observer error testing on a subset of the data yielded a Kappa value of 0.85 for the whole age range (AlQahtani et al. 2010). This Kappa value indicates high levels of agreement for the application of dental development scores (Moorrees et al. 1963) and eruption scores (Bengston 1935). Agreement was higher in younger individuals than older individuals, but this disparity may also be a product of differing subject material, with individuals younger than two years of age represented by a combination of radiographs and skeletal material and individuals two years of age or older represented solely by radiographs (AlQahtani et al. 2010).

While intra-observer agreement for the application of developmental and eruption scores is high, the results of accuracy tests using the London Atlas are divided. When tested on a sample comprised of the same ethnic groups as the original study (AlQahtani et al. 2014), the London Atlas demonstrated higher accuracy rates than either the atlas from Schour and Massler (1941) or Ubelaker (1978). However, when tested on a sample from Saudi Arabia (Alshihri et al. 2015), the estimated age from the London Atlas was significantly different from the chronological age. Though estimated and chronological ages did not show significant differences in a sample from the United States, Adams and colleagues (2016) found the London Atlas overestimated age for Native American and African American individuals. These studies suggest that while the London Atlas may perform well on individuals from England, this method may not be applicable to other populations.

A common feature among atlases is the lack of statistical support. Though many subsequent studies have tested the accuracy of atlases (e.g., Adams et al. 2016; AlQahtani

et al. 2014; Alshihri et al. 2015; Liversidge 1994; Smith 2005), no current atlases provide their own accuracy rating or measure of probability, meaning they are inappropriate for use in a forensic context (Dirkmaat and Cabo 2012; Ousley and Hollinger 2012). Another confounding variable in age estimations produced by an atlas is the potential that one or more teeth will not agree with the overall picture of development or eruption at a given age (e.g., Adams et al. 2016; Alshihri et al. 2015; Liversidge 2016a; Moorrees et al. 1963; Schmidt 2016). When an individual is between the illustrated ages of the atlas, it is up to the researcher to decide the appropriate course of action.

A way to resolve this final methodological issue is by scoring each tooth independently from the others (e.g., Arany et al. 2004; Caldas et al. 2010; Demirjian et al. 1973; Kasper et al. 2009; Knell et al. 2009; Mincer et al. 1993; Moorrees et al. 1963; Orhan et al. 2007; Prieto et al. 2005; Solari and Abramovitch 2002). Rather than assuming every individual develops teeth in the same order and at the same rate, methods that score individual teeth allow for variation within and between individuals in the process of dental development. These scores are considered together to arrive at an age estimate, either through the use of graphs (e.g., Moorrees et al. 1963), the application of statistical formulae (e.g., Arany et al. 2004; Caldas et al. 2010; Kasper et al. 2009; Knell et al. 2009; Mincer et al. 1993; Orhan et al. 2007; Prieto et al. 2005; Solari and Abramovitch 2002), or both (e.g., Demirjian et al. 1973).

Moorrees and colleagues (1963) created one of the first methods for evaluating teeth individually. The authors focused on maxillary incisors and all mandibular teeth, ignoring the maxillary posterior teeth due to the poor quality of radiographs. Fourteen stages of development were identified, and each tooth in the sample was assigned a stage

(Moorrees et al. 1963). The authors calculated the median age at which individuals enter each stage for each tooth and plotted this information along with two standard deviations on a graph. Age can be estimated by assigning each tooth to its developmental stage, plotting these stages on the graph, and then drawing a vertical line through all the teeth to arrive at an age estimate (Moorrees et al. 1963). While interobserver error in assigning stages was relatively low, the authors suggest that the complicated nature of this age estimation technique may lead to higher intraobserver error rates in researchers inexperienced with this technique. This method relies on plotting the developmental stages of each tooth on a graph and suffers from the same potential problem of accounting for variation previously discussed; that is, one or more teeth that are not in agreement makes deciding on a final age estimate subjective (Moorrees et al. 1963).

Many authors have published modifications to the Moorrees method (1963) to make age estimation more practical (e.g., Harris and Buck 2002; Millard and Gowland 2002; Shackelford et al. 2012; Smith 1991). For example, Shackelford and colleagues (2012) used a digitizer to make digital copies of the graphs produced by Moorrees et al. (1963), which enabled the authors to assign numerical values to the median ages and standard deviations of each developmental stage. Using these values, point estimates of age and standard deviations could be created for any combination of teeth, and after applying univariate and multivariate cumulative probit models to these values, a maximum likelihood probability value can be produced (Shackelford et al. 2012).

Demirjian and colleagues (1973) attempted to alleviate many of the methodological problems associated with the Moorrees et al. (1963) method. Fourteen stages of development were arbitrarily chosen by Moorrees and colleagues (1963), while

Demirjian and colleagues (1973) identified only eight stages to reduce potential interobserver error. Additionally, the Demirjian et al. (1973) stages are based on morphological changes rather than an estimate of future size or length. For example, the root development stages for single-rooted teeth proposed by Moorrees and colleagues (1963) are based on the length of the root (i.e., ¼ complete, ½ complete, ¾ complete, or complete). As an alternate evaluation of root development, Demirjian and colleagues (1973) defined root length in stages E and F relative to the crown height, as opposed to estimating how long the root is relative to its final length. These developmental stages are further defined by changes in shape. For stage F, the following changes can be observed: "The walls of the pulp chamber now form a more or less isosceles triangle. The apex ends in a funnel shape" (Demirjian et al. 1973: 223). Researchers suggest that stages defined through morphological changes produce lower intra- and interobserver error rates than those based on estimates of size changes (Dhanjal et al. 2006; Olze et al. 2005; Sisman et al. 2007).

In the Demirjian et al. (1973) method, each developmental stage has a point value, and the points for the first seven permanent mandibular teeth[3] are added to obtain a single maturity score. This maturity score is compared to a table to obtain an estimate of chronological age based on dental maturity (Demirjian et al. 1973). The smaller number of stages and the ease of use make this method one of the most widely applied for scoring dental development (Yan et al. 2013). While the Demirjian et al. (1973) method seems to be the better choice for producing age estimates, there is one serious problem: this

[3] There are eight teeth in each quadrant of the dentition. The Demirjian et al. method (1973) creates an age estimation using the developmental scores for the central and lateral incisors, the canine, both premolars, and the first two molars in one quadrant of the mandible.

technique does not account for missing teeth (Chaillet and Demirjian 2004; Demirjian et al. 1973). In the forensic context, this may preclude the use of the method on individuals whose teeth are not all recovered or individuals who have congenitally missing teeth.

During late adolescence and early adulthood, there are very few skeletal elements still developing, one of which is the third molar (Garvin et al. 2012; Ritz-Timme et al. 2000). Because it is one of the few skeletal elements that can be used for age estimation during this period, many methods have been created to estimate age from the development of the third molar (e.g., Arany et al. 2004; Caldas et al. 2010; Kasper et al. 2009; Knell et al. 2009; Mincer et al. 1993; Orhan et al. 2007; Prieto et al. 2005; Solari and Abramovitch 2002). A number of these techniques use the developmental stages created by Demirjian and colleagues (1973) to estimate the probability that an individual has reached the age of majority, or adulthood. The age of majority is legally defined in the United States, but other countries utilize different ages as important legal cutoffs (e.g., Arany et al. 2004; Caldas et al. 2010; Cameriere et al. 2012; Knell et al. 2009; Orhan et al. 2007; Prieto et al. 2005). In the United States, these methods specifically evaluate the probability that an individual is older or younger than 18 years of age (e.g., Kasper et al. 2009; Mincer et al. 1993; Solari and Abramovitch 2002). The age of majority can have dual significance for living individuals in the criminal sphere (Cameriere et al. 2012; Cunha et al. 2009). For juveniles who have committed a crime, a determination of adult status changes the legal consequences they face. The age of adulthood is also important in cases in which a juvenile has been victimized, such as sexual assault or child pornography. If the victim is not an adult, the punishment for the offenders is much greater (Cameriere et al. 2012).

3.3: The Importance of Appropriate Reference Samples

Subadult age estimation methods have been summarized, and the analysis of development through dental radiographs is suggested to be the most accurate, based on its high level of heritability and the relative resistance to external and internal factors (Cunningham et al. 2016; Garn et al. 1973a; Garvin et al. 2012; Jernvall and Jung 2000; Liversidge 2016a; Liversidge et al. 2006; Schmidt 2016; Smith 1991). However, the importance of an appropriate reference sample cannot be overstated. The technique described by Demirjian and colleagues (1973) is based on a French-Canadian sample, and the published tables to calculate chronological age from maturity scores may not be applicable to other populations. This is less a methodological problem than a general issue in the field of biological anthropology. Variation exists both within and between populations, and this variation must be addressed. Odontogenesis can be affected by secular change (e.g., Heuzé and Cardoso 2008; Liversidge 1999; Muller-Bolla et al. 2003; Rautman and Edgar 2013), socioeconomic status (e.g., Cardoso 2005, 2007; Garn et al. 1973a; Gustafson 1950; Heuzé and Cardoso 2008), sex (e.g., Blankenship et al. 2007; Caldas et al. 2010; Cameriere et al. 2006; Daito et al. 1992; Demirjian and Levesque 1980; Gleiser and Hunt 1955; Harris 2007; Harris and McKee 1990; Knell et al. 2009; Levesque et al. 1981; Liversidge 2010; Prince and Ubelaker 2002), and ancestry (e.g., Caldas et al. 2010; Demirjian et al. 1973; Drvostep and Senn 2017; Garn et al. 1973b; Gunst et al. 2003; Harris 2007; Harris and McKee 1990; Kaiser and Senn 2004; Kasper et al. 2009; Kimura 1994; Knell et al. 2009; Kullman et al. 1992; Lewis and Senn 2010; Moorrees et al. 1963; Olze et al. 2003; Olze et al. 2004; Olze et al. 2007; Orhan et

al. 2007; Prieto et al. 2005; Sisman et al. 2007; Solari and Abramovitch 2002; Te Moananui et al. 2008; Willems et al. 2001).

Secular change affects many biological processes. Present populations exhibit earlier ages of menarche (e.g., Cole 2006; Herman-Giddens 2006; Wyshak and Frisch 1982) and increased weight and height relative to previous generations (e.g., Cole 2006; Freedman et al. 2000; Jantz and Jantz 2000a). The facial portion of the skull exhibits narrower and taller dimensions in present populations compared to past populations (e.g., Jantz and Jantz 2000b; Smith et al. 1986). Some researchers suggest that the dimensions of the dental arcade have experienced a decrease over time (e.g., Truesdell 2005; Lavelle 1973), while others report an increase in arcade dimensions, specifically in the anterior maxillae (e.g., Jonke et al. 2007) and the length of the mandible (e.g., Smith et al. 1986).

While secular change is well documented in other areas of the human body, there are conflicting opinions as to whether secular change has a large effect on dental development. Some authors have found children in the United States and Europe are developing their teeth at earlier ages than in previous generations, with the difference in ages ranging from 0.5 to 1.52 years earlier (e.g., Cardoso et al. 2010; Heuzé and Cardoso 2008; Nadler 1998; O'Neill 2012; Sasso et al. 2012). Others disagree with this conclusion, suggesting that recent populations are reaching developmental stages between 0.2 and 5.4 months later (e.g., Rautman and Edgar 2013: 33). Finally, there is the possibility that the effect of secular change is negligible; some researchers suggest the mean ages at which children are reaching developmental stages show no significant differences over time (e.g., Liversidge 1999; Muller-Bolla et al. 2003).

Individuals associated with low socioeconomic status are at greater risk of experiencing biological stress events (e.g., Crooks 1995; Hadley and Crooks 2012; Schell 1997), and this is evident in the process of odontogenesis (Cardoso 2005, 2007; Conceição and Cardoso 2011; Garn et al. 1973a; Heuzé and Cardoso 2008). While the influence of socioeconomic status on odontogenesis is difficult to disentangle from the influence of population or ancestry, research is often designed specifically to control for the potentially intertwined relationship between these variables. Garn and colleagues (1973a) evaluated the effect of socioeconomic status separately for American white and black children and found that the eruption of the permanent teeth was delayed in the sample with lower socioeconomic status for both ancestry groups.

Development of dental hard tissues may also be affected by socioeconomic status. Cardoso (2005, 2007) analyzed dental development in an historic sample of known individuals from Lisbon, Portugal. All individuals in the sample were born in Portugal and had at least one Portuguese-born parent, which should control for the influence of population or ancestry. The sample was divided into high and low socioeconomic status groups for comparison. Dental development was delayed in the group with lower socioeconomic status by up to two years, likely as a product of stress (Cardoso 2007: 230). In this sample, dental development was delayed to a greater degree than skeletal development relative to chronological age, since the skeleton can experience catch-up growth while the teeth cannot (Cardoso 2005, 2007). Heuzé and Cardoso (2008) suggest that socioeconomic status, along with a shared population history, may be the underlying cause behind studies that find population differences in rates of dental development. The influence of socioeconomic status on odontogenesis may not be as extreme as sex or

population differences but may contribute to variation in the rates of dental development between groups (e.g., Cardoso 2005, 2007; Conceição and Cardoso 2011; Garn et al. 1973a; Gustafson 1950; Heuzé and Cardoso 2008). Therefore, this factor must be considered in the formation of age estimation techniques.

As with other developmental milestones, females reach developmental stages earlier than males (e.g., Anderson et al. 1976; Gleiser and Hunt 1955; Moorrees and Kent 1978; Nolla 1960; Schour and Massler 1941), although Liversidge (2010) suggests these sex differences are more pronounced during root development. The only tooth in which female development lags behind male development is the third molar (e.g., Anderson et al. 1976; Arany et al. 2004; Engström et al. 1983; Garn et al. 1962; Gunst et al. 2003; Harris 2007; Kasper et al. 2009; Knell et al. 2009; Kullman et al. 1992; McGettigan et al. 2011; Mesotten et al. 2002; Mincer et al. 1993; Prieto et al. 2005; Sisman et al. 2007; Solari and Abramovitch 2002). Male developmental rates appear to be delayed due to the differential time required for the process of amelogenesis to be completed between sexes. Research suggests males spend a greater amount of time from the cap stage of embryological development to the completion of the crown (e.g., Moss 1978; Pilloud and Kenyhercz 2016). Blankenship and colleagues (2007) suggest that sex differences in rates of dental development vary by ancestry. Since the influence of sex on the rate of dental development has long been accepted, this variable must be considered in age estimation techniques that utilize the dentition.

Finally, variation has been observed in the rates of dental development among populations or ancestral groups. Many authors suggest that differences in the rates of dental development are great enough that population-specific standards for estimating age

from the dentition should be created (e.g., Caldas et al. 2010; Demirjian et al. 1973; Gunst et al. 2003; Kasper et al. 2009; Lewis and Senn 2010; Moorrees et al. 1963; Orhan et al. 2007; Prieto et al. 2005; Sisman et al. 2007; Solari and Abramovitch 2002; Te Moananui et al. 2008; Willems et al. 2001). Others argue that what appears to be population variation may be the product of differences in methods of analysis (e.g., Cunningham et al. 2016; Davis and Hägg 1993; Liversidge 2010; Smith 1991).

In the United States, there are differences in the rates of dental development among ancestry groups (e.g., Blankenship et al. 2007; Garn et al. 1972; Garn et al. 1973b; Harris 2007; Harris and McKee 1990; Kaiser and Senn 2004; Kasper et al. 2009; Lewis and Senn 2010; Solari and Abramovitch 2002). Based on the research on third molar development by Lewis and Senn (2010: 83), American black individuals tend to reach developmental stages earliest, followed by Hispanic individuals about 0.5 years later, and finally followed by American white individuals, approximately 1 year behind the American black sample and 0.5 years behind the Hispanic sample. It is important to note, however, that fewer data exist for Asian American populations (Lewis and Senn 2010; Solari and Abramovitch 2002). Recent work by Drvostep and Senn (2017) suggests Asian American populations reach developmental stages earlier than Hispanic or American white individuals, but no comparison has yet been made to an American black sample.

Population differences in dental development remain somewhat contentious. In studies that compare ancestral groups in the United States, researchers often analyze one or two groups and compare the results to previously published data on other populations (e.g., Blankenship et al. 2007; Drvostep and Senn 2017; Kaiser and Senn 2004; Kasper et

al. 2009; Solari and Abramovitch 2002). There are many problems with comparing results from independent studies. First, these results have been derived from different samples, and the authors have made different statistical assumptions in performing their analyses (Garvin and Passalacqua 2012; Garvin et al. 2012; Liversidge 2010). Second, age ranges may incorporate different measures of error, such as standard error or standard deviation (Cunha et al. 2009). Direct comparisons of age ranges from studies that did not use the same measure of error are not statistically defensible (Garvin and Passalacqua 2012; Garvin et al. 2012).

Finally, many studies use the average age of individuals within a developmental stage for group comparisons, although differing sample compositions and age distributions could be inflating perceived differences between populations (Liversidge 2010; Smith 1991). As an illustration, provided by Liversidge (2010), consider two studies whose minimum ages are two and seven years of age. The average age of individuals within a developmental stage will inherently be higher in the sample whose minimum age is seven years, due to the amount of variation below the age of seven that is not being considered (Liversidge 2010: 20). This relationship between age estimates and the age distribution of the training sample is referred to as "age mimicry," an acknowledged hurdle in the field of age estimation (e.g., Bocquet-Appel and Masset 1982; Boldsen et al. 2002; Konigsberg and Frankenberg 1992; Liversidge et al. 2010; Mensforth 1990: 91). These factors introduce error into comparative studies of dental development, lending credence to the argument that population differences may be a product of different statistical analyses (e.g., Cunningham et al. 2016; Davis and Hägg 1993; Liversidge 2010; Smith 1991).

3.4: Conclusions

It is a well-established principle in biological anthropology that methods are most effective on populations whose composition is like the sample from which the method was derived (Garvin et al. 2012; Milner and Boldsen 2012; SWGAnth 2013; Ubelaker 2006). Knowing that dental development can be affected by secular change, socioeconomic status, sex, and ancestry, forensic practitioners in the United States should use techniques derived from a comprehensive, modern American sample. However, the subadult age estimation methods currently in use in a forensic context in the United States are either based on foreign samples (e.g., AlQahtani et al. 2010; Demirjian et al. 1973) or are outdated (e.g., Moorrees et al. 1963; Schour and Massler 1941). Accuracy in age estimation is critical in the forensic sciences, for both the living and the deceased, and across the biological profile, one component of an accurate method is the use of an appropriate sample.

Chapter 4: Materials and Methods

The primary purpose of this dissertation is to create a method for age estimation from dental development based on a modern sample from the United States. This new model will incorporate variation based on secular change, sex, and ancestry. Secular change is potentially mitigated by using modern radiographic material. Sex and ancestry are evaluated for significant differences and subsequently built into the age estimation models to account for normal variation between populations. The evaluation of sex and/or ancestry differences in the rates of dental development contributes to testing the first hypothesis presented in this research, while the comparison of age estimation methods based on all individuals to those based on subsamples divided by sex, ancestry, and sex/ancestry contribute to testing the second hypothesis.

4.1: Materials

Data were generated from 1,757 panoramic dental radiographs (i.e., orthopantomograms) of modern individuals receiving dental treatment between 1972 and 2017. The orthopantomograms were obtained from three databases: the James K. Economides Orthodontics Case File System from the Maxwell Museum of Anthropology at the University of New Mexico in Albuquerque, NM (hereafter referred to as UNM); the School of Dentistry at the University of Texas Health Science Center at San Antonio in San Antonio, TX (hereafter referred to as UT); and the Oregon Health Sciences University School of Dentistry in Portland, OR (hereafter referred to as OHSU) (Table 4.1). The demographic information collected for each orthopantomogram includes the age of the individual when the radiograph was taken, sex, and ancestry (Table 4.2). Each individual is represented by a single orthopantomogram.

Table 4.1: Number of individuals from each location.

	UNM	UT	OHSU	Total
Sample size (n)	841	567	349	1,757

Table 4.2: Sample composition.

Age in Years	African American		Asian American		European American		Hispanic		Hawaiian		Native American		Total		
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	Total
5	0	0	1	0	8	2	5	6	0	0	0	0	14	8	22
6	3	1	0	5	15	14	14	9	0	0	0	0	32	29	61
7	1	1	4	3	34	29	45	23	0	0	0	0	84	56	140
8	7	3	1	5	55	51	60	46	0	0	0	2	123	107	230
9	2	4	6	4	46	46	39	43	0	0	3	3	96	100	196
10	2	4	3	1	49	59	55	39	0	0	5	3	114	106	220
11	0	7	2	4	42	40	27	41	0	0	5	1	76	93	169
12	5	2	1	2	41	30	34	22	0	0	4	5	85	61	146
13	4	5	1	2	29	22	20	19	0	0	4	1	58	49	107
14	2	4	3	2	29	21	19	22	0	0	3	3	56	52	108
15	2	4	2	5	23	21	13	13	0	0	4	2	44	45	89
16	3	1	0	2	16	21	10	10	3	0	4	2	36	36	72
17	0	2	1	2	14	14	11	7	0	0	2	1	28	26	54
18	2	3	3	2	19	14	6	2	0	0	1	0	31	21	52
19	3	0	2	1	17	17	8	1	0	0	1	3	31	22	53
20	3	0	2	1	17	10	1	2	0	1	0	1	23	15	38
Total	39	41	32	41	454	411	367	305	3	1	36	27	931	826	1,757
	80		73		865		672		4		63		1,757		

This research is interested in geographically patterned human variation, i.e., differences in ancestry groups. Five major ancestry groups are typically encountered in the forensic context in the United States: African, Asian, European, Hispanic, and Native American (e.g., Bass 2005; Burns 2007; Kennedy 1995; Klepinger 2006; Sauer 1992, 1993; Spradley et al. 2008; Spradley and Weisensee 2013). With the exception of Hispanic individuals, these groups are named for the continents from which the people were originally derived. However, it is important to recognize that the individuals comprising this study are entirely from the United States, rather than from separate continents. Ancestry groups in the United States have experienced gene flow with other populations, such that their genetic composition is no longer the same as their continental counterparts. For example, individuals of African ancestry in the United States typically have a greater genetic component from Europe than individuals from Africa (e.g., Parra et al. 1995, 1998).

For this reason, the ancestry groups represented in this research have been assigned names that reflect the unique population histories each group experiences in the United States, e.g. African American or European American, rather than using continental names. Furthermore, the collections use different terminology when identifying ancestry groups, e.g., European American vs. White/Caucasian vs. White; in order to remain consistent across collections, standard group names have been applied to all individuals. In this research, population labels include African American, Asian American, European American, Hawaiian, Hispanic, and Native American. These labels are similar to those employed by the U.S. Census (U.S. Census 2010a), are closely

aligned to the labels provided to the participants for self-identification, and best reflect the population histories experienced in the United States.

The Orthodontics Case File System from the Maxwell Museum of Anthropology at UNM consists of material collected by an orthodontist practicing in Albuquerque, NM between 1972 and 1999, Dr. James K. Economides (Edgar et al. 2011). All material in this collection has been anonymized and made publicly available by the director of the Maxwell Museum of Anthropology; therefore, the orthopantomograms and demographic information were downloaded from the internet. Patient records originally included age and sex but no ancestry designation, either from the patients themselves or from Dr. Economides. Therefore, ancestry was estimated for each individual in the collection by graduate and undergraduate students working in the Laboratory of Human Osteology at the Maxwell Museum of Anthropology. These ancestry designations were based on names, addresses, and facial photographs of the patients, specifically focused on skin color, facial features, and hair form and color (Edgar 2013; Edgar et al. 2011). Ancestry of each individual in the Economides Collection has been designated by at least two separate researchers, and researchers were encouraged to choose as few or as many ancestry designations as seemed applicable (Edgar et al. 2011).

Only individuals from the Orthodontics Case File System who have a single ancestry designation listed were included in this research, as this indicates that at least two observers agreed on the individual's ancestry (personal communication, Edgar 2017a). Researchers could select from African American, Asian American, European American, Hispanic American, Native American, and Native Hawaiian/Pacific Islander. The five ancestry groups from UNM that were included in this sample are African

American, Asian American, European American, Hispanic, and Native American. Additionally, orthopantomograms were chosen for inclusion based on clarity, to include only those radiographs in which the apical ends of the teeth could be seen and assigned developmental scores.

The orthopantomograms from UT and OHSU came from patient files. These data were queried and deidentified by contacts at their respective universities before access was allowed. The orthopantomograms from UT were taken between 2005 and 2017. Demographic information for these patients was collected using axiUm Dental Software for patient management, and ancestry for each patient was either self-reported or reported by the individual's parent or guardian. Patients at UT are asked to identify their ethnicity and can choose between White/Caucasian, African American, Asian, Hispanic, or Other. None of the patients in the current study identified as other. Therefore, the four ancestry groups represented at UT include European American, African American, Asian American, and Hispanic, respectively. The original sample collected from UT comprised 600 orthopantomograms, but 33 cases were removed due to a lack of demographic information (e.g., no sex or ancestry listed, typing errors in sex or ancestry, etc.).

The orthopantomograms from OHSU were taken between 2002 and 2017. Ancestry was self-reported or reported by the individual's parent or guardian for all cases in the sample. Patients at OHSU are asked to identify their ethnicity and can choose between White, Asian, Black/African American, American Indian or Alaska Native, or Native Hawaiian or other Pacific Islanders. Therefore, the five ancestry groups represented at OHSU include European American, Asian American, African American, Native American, and Hawaiian, respectively. The original sample collected from OHSU

comprised 363 orthopantomograms, but 14 cases were removed, either due to unintentional duplication or poor radiograph quality, e.g., warped images. Therefore, the final sample from OHSU includes 349 individuals.

Since all orthopantomograms are considered modern (collected between 1972 and 2017), it is likely that many individuals comprising this study are living. The radiographs were previously collected and have been deidentified; therefore, the Institutional Review Board (IRB) at the University of Nevada, Reno has determined that the current research is exempt from IRB Review according to federal regulations (IRBNet Project ID 1101881-1). The use of the radiographic material is also in compliance with all IRB requirements from UNM (personal communication, Edgar 2017b), UT (personal communication, Biesenbach 2017), and OHSU (personal communication, Wu 2017).

The complete set of orthopantomograms was divided into two separate samples for analysis: a small group was held out to constitute the test sample (n = 100), while the remaining individuals comprised the training sample (n = 1,657). As the Hawaiian subset is very small (n = 4), all individuals of Hawaiian ancestry were placed in the test sample, since specific versions of confidence intervals and linear models for estimating age cannot be created and tested with so few individuals. The remaining 96 individuals in the test sample were randomly generated from the total database. Ideally, the training sample should include equal representation of all ages, sexes, and ancestry groups. However, a uniform distribution is impossible using the collected sample. While the sex distribution is relatively equal, even representation is not true of the age or ancestry distributions (see Table 4.2). Individuals between the ages of seven and 12 are overrepresented, while those six and under or 15 and over are underrepresented (Figure 4.1). In the case of

ancestry as illustrated in Figure 4.2, European American individuals dominate the sample, followed by Hispanic individuals. Those of African American, Asian American, and Native American ancestry are underrepresented, each comprising less than 5% of the total sample (see Table 4.2). In studies that analyze age estimation and population differences, a uniform distribution of individuals should be used; this prevents any overrepresented groups from skewing the statistical analyses (Konigsberg and Frankenberg 1992; Konigsberg et al. 2008; Liversidge 2010). The unbalanced age and ancestry distributions in the current sample are a problem, and the potential biases created by the sample composition are addressed in the discussion.

The training sample was used for intraobserver error tests to establish precision of the developmental scores assigned (discussed further in section 4.3: Data Analysis). The training sample was also used to create four distinct groups of age estimation formulae: general formulae in which neither sex nor ancestry is specified; sex-specific formulae in which ancestry is not specified; ancestry-specific formulae in which sex is not specified; and sex- and ancestry-specific formulae in which both sex and ancestry are specified (e.g., African American male, African American female, etc.).

The test sample was used to evaluate the accuracy and precision of the age estimation formulae created from the training sample; setting aside this subsample of individuals ensures the age estimation formulae are not tested on individuals that were used to inform the model, a practice that could lead to a false sense of accuracy. Accuracy rates of the four age estimation formulae were compared to one another. This evaluation determines whether sex- and/or ancestry-specific formulae should be favored over a general age estimation formula.

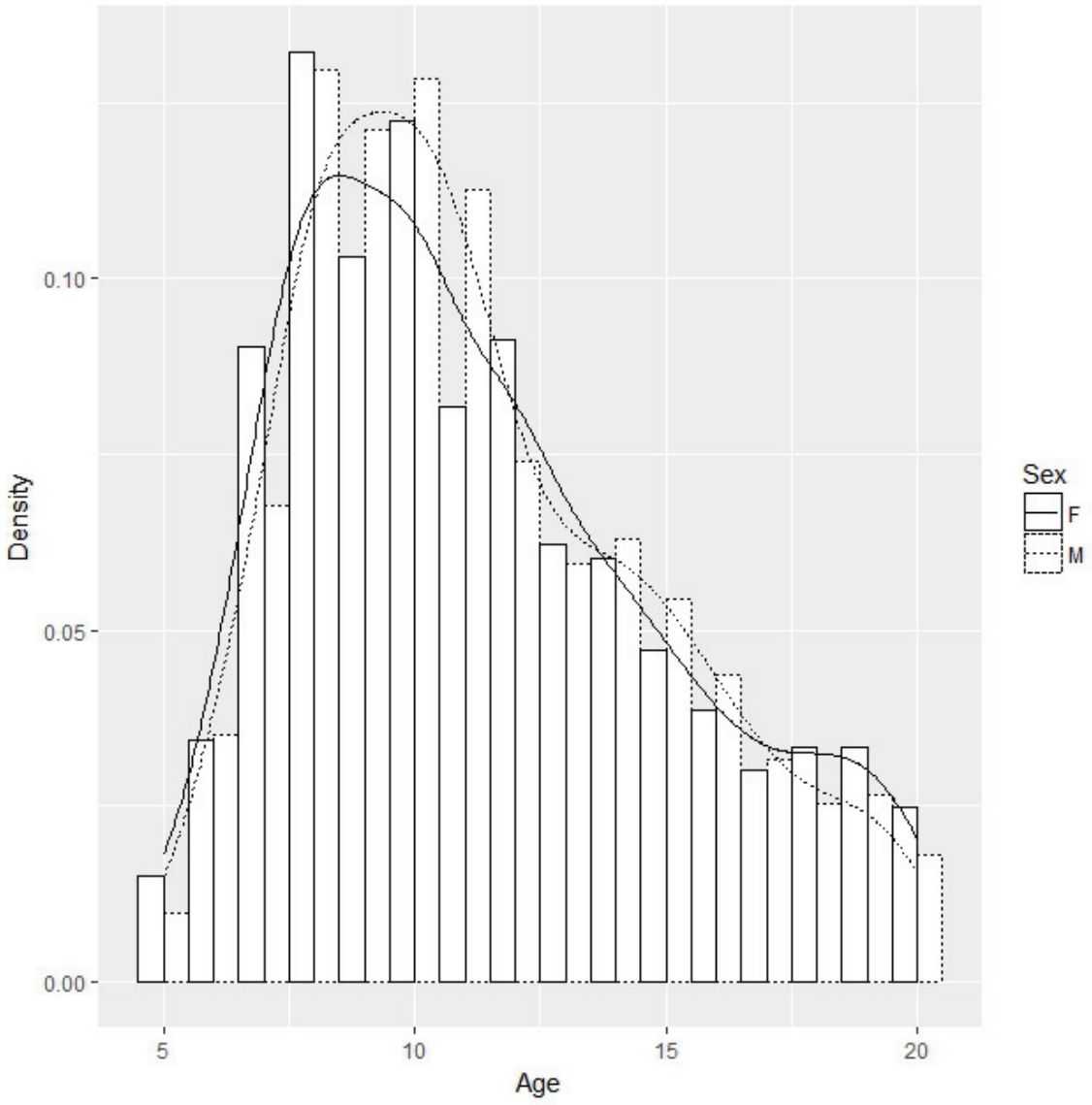


Figure 4.1: Age distribution of total sample, separated by sex. Graphic created using R package "ggplot2" (Wickham and Chang 2016).

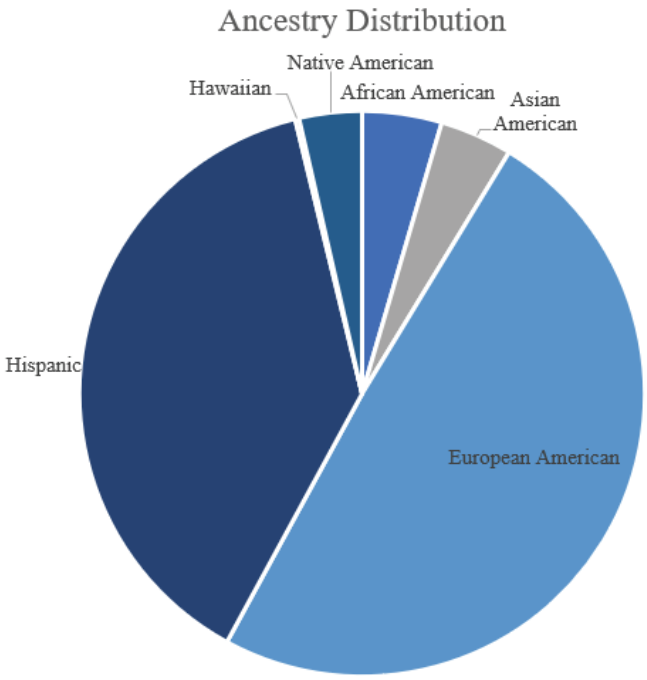


Figure 4.2: Ancestry distribution of total sample.

4.2: Methods

For ease of discussion, teeth are referred to by tooth numbers assigned by the Universal Numbering System, rather than tooth names or abbreviations. The Universal Numbering System assigns each permanent tooth a number between 1 and 32 beginning at the right maxillary third molar and ending at the right mandibular third molar (Figure 4.3). While it is called the "Universal" system, it is typically used in North America (ADA 1999).

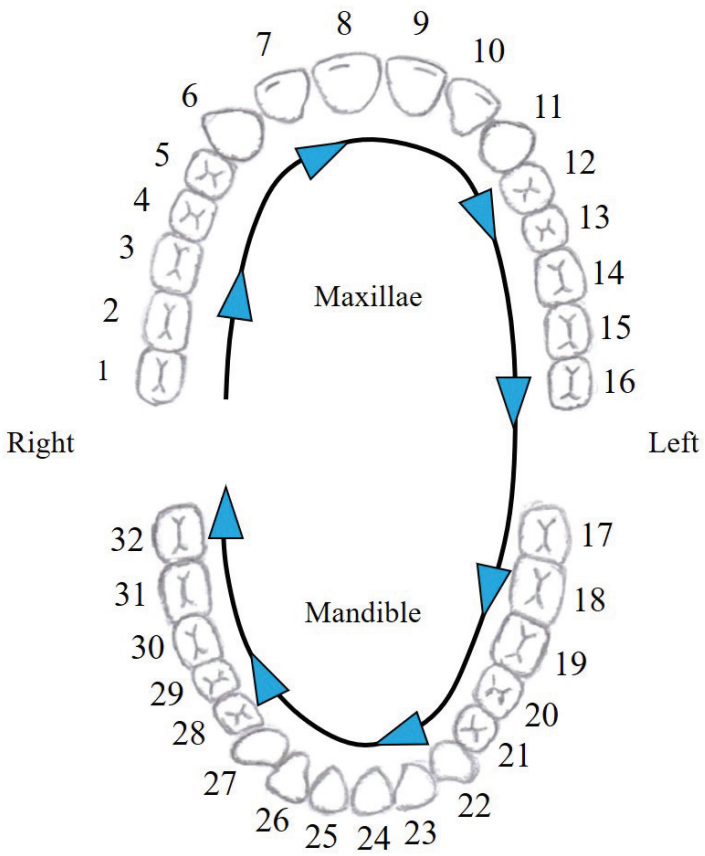


Figure 4.3: Tooth numbers as defined by the Universal Numbering System (ADA 1999). Numbers begin at the right maxillary M3 (#1) and proceed in clockwise order to the right mandibular M3 (#32), indicated by the blue arrows.

Every permanent tooth in each orthopantomogram was scored for stage of development, in the maxillae and mandible. Age can be estimated from the development of the deciduous dentition (e.g., Irurita et al. 2014; Nystrom and Ranta 2003), but these studies are far less common due to the difficulty in obtaining radiographs of young children (Liversidge 2016a). Additionally, development of the mandibular deciduous teeth is typically complete before the age of four (e.g., Irurita et al. 2014; Liversidge and Molleson 2004; Moorrees et al. 1963). As the current sample only includes individuals

between 5-20 years, no deciduous development can be observed, and developmental scores are only assigned to permanent teeth.

Although all 32 permanent teeth were scored, the developmental stages assigned to dental antimeres[4] will inherently be highly correlated for the purposes of data analysis. Therefore, only the teeth from the left side of the maxilla and mandible were used in modeling to prevent collinearity of variables. If a tooth on the left side was missing, the antimere from the right side was substituted. While antimeres are thought to be under similar genetic control during odontogenesis, asymmetry is still observed in the dentition (Townsend et al. 2016). Since asymmetry in rates of dental development is not the focus of this dissertation, antimeres are assumed to develop at similar rates, though this may be a variable worth examining in future research.

Dental development was analyzed using two methods: that of Moorrees and colleagues (1963) and that of Demirjian and colleagues (1973) (Figures 4.4 through 4.7). The Moorrees et al. method (1963) is advantageous due to the greater number of defined developmental stages. With ordinal data, more stages provide more discriminatory power and an increase in precision (Harris 2007; Olze et al. 2005). This means that the greater number of stages defined by Moorrees and colleagues (1963) can offer more sensitivity in the analysis of dental development. To assist in consistent scoring of root stages in the Moorrees et al. system (1963), the modification created by Liversidge and Molleson (2018) was applied (Figure 4.8). This modification allows root length to be

[4] When discussing the dentition, antimeres are defined as the corresponding tooth on the left and right sides of the same jaw (Irish 2016). For example, the left and right mandibular M1 are antimeres of one another.

estimated relative to crown length, rather than in relation to future root length (Liversidge and Molleson 2018).

The Demirjian et al. (1973) method was used because of its reported accuracy and well-defined stages. Since Demirjian and colleagues (1973) define fewer stages of development than those recognized by Moorrees et al. (1963), each stage inherently encompasses a wider timespan. For this reason, authors utilizing the Demirjian et al. (1973) method report an increase in the accuracy of age estimations (e.g., Hägg and Matsson 1985; Lewis and Senn 2010; Olze et al. 2005). Additionally, developmental stages are based on morphological changes in the developing tooth, reducing the inter- and intraobserver error in assigning developmental scores (Dhanjal et al. 2006; Olze et al. 2005; Sisman et al. 2007).

Intraobserver error for assigning developmental scores was established by rescoring 30 randomly selected individuals from the total sample. This second evaluation took place one month after the orthopantomograms were initially scored.

4.3: Data Analysis

All data were collected in Microsoft Excel (2016) using a graphical user interface (GUI) created by the author; initial data organization was also accomplished in Microsoft Excel (2016). Data were analyzed using the statistical software R, version 3.4.0 (R Core Team 2017).

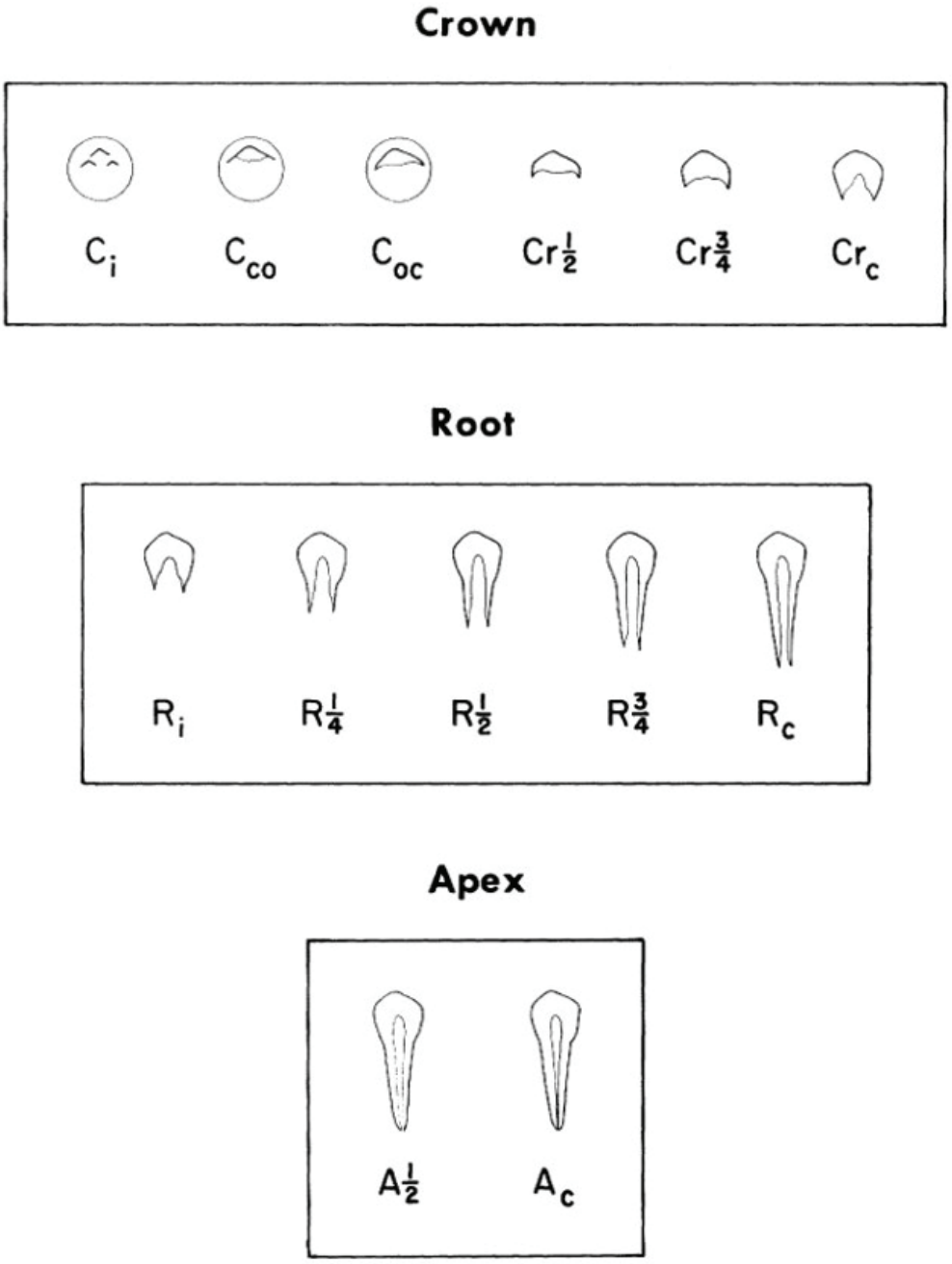


Figure 4.4: Single-rooted tooth developmental stages defined by Moorrees et al. (1963: 1492). "C_i = initial cusp formation; C_{co} = coalescence of cusps; C_{oc} = cusp outline complete; $Cr_{1/2}$ = crown ½ complete; $Cr_{3/4}$ = crown ¾ complete; Cr_c = crown complete; R_i = initial root formation; $R_{1/4}$ = root length ¼; $R_{1/2}$ = root length ½; $R_{3/4}$ = root length ¾; R_c = root length complete; $A_{1/2}$ = apex ½ closed; A_c = apical closure complete" (Moorrees et al. 1963: 1492). Image reprinted from original article with permission of SAGE Publications, Inc.

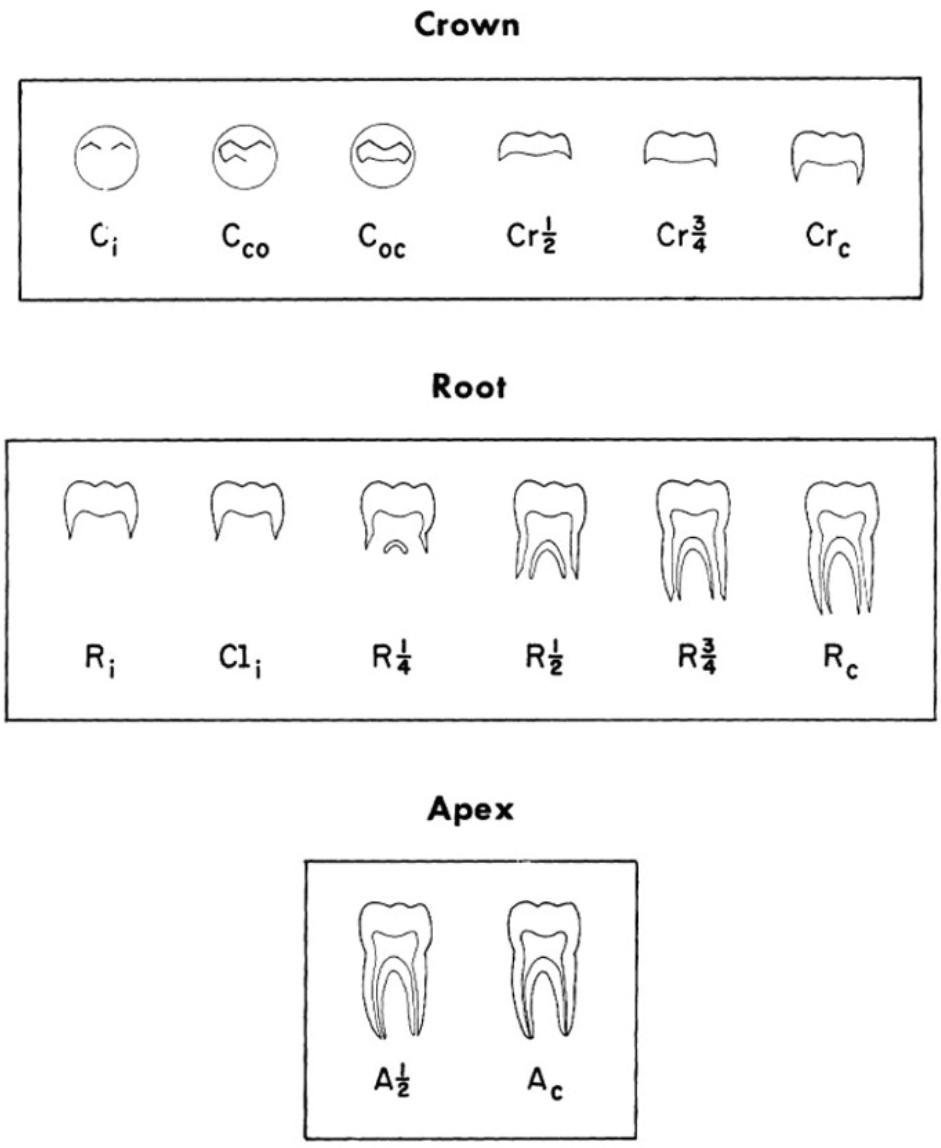


Figure 4.5: Molar developmental stages defined by Moorrees et al. (1963: 1493). "C_i = initial cusp formation; C_{co} = coalescence of cusps; C_{oc} = cusp outline complete; $Cr_{1/2}$ = crown ½ complete; $Cr_{3/4}$ = crown ¾ complete; Cr_c = crown complete; R_i = initial root formation; Cl_i = initial cleft formation; $R_{1/4}$ = root length ¼; $R_{1/2}$ = root length ½; $R_{3/4}$ = root length ¾; R_c = root length complete; $A_{1/2}$ = apex ½ closed; A_c = apical closure complete" (Moorrees et al. 1963: 1492). Image reprinted from original article with permission of SAGE Publications, Inc.

	Premolar	Canine	Incisor			Premolar	Canine	Incisor	
A				A beginning of calcification is seen at the superior level of the crypt in the form of an inverted cone or cones. There is no fusion of these calcified points.	E				a. The walls of the pulp chamber now form straight lines, whose continuity is broken by the presence of the pulp horn, which is larger than in the previous stage. b. The root length is less than the crown height.
B				Fusion of the calcified points forms one or several cusps which unite to give a regularly outlined occlusal surface.	F				a. The walls of the pulp chamber now form a more or less isosceles triangle. The apex ends in a funnel shape. b. The root length is equal to or greater than the crown height.
C				a. Enamel formation is complete at the occlusal surface. Its extension and convergence towards the cervical region is seen. b. The beginning of a dentinal deposit is seen. c. The outline of the pulp chamber has a curved shape at the occlusal border.	G				The walls of the root canal are now parallel and its apical end is still partially open.
D				a. The crown formation is completed down to the cementoenamel junction. b. The superior border of the pulp chamber has a definite curved form, being concave towards the cervical region. The projection of the pulp horns if present, gives an outline shaped like an umbrella top. c. Beginning of root formation is seen in the form of a spicule.	H				a. The apical end of the root canal is completely closed. b. The periodontal membrane has a uniform width around the root and the apex.

Figure 4.6: Developmental stages for single-rooted teeth defined by Demirjian and colleagues (1973). Drawings based on images from original article; dashed lines indicate the enamel-dentine junction. Stage definitions from Demirjian et al. (1973: 221-226).

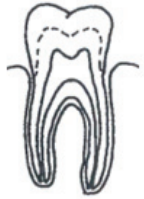
A		A beginning of calcification is seen at the superior level of the crypt in the form of an inverted cone or cones. There is no fusion of these calcified points.	E		a. Initial formation of the radicular bifurcation is seen in the form of either a calcified point or a semi-lunar shape. b. The root length is still less than the crown height.
B		Fusion of the calcified points forms one or several cusps which unite to give a regularly outlined occlusal surface.	F		a. The calcified region of the bifurcation has developed further down from its semi-lunar stage to give the roots a amore definite and distinct outline with funnel shaped endings. b. The root length is equal to or greater than the crown height.
C		a. Enamel formation is complete at the occlusal surface. Its extension and convergence towards the cervical region is seen. b. The beginning of a dentinal deposit is seen. c. The outline of the pulp chamber has a curved shape at the occlusal border.	G		The walls of the distal root canal are now parallel and its apical end is still partially open.
D		a. The crown formation is completed down to the cementoenamel junction. b. The superior border of the pulp chamber has a definite curved form, being concave towards the cervical region. The pulp chamber has a trapezoidal form. c. Beginning of root formation is seen in the form of a spicule.	H		a. The apical end of the distal root canal is completely closed. b. The periodontal membrane has a uniform width around the root and the apex.

Figure 4.7: Developmental stages for multi-rooted teeth defined by Demirjian and colleagues (1973). Drawings based on images from original article; dashed lines indicate the enamel-dentine junction. Stage definitions from Demirjian et al. (1973: 221-226).

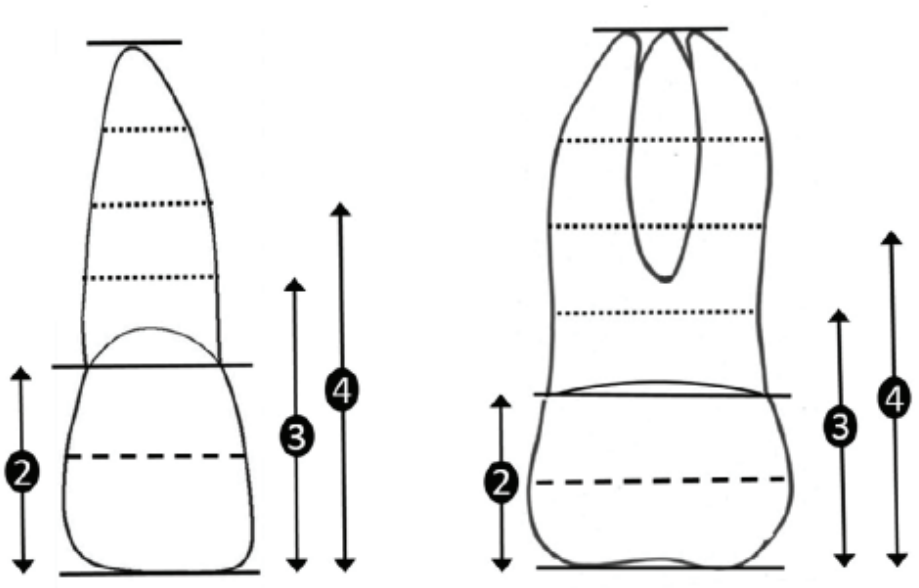


Figure 4.8: Root quantifications for use with the Moorrees et al. (1963) scoring system, defined by Liversidge and Molleson (2018: 167). This modification indicates that the height of the tooth crown (measured from the cementoenamel junction to the cusp tips) is equal to 2 units, while the root length (measured from the cementoenamel junction to the apices) is equal to 4 units. In other words, half of the crown height is equal to ¼ of the root length. Image reprinted from original article with permission of Dr. Helen M. Liversidge (personal communication, Liversidge 2018).

4.3.1: Intraobserver Error

Precision in the application of dental developmental stages, that is intraobserver error, was measured with Cohen's weighted Kappa in the R package "irr" (Cohen 1968; Gamer et al. 2015). Cohen's weighted Kappa (Cohen 1968) is a more robust measure of observer error than percent concordance, as this statistic considers agreement by chance. The added benefit of using weighted Kappa (Cohen 1968) rather than the original Kappa statistic (Cohen 1960) is the ability to consider partial agreement. In an ordinal scale, such as those designed to describe dental development, adjacent scores are more similar than the scores at either end of the spectrum, e.g., a Demirjian et al. (1973) score of B is

more like scores of A or C than to the final score of H. Therefore, Cohen's weighted Kappa considers degrees of agreement between ordinal scores, rather than counting every incorrect score as equally wrong (Cohen 1968).

To perform a Cohen's weighted Kappa test (Cohen 1968), the researcher must specify whether weights should be linear or quadratic (Gamer et al. 2015). A practical example is the simplest way to visualize this distinction. If the two observers assigned Demirjian et al. (1973) scores of A and H to the same tooth, this would be a difference of seven developmental stages. Linear weights are also referred to as equal weights, because in this case, the difference between developmental scores would be treated as seven. However, quadratic weights would treat the difference as 49, the squared product of the original difference. Quadratic weights exponentially increase the punishment for disagreement as the difference increases, as opposed to linear weights that treat each stage of disagreement equally (Cohen 1968). Both linear and quadratic weights are calculated for the intra- and interobserver error tests; however, discussion is limited to the linear weight results. Since 16 permanent teeth are incorporated in the age estimation models, disagreement in assigning developmental stages to a single tooth is less problematic for the final outcome. Therefore, linear weights will not assign an exceedingly harsh punishment to disagreements.

Thresholds defined by Landis and Koch (1977) are used to evaluate whether each tooth was scored reliably (Table 4.3). Teeth included in age estimation models should demonstrate "moderate" agreement or better in the intraobserver error tests. While these thresholds are arbitrarily defined, their use is common in anthropology (e.g., AlQahtani et al. 2010; Blenkin and Taylor 2012; Bolaños et al. 2000; Hefner 2009; Maier 2017;

Walker 2005), and the descriptions of the Kappa score ranges provide a systematic means of discussing the observer error results (Landis and Koch 1977).

Table 4.3: Potential Kappa values and the associated description for the level of agreement. Definitions of thresholds from Landis and Koch (1977: 165).

Kappa Value	Description of Agreement
<0.00	Poor
0.00-0.20	Slight
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Substantial
0.81-1.00	Almost Perfect

4.3.2: Testing for Differences by Sex and/or Ancestry

Before age estimates were created, sex and ancestry differences in the rates of dental development were evaluated. To evaluate these differences, non-parametric test statistics are utilized. A non-parametric test does not assume a normal distribution of the population; since ordinal data are inherently reducing a set of continuous information into a defined number of ranks, a normal distribution of individuals within these ranks cannot be assumed (Welkowitz et al. 1976).

A Kruskal-Wallis test (Kruskal and Wallis 1952) can be used to compare the rates of dental development for every permanent tooth, while accounting for all variables of interest. First, females and males were compared to one another, then ancestry groups were compared. Lastly, the Kruskal-Wallis test (Kruskal and Wallis 1952) was used to investigate sex and ancestry simultaneously. For example, the developmental rate for the mandibular M1 can be compared between African American females, Asian American females, European American females, Hispanic females, and Native American females. While a Kruskal-Wallis test (Kruskal and Wallis 1952) can determine whether

differences exist, this test does not determine where the differences lie. In the case of the Kruskal-Wallis test (Kruskal and Wallis 1952), the most appropriate post-hoc analysis is Dunn's test, from the R package "dunn.test" (Dinno 2015, 2017; Dunn 1964).

In the current sample, the Dunn's post-hoc test compares the first sample listed to the second sample, and the sign of the z-score indicates which group exhibits the higher developmental scores (Dunn 1964). Since developmental scores are compared by individual years and biological periods, a higher developmental score in one sample should indicate that this group is reaching developmental stages at an earlier age than the other sample. For example, consider a positive z-score in the comparison of females to males at tooth 11 during year nine ($z = 3.7076$, Appendix A2.5.1). This positive score indicates that females have significantly higher developmental scores than males for the maxillary canine at age nine; therefore, the female sample must have reached the same developmental stage at an earlier age compared to the males, suggesting an advanced rate of dental development.

With the number of comparisons being performed using the Kruskal-Wallis statistic (Kruskal and Wallis 1952) and Dunn's post-hoc test (Dunn 1964), an alpha adjustment should be taken into consideration. A type I statistical error is defined as the probability of a false positive, i.e., rejecting a true null hypothesis. The Bonferroni (1936) alpha correction is commonly applied in anthropology (e.g., Maier 2017; Pilloud and Hillson 2012; Stull 2013; Willems et al. 2001). This correction simply divides the original alpha value of 0.05 by the number of tests being performed. In the sex comparison, one Kruskal-Wallis test and one Dunn's post-hoc test are being performed on 16 teeth (Kruskal and Wallis 1952). Therefore, the Bonferroni (1936) corrected alpha

value would be 0.05/32, or $\alpha = 0.0015625$. In the ancestry test and the combined sex and ancestry tests, one Kruskal-Wallis test is being performed, in addition to ten pair-wise ancestry comparisons in the Dunn's post-hoc test (e.g., African American to Asian American, African American to European American, African American to Hispanic, African American to Native American, Asian American to European American, Asian American to Hispanic, Asian American to Native American, European American to Hispanic, European American to Native American, and Hispanic to Native American) (Dunn 1964; Kruskal and Wallis 1952). This is a total of 11 tests on 16 teeth. Therefore, the Bonferroni (1936) corrected alpha value would be 0.05/176, or $\alpha = 0.000284$.

4.3.3: Age Estimation from Confidence Intervals

Age estimates can be derived in several ways. In this case, the means and standard deviations of the ages of individuals in the training sample within any given developmental stage can be used to create age ranges. Traditionally, percentiles of individuals within any given developmental stage are presented and used to create an age range, i.e., the ages of the individuals at the 25th and 75th percentile can be used to create a 50% confidence interval (Konigsberg et al. 2008). Percentiles are not statistically ideal, because they may introduce sampling biases and may not adequately describe the variation within each stage. However, to mitigate the sampling bias, confidence intervals can be created using bootstrapped means in the R packages "rcompanion" (Mangiafico 2018) and "boot" (Canty and Ripley 2017). The bootstrap portion of the code samples 1,000 random groups of individuals from each population, finds the average age of individuals within each random iteration, and then averages these means to find the bootstrapped mean. With each subdivision of the dataset, the sample size decreases (e.g.,

females have the largest sample, the African American group has a smaller sample size, and African American females are an even smaller group) (see Table 4.2). With a smaller sample size, the bootstrapped mean becomes more important; this value approximates an average that might have been obtained with a greater number of individuals.

Using the bootstrapped mean, intervals for 51% and 95% confidence were created for each stage of development at every tooth. A confidence interval describes how well the true population mean can be estimated from a sample. If 100 random samples are pulled from the population and a confidence interval is calculated around the estimated means of these samples, 95% confidence suggests that the true population mean will lie within those confidence intervals 95 times. The "basic" confidence interval function was utilized for two reasons (Canty and Ripley 2017; Mangiafico 2018). First, the standard error is derived using the t-distribution rather than the z-distribution, as t-scores are more appropriate when the true average of the population is unknown, and the sample size is relatively small. Second, the "basic" bootstrap confidence interval is not required to be symmetrical about the mean; the possibility of asymmetrical left and right sides accounts for the skewed nature of the age distribution within developmental stages.

The bounds for 51% and 95% confidence intervals are presented in this research, as this maximizes the applicability in a medicolegal context (Konigsberg et al. 2008; Liversidge 2010). In civil cases, the burden of proof is on the "balance of probabilities" (Liversidge 2010: 19); in other words, a 51% confidence interval ensures that it is more likely that an individual is within the age range than not. In criminal cases, however, the burden of proof is beyond a reasonable doubt. Therefore, 95% confidence ensures more

certainty that the individual truly falls within the age range (Konigsberg et al. 2008; Liversidge 2010).

Two adjustments were made to the confidence intervals for the final developmental score, e.g., a Demirjian et al. (1973) score of H. The first modification is that the upper bounds for the confidence intervals were not used during accuracy testing. A score of H implies that the tooth has finished development; therefore, a mandibular first molar with a score of H at age 15 would be assigned the same score of H at age 80. Since the upper bounds for this confidence interval are not meaningful, the values have been reported but not implemented in accuracy tests.

The second adjustment concerns the age range used for each tooth (Roberts et al. 2018). Again, using the mandibular first molar as an example, 16 years of age is the final year in which a score other than H was recorded (Figure 4.9). Since scores are assigned specifically to measure dental development, years in which development has been completed for all individuals are providing extraneous information (Roberts et al. 2018). In fact, the inclusion of these extra years only increases the bootstrapped mean age and subsequently increases the bounds of the confidence interval, to the exclusion of younger individuals who would otherwise be represented (Roberts et al. 2018). Therefore, the age range of individuals used to create the confidence intervals of the final developmental score was adjusted for each tooth. Rather than using all individuals between the ages of five and 20, the upper limit of the age range is one year higher than the final year during which development is still occurring, to account for potential variation lost during sampling. In the mandibular first molar example, this means that the age range used to create the confidence interval for a Demirjian et al. (1973) score of H was 5-17 years.

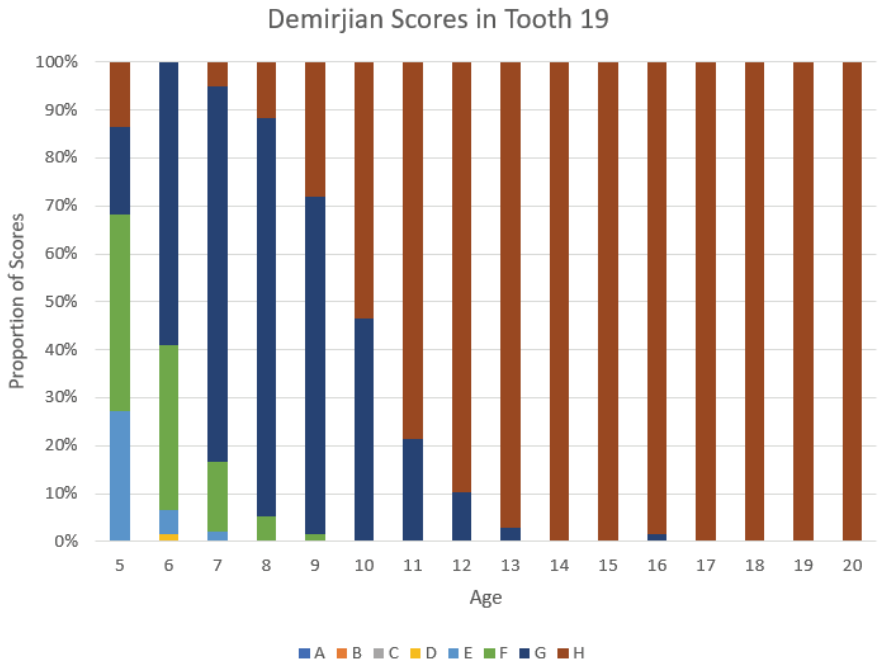


Figure 4.9: Distribution of Demirjian et al. (1973) scores for each year of the age range, at tooth #19.

Accuracy of the confidence intervals created from the training sample was measured by determining the proportion of individuals in the test sample whose chronological age falls within the confidence interval at each tooth. Since chronological age is reported as an integer, the upper and lower bounds of the confidence intervals are rounded down to the nearest whole number, e.g., the confidence interval of 8.957-9.450 years for a Demirjian et al. (1973) score of A for tooth 16 becomes 8-9 years (Appendix A3.1). The number of individuals whose chronological age is within the bounds of the confidence interval was divided by the total number of individuals for whom a score was recorded at each tooth to find the proportion correct. These values were then summarized for all 16 teeth combined to get a total accuracy rate.

Confidence intervals were created using the entire training sample to act as a general model for age estimation. Then sex-specific, ancestry-specific, and sex-and-ancestry-specific confidence intervals were created. The accuracy, or proportions correct, were compared between the general model and the specific models using z-scores for comparing proportions in two populations, to assess whether accounting for sex and/or ancestry increased the accuracy of the confidence intervals. The following formula was used to create the z-scores for comparing proportions in two populations:

$$z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{(p^*(1-p^*)(\frac{1}{n_1} + \frac{1}{n_2})}} \qquad \text{where} \qquad p^* = \frac{x_1 + x_2}{n_1 + n_2}$$

Accuracy was compared between the general model and 17 population specific models for 16 teeth and all teeth combined; therefore, the Bonferroni (1936) corrected alpha value is 0.05/289, or $\alpha = 0.000173$.

Aside from comparing accuracy, i.e., proportions correct, an additional factor to consider is the precision of the confidence intervals. If accuracy rates do not demonstrate significant differences between the general confidence intervals and the specific confidence intervals, then the model that produces the narrowest confidence interval, i.e., the more precise model, would be more informative in the forensic context. The accuracy and precision comparisons between the general confidence intervals and the specific confidence intervals contribute to testing the second hypothesis: that sex- and ancestry-specific methods of age estimation perform better than general methods.

4.3.4: Age Estimation from Linear Models

Confidence intervals were created for the total sample and each sex, ancestry, and sex/ancestry group for every developmental score and every tooth represented in the

training sample. However, combining confidence intervals from multiple teeth without a statistically valid approach introduces error into the process of age estimation (e.g., Garvin and Passalacqua 2012; Garvin et al. 2012). Therefore, in addition to confidence intervals, linear models were created to estimate age from multiple teeth, using formulae built into the statistical software R (R Core Team 2017).

Thirteen linear models were created: eight based on biological and taphonomic principles and five based on statistical criteria. The teeth included in each of the eight biological/taphonomic models were strategically chosen to increase the applicability of this age estimation method in the forensic context. Six linear models were created that focus on the maxilla or mandible exclusively, if the skeletal remains are not all recovered or are damaged. The remaining two models incorporate teeth from both the maxilla and the mandible for cases in which all information is available.

The specific teeth chosen for the first eight linear models were informed by three biological or taphonomic principles. First, models were created that incorporate the polar teeth (e.g., Dahlberg 1945). Polar teeth are considered the most stable member of a tooth field, and this is typically the most mesial tooth (Butler 1939; Dahlberg 1945, 1986; Townsend et al. 2009). The maxillary polar teeth include I1, C, P1, and M1, while the mandibular polar teeth are the same except for the incisor; in the mandible, the lateral incisor is considered the polar tooth as it shows the least variation (e.g., Townsend et al. 2009). Second, linear models were created that incorporate the teeth most frequently recovered in the forensic context. Anterior teeth have a single root, which means these teeth are more likely to fall out of their alveoli when remains are skeletonized. However, molars typically have three roots in the maxilla and two roots in the mandible, while

maxillary premolars are subject to variants in root number (Scott et al. 2016, 2018; Turner et al. 1991). Therefore, posterior teeth are more difficult to remove from the alveolus and are considered the most likely to be recovered in a forensic context (Bass 2005).

Finally, third molars were typically avoided in linear models, as these teeth are most subject to variation during the process of dental development (e.g., Liversidge 2016a). Additionally, third molars experience congenital absence more frequently than other teeth (Nelson 2016), with as much as 20% of the population congenitally missing one or more of their third molars (Vastardis 2000: 650). Third molars are also most subject to impaction (e.g., Carter and Worthington 2015; Grover and Lorton 1985). In a sample of males of primarily European ancestry, Heim and Pilloud (2018) found impacted third molars demonstrate delayed development relative to third molars in normal occlusion. However, as the third molar is one of the few skeletal elements still developing during late adolescence (Garvin et al. 2012; Ritz-Timme et al. 2000), two linear models were created that use this tooth to determine if its inclusion improves age estimation during the adolescent period.

Using these guiding principles, eight linear models for age estimation were created for: 1) maxillary polar teeth; 2) mandibular polar teeth; 3) maxillary forensic teeth; 4) mandibular forensic teeth; 5) maxillary and mandibular polar teeth most frequently recovered in a forensic context; 6) maxillary and mandibular first and second molars; 7) all three maxillary molars; and 8) all three mandibular molars. Individual teeth included in each biological/taphonomic model are listed in Table 4.4. Each of these models includes only three or four teeth. As more teeth are incorporated into the linear

model, the likelihood that an individual could not be assigned a developmental score at one of the teeth increases, thereby precluding the use of the model on that individual, thus limiting the model's applicability.

In addition to the eight linear models based on biological/taphonomic principles, six models were created based on statistical criteria, using the confidence intervals created from the entire training sample. The lower bounds of the 95% confidence intervals were subtracted from the upper bounds to determine the width. For every tooth, the widths of the confidence intervals for all developmental scores were averaged, producing a measure of precision for each tooth. Six models were devised using some combination of teeth that present the narrowest average confidence intervals. However, one statistically defined model overlaps a biologically/taphonomically defined model: the four teeth with the narrowest average confidence intervals in the mandible are also the four mandibular polar teeth (#19, 21, 22, and 23). Therefore, the biological/taphonomic model was retained, and the duplicate statistical model was dropped, leaving five statistically defined linear models. These models are based on: 1) the four teeth from both jaws with the narrowest average confidence intervals; 2) the four posterior teeth from both jaws with the narrowest average confidence intervals; 3) the four maxillary teeth with the narrowest average confidence intervals; 4) the three posterior maxillary teeth with the narrowest average confidence intervals; and 5) the three posterior mandibular teeth with the narrowest average confidence intervals. The teeth included in the final 13 models are listed in Table 4.4.

When applied to the test set, the linear models were used to create a point estimate of each individual's age, as well as the 51% and 95% prediction intervals. While a

confidence interval is designed to estimate the true population mean, a prediction interval is concerned with predicting the next sampling point. Suppose a random sample is selected from a population, and the 95% prediction interval is calculated from the mean of this sample. The prediction interval suggests that if another point is drawn from the population, its value will fall within the prediction interval 95 out of 100 times. A confidence interval only accounts for the unknown population mean, while a prediction interval considers the distribution of the data within the sample; therefore, prediction intervals tend to be wider. The point estimates and prediction intervals were evaluated for accuracy by assessing whether the individual's chronological age either matched the point estimate or fell within the bounds of the prediction interval. Estimates that were incorrect were further evaluated to determine whether the individual was under-aged (i.e., the estimated age is too low, or under the chronological age) or over-aged (i.e., the estimated age is too high, or over the chronological age).

Table 4.4: Teeth incorporated into the linear models created for age estimation.

Linear Model	Teeth Included
Maxillary Polar	#9, 11, 12, and 14
Mandibular Polar	#19, 21, 22, and 23
Maxillary Forensic	#12, 13, 14, and 15
Mandibular Forensic	#18, 19, 20, and 21
Polar Forensic Both Jaws	#12, 14, 19, and 21
2 Molars Both Jaws	#14, 15, 18, and 19
Maxillary 3 Molars	#14, 15, and 16
Mandibular 3 Molars	#17, 18, and 19
Narrowest 4 Both Jaws	#21, 11, 22, and 19
Narrowest 4 Posterior Both Jaws	#21, 19, 13, and 20
Narrowest 4 Maxillary	#11, 9, 13, and 10
Narrowest 3 Posterior Maxillary	#13, 12, and 16
Narrowest 3 Posterior Mandibular	#21, 19, and 20

All 13 linear models were originally built using the entire training sample (see Table 4.4). However, the second hypothesis of this dissertation concerns the practicality of sex- and ancestry-specific methods of age estimation. Therefore, in addition to testing specific confidence intervals, two sex-specific and five ancestry-specific versions of each linear model were created, leading to eight versions of all 13 models. The linear models based on all individuals and the linear models based on subsets of the training sample were evaluated using three criteria: accuracy of the 95% prediction intervals, precision of the 95% prediction intervals as measured by width of the estimate, and applicability of the model to the test sample. To be useful in a forensic context, models should exhibit high levels of accuracy and narrow age ranges, but applicability is also an important variable. The best models should estimate age in a high proportion of individuals from the test sample, rather than frequently producing NAs because of missing data.

The linear models developed using the training sample were subsequently tested for accuracy on the holdout test sample. The test sample includes 100 individuals, but all models could not be tested using the full test set. Since individuals in the test sample were randomly selected, it is unlikely that the developmental scores represented in both datasets are the same. In other words, there are many cases in which scores exist in the training sample that are not present in the test sample. This occurrence does not interfere with age estimation, as scores that are not present in an individual are not considered in the formulae. Conversely, there are cases in which developmental scores are present in individuals in the test set but not the training set, which does present a problem for age estimation. Because the models were not created on a sample that included these developmental scores, the ages of these individuals cannot be predicted. Therefore, these

individuals must be excluded from the test set when the linear model could not run as intended.

All maxillary linear models based on the entire training sample are affected. The maxillary polar model, the maxillary forensic model, the maxillary/mandibular polar forensic model, and the maxillary/mandibular two molar model were tested on 99 individuals. The maxillary three molar model was tested on 98 individuals, while the model based on the three posterior maxillary teeth with the narrowest average confidence intervals was tested on 97 individuals. The remaining linear models based on the entire training sample were tested on the full set of 100 individuals from the test sample. Additionally, applicability tends to decrease when the linear models are based on subsets of the training sample. With each division of the data, fewer individuals in the training sample are informing the model. Therefore, sex- and ancestry-specific linear models are often applied to fewer individuals in the test set than the models based on all individuals.

4.4: Summary of Methods

Dental development was scored for each permanent tooth in every orthopantomogram using two methods, that of Moorrees and colleagues (1963), using the modification devised by Liversidge and Molleson (2018), and that of Demirjian and colleagues (1973). Intraobserver error in the application of developmental scores was evaluated using Cohen's weighted Kappa (Cohen 1968). Before creating age estimation methods, Kruskal-Wallis and Dunn's tests were used to evaluate whether sex and/or ancestry groups demonstrate significant differences in the rates of dental development, to test the first hypothesis of this research (Dunn 1964; Kruskal and Wallis 1952). After

testing for significant differences, sex and/or ancestry were included as variables in the creation of age estimation methods.

The two methods for age estimation created in this project include confidence intervals to estimate age from a single tooth and linear models to estimate age from multiple teeth. Age estimation methods were first created using the entire training sample to act as a general model, then sex- and/or ancestry-specific models were created. All age estimation methods, both the general and specific versions, were applied to the hold-out test sample to evaluate their performance. Accuracy and precision were compared between the general CIs and the specific CIs, while accuracy, precision, and applicability were considered when comparing the linear models based on all individuals to the linear models based on subsets of the training sample. The comparison of general age estimation methods based on all individuals and population-specific methods based on subsets of the training sample contribute to testing the second hypothesis.

Chapter 5: Results

There are two objectives in this dissertation: 1) create an age estimation method based on dental development from a modern sample of children from the United States, and 2) investigate sex and/or ancestry differences in dental development and their effects on age estimation. The results are presented in an order that facilitates these goals. First, observer error is presented to determine which scoring system can be most consistently applied and to allow the developmental scores from this system to be utilized for the remainder of the tests. Next, the results of the Kruskal-Wallis and Dunn's tests for analyzing sex and/or ancestry differences are presented (Dunn 1964; Kruskal and Wallis 1952). The presence or absence of such differences must be evaluated prior to the creation of age estimation methods. If there are no significant differences between sex and ancestry groups, these variables need not be incorporated into the age estimation methods. However, if significant differences do exist, age estimation methods should be designed to account for this variation.

In the final sections, age estimation methods are presented. Confidence intervals are created at 51% and 95% confidence levels for every developmental score at every tooth for the training set and then subsets divided by sex, ancestry, and sex/ancestry. These confidence intervals are then applied to the holdout test set to obtain accuracy and precision values. The accuracy and precision of the set of confidence intervals based on all individuals are compared to the values produced by the confidence intervals based on subsets. These accuracy and precision tests relate to the second hypothesis: whether sex- and/or ancestry-specific models of dental development provide more accurate age estimates.

Linear models are presented that incorporate multiple teeth to allow more information to be utilized in the age estimate. As with confidence intervals, linear models are created from the entire training sample and then from subsets divided by sex and ancestry. Each linear model is applied to the holdout test set, producing accuracy and precision values. As with confidence intervals, the accuracy and precision of the linear models based on all individuals are compared to the values produced by models based on subsets of the training sample, to evaluate whether specific models of development outperform general models. These final sections represent the culmination of this research: the creation of age estimation methods that are more appropriate for use in a forensic context in the United States.

5.1: Intraobserver Error Results

The results of the Cohen's weighted Kappa tests for intraobserver error (Appendix 1) suggest that the developmental scoring systems of Moorrees and colleagues (1963) and Demirjian and colleagues (1973) can both be consistently applied to orthopantomograms. Cohen's weighted Kappa tests were run using both linear weights and quadratic weights. While all values are reported in Appendix 1, discussion is limited to the results of the linear weights tests.

The intraobserver error results suggest internal consistency in the application of developmental scores (Appendix A1.1). Based on the thresholds defined by Landis and Koch (1977), every tooth demonstrates moderate agreement or better for both scoring systems. Using the Moorrees et al. (1963) system, one tooth shows moderate agreement, nine show substantial agreement, and six show almost perfect agreement. With the Demirjian et al. (1973) system, two teeth show moderate agreement, two show

substantial agreement, and 12 show almost perfect agreement. All intraobserver error scores are within the acceptable threshold for agreement, suggesting that these variables should remain in the following analyses.

In the intraobserver error tests, the Demirjian et al. (1973) scoring system typically generates higher Kappa scores than the Moorrees et al. (1963) scoring system (ten of 16 teeth). The remaining six teeth demonstrate higher Kappa scores using the Moorrees et al. (1963) scoring system (#9, 14, 15, 16, 17, and 24). Teeth #9 and #24 are the maxillary and mandibular central incisors respectively, while teeth #14-17 are molars (all three maxillary molars and mandibular M3). The difference in Kappa scores between developmental scoring systems is minimal for these six teeth. Only teeth #16 and #24 demonstrate a difference in Landis and Koch (1977) classifications between systems, with the Moorrees et al. (1963) system showing substantial agreement and the Demirjian et al. (1973) system showing moderate agreement.

Overall, the Demirjian et al. (1973) system exhibits higher Kappa values in the intraobserver error tests, suggesting this scoring system can be more consistently applied than the Moorrees et al. (1963) system. For this reason, the following results have been limited to tests run on the Demirjian et al. (1973) developmental scores. Using only one scoring system reduces redundancy in the discussion of sex and ancestry differences. Additionally, confidence intervals and linear models created from the Demirjian et al. (1973) scores can be easily incorporated into a forensic context as this scoring system is already commonly used (e.g., Drvostep and Senn 2017; Kaiser and Senn 2004; Roberts et al. 2018; Yan et al. 2013).

5.2: Population Variation in Dental Development

Kruskal-Wallis tests and Dunn's post-hoc tests were conducted for every age in the sample. As these comparisons produced a total of 64 tables, results are contained in Appendix 2 (Dunn 1964; Kruskal and Wallis 1952). For ease of discussion, a subsequent round of tests was performed after dividing the sample into groups based on biologically defined breakpoints. According to Bogin (1999), three biological phases of life can be applied to the present dataset: 1) childhood includes individuals of ages 5-6; 2) juvenile is defined as ages 7-10 for females and 7-12 for males; and 3) adolescence lasts for five to eight years after the onset of puberty, which is treated as the remainder of the age range in this sample (Bogin 1999). To ensure the male and female samples are comparable, the average of the upper bounds for the juvenile sample has been used, such that the juvenile period comprises years 7-11 for both sexes. The results of these comparisons are presented in Tables 5.2, 5.5, 5.8, and 5.11. All individuals have been included in these analyses (n = 1,753), except for the four individuals of Hawaiian ancestry (see Table 4.2). With such a small sample size, a comparison of the Hawaiian subset against other ancestry groups would be statistically invalid and would generate no meaningful information. Results presented are significant at $\alpha = 0.05$, unless Bonferroni (1936) corrected alpha values are specified.

5.2.1: Sex Differences in Dental Development

Across the entire age range, 214 total comparisons are made between females and males using the Dunn's post-hoc tests. Of those 214 comparisons, 41 yield significant differences between the sexes (19.16%); 26 differences are significant at $\alpha = 0.05$, and the remaining 15 are significant at the Bonferroni corrected $\alpha = 0.0015625$ (Table 5.1).

When significant differences exist between females and males, the majority indicate that female developmental scores are higher (39 of 41 instances), meaning that female development is advanced relative to male development. In only two cases are male developmental scores significantly higher than female scores, once at age seven and once at age 20. Additionally, only females exhibit significantly higher developmental scores at the Bonferroni corrected $\alpha = 0.0015625$. However, there are more cases where developmental scores do not demonstrate significant differences between males and females (80.84%).

Table 5.1: Summary of significant differences between sexes from Dunn's pair-wise comparisons, through the entire age range (years 5-20). 0.05 = significant at $\alpha = 0.05$; Bon = significant at Bonferroni corrected $\alpha = 0.0015625$. Positive z-scores indicate females have higher developmental scores; negative z-scores indicate males have higher developmental scores. Total n = total number of comparisons.

	Female-Male
0.05	26
Bon	15
Positive z-scores	39
Negative z-scores	2
Total n	214

During childhood, no teeth exhibit significantly different Demirjian et al. (1973) scores between females and males. While the differences are not significant, females exhibit a higher score in seven teeth and males in eight teeth; higher developmental scores indicate advanced development, suggesting neither sex is consistently developmentally advanced or delayed during childhood (Table 5.2 and Appendix A2.17.1). Separated by year, individuals at age five and six exhibit no significant differences between the sexes in the Kruskal-Wallis tests (Appendices A2.1.1 and 2.2.1).

Table 5.2: Sex comparison using Kruskal-Wallis and Dunn's post-hoc tests across age categories (Dunn 1964; Kruskal and Wallis 1952). C = childhood; J = juvenile; A = adolescence; one asterisk (*) = 0.05 alpha level; two asterisks (**) = Bonferroni adjusted $\alpha = 0.0015625$; n = N/A, i.e., a comparison that could not be performed due to lack of information. Plus signs indicate positive z-scores in which female Demirjian et al. (1973) scores are higher than males; minus signs indicate negative z-scores in which male developmental scores are higher than females. / indicates no significant difference.

Tooth	Sex		
	C	J	A
9: UI1	/	/	/
10: UI2	/	/	+*
11: UC	/	+**	/
12: UP1	/	/	/
13: UP2	/	/	/
14: UM1	/	/	/
15: UM2	/	/	/
16: UM3	n	+*	/
17: LM3	/	/	/
18: LM2	/	/	/
19: LM1	/	+*	/
20: LP2	/	/	/
21: LP1	/	+*	/
22: LC	/	+**	+**
23: LI2	/	/	/
24: LI1	/	/	/

Sex differences are most pronounced during the juvenile period (see Table 5.2). The pair-wise comparison for sex differences reveals significantly higher developmental scores in females for three teeth (#16, 19, and 20), with an additional two teeth demonstrating significance at the Bonferroni adjusted $\alpha = 0.0015625$ (#11 and 22) (Appendix A2.18.1). Between the ages of seven and 11, females exhibit significantly higher developmental scores compared to males during every year, in as few as two teeth at age seven and in as many as nine teeth at age nine at $\alpha < 0.05$ (Appendices A2.3.1-A2.7.1). Of the whole age range, the Kruskal-Wallis and Dunn's tests identify the

greatest number of teeth that exhibit significant differences between females and males at age nine. Females exhibit significantly higher developmental scores for five teeth (#15, 16, 17, 18, and 21), with an additional four teeth exhibiting significance at the Bonferroni alpha level (#11, 14, 19, and 22) (Appendix A2.5.1). Only once during this period do males exhibit significantly higher developmental scores, at tooth #17 during year seven (Appendix A2.3.1).

While sex differences are most pronounced during the juvenile period, comparisons between females and males yield fewer significant differences with the transition into adolescence (see Table 5.2). Females exhibit higher developmental scores in 12 of the 16 teeth during the adolescent period, but only two teeth are significant at $\alpha < 0.05$. Males exhibit higher developmental scores in the remaining four teeth (#15, 16, 17, and 24), though these differences are not statistically significant (Appendix A2.19.1).

When the years are analyzed individually, females exhibit significantly higher developmental scores compared to males during years 12-15, in as few as one tooth each during years 14 and 15 and as many as five teeth during year 12 (Appendices A2.8.1-A2.11.1). At age 12, females exhibit significantly higher developmental scores than males for five teeth at $\alpha < 0.05$ (Appendix A2.8.1). After age 13, sex differences are minimal, with each subsequent year showing significant differences in either a single tooth or none. Additionally, the number of teeth in which female developmental scores are higher than males begins to reduce after this year, with males eventually exceeding females. Males only exhibit significantly higher developmental scores than females in one instance during this period, for tooth #16 during year 20 (Appendix A2.16.1).

Sex differences are tallied by tooth across the whole age range in Table 5.3. The canines exhibit the greatest number of significant differences between females and males, both absolutely and proportionally. In the maxilla and mandible combined, canines exhibit significant differences in 15 of the 30 total comparisons (50.00%). After the canines, molars exhibit the next highest proportion of significant differences (17.50%), followed by the premolars (13.56%), with incisors exhibiting the fewest significant differences between females and males (8.89%). In addition to exhibiting the highest proportion of significant differences at $\alpha < 0.05$, canines also yield the highest proportion of differences that are significant at the Bonferroni corrected $\alpha = 0.0015625$ (60% of differences). Molars and premolars exhibit Bonferroni significance in relatively even proportions (28.57% and 25%, respectively), while incisors yield no differences that are significant at the Bonferroni alpha level.

As the canines exhibit the most significant differences between females and males, the age ranges present at each Demirjian et al. (1973) score for these teeth are presented in Figures 5.1 and 5.2. Apart from the Demirjian et al. (1973) score of H in both canines and a score of F in the mandibular canine, all female box plots indicate lower ages for developmental scores, indicating that female dental development is advanced relative to male development.

Overall, the Kruskal-Wallis and Dunn's tests suggest that, when significant differences exist between the sexes, female developmental scores are higher than male scores, indicating advanced development in the female sample (see Table 5.1). There are no significant differences between females and males during childhood. The juvenile period yields the greatest number of significant differences, while fewer significant

differences exist between the sexes during the adolescent period (see Table 5.2). Year nine yields the greatest number of significant differences between female and male developmental scores (see Appendix A2.5.1). Canines exhibit the greatest number of significant differences between females and males, both absolutely and proportionally, and canines also yield the highest proportion of differences that are significant at the Bonferroni corrected $\alpha = 0.0015625$. After canines, molars and premolars exhibit the greatest proportion of significant differences, with incisors yielding the fewest significant differences between females and males (see Table 5.3).

Table 5.3: Number of significant differences in Dunn's (1964) pair-wise comparisons between females and males, by tooth. Bon = Bonferroni adjusted $\alpha = 0.0015625$. Total n = total number of comparisons. Since no differences are significant at the Bonferroni level during childhood, the Bonferroni column is not included.

Tooth	Childhood (5-6)		Juvenile (7-11)			Adolescence (12-20)			Total			
	0.05	Total n	0.05	Bon	Total n	0.05	Bon	Total n	0.05	Bon	All α	Total n
9: UI1	0	2	1	0	5	0	0	4	1	0	1	11
10: UI2	0	2	1	0	5	1	0	6	2	0	2	13
11: UC	0	2	2	3	5	1	1	9	3	4	7	16
12: UP1	0	2	0	0	5	0	0	7	0	0	0	14
13: UP2	0	2	0	0	5	1	0	9	1	0	1	16
14: UM1	0	2	0	1	5	0	0	3	0	1	1	10
15: UM2	0	2	1	1	5	0	0	9	1	1	2	16
16: UM3	0	0	2	0	5	1	0	9	3	0	3	14
17: LM3	0	0	3	0	5	0	0	9	3	0	3	14
18: LM2	0	2	1	1	5	1	0	9	2	1	3	16
19: LM1	0	2	1	1	5	0	0	3	1	1	2	10
20: LP2	0	2	1	0	5	0	1	9	1	1	2	16
21: LP1	0	2	2	1	5	2	0	6	4	1	5	13
22: LC	0	2	1	4	5	2	1	7	3	5	8	14
23: LI2	0	2	1	0	5	0	0	4	1	0	1	11
24: LI1	0	2	0	0	5	0	0	3	0	0	0	10
Total n	0	28	17	12	80	9	3	106	26	15	41	214

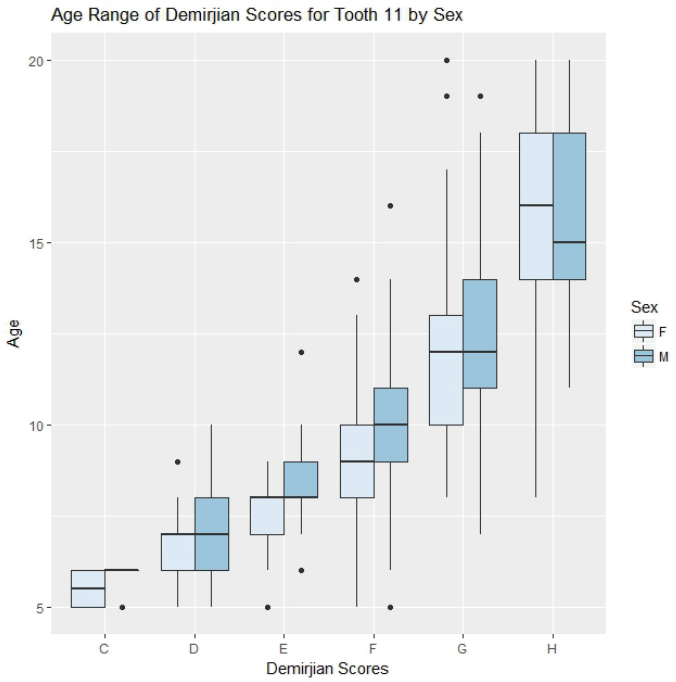


Figure 5.1: Box and whisker plots of age distribution for each Demirjian et al. (1973) score for tooth #11 (UC), divided by sex.

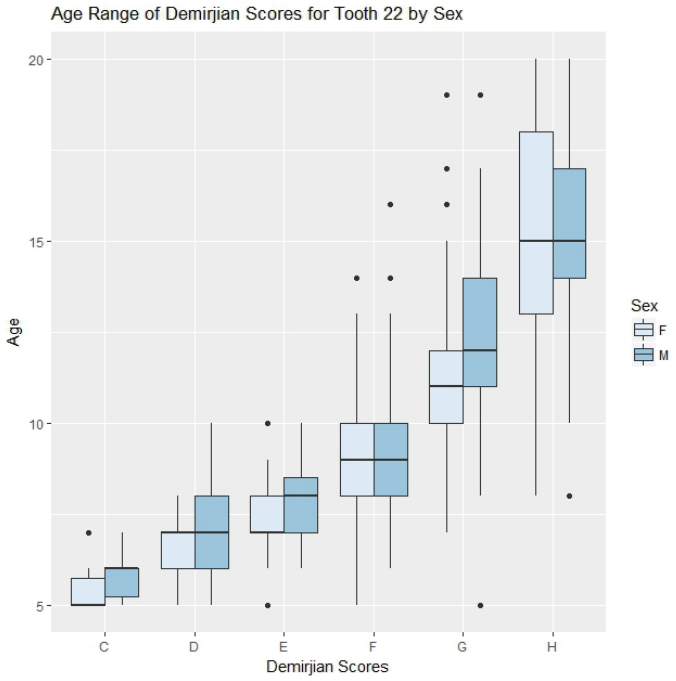


Figure 5.2: Box and whisker plots of age distribution for each Demirjian et al. (1973) score for tooth #22 (LC), divided by sex.

5.2.2: Ancestry Differences in Dental Development

Across the whole age range, 1,870 pair-wise comparisons are performed between total ancestry groups using Dunn's post-hoc tests. Of those 1,870 comparisons, 138 indicate that significant differences exist between ancestry groups (7.38%); 122 of these differences are significant at $\alpha = 0.05$, and the remaining 16 are significant at the Bonferroni adjusted $\alpha = 0.000284$ (Table 5.4). The European American-Hispanic comparisons yield the highest number and proportion of significant results, with 60 of 215 comparisons revealing significant differences in developmental scores between these two ancestry groups (27.91%). Other ancestry groups yield fewer significant results, with 3-7% of the comparisons indicating significant differences.

Table 5.4: Summary of significant differences between total ancestry groups from Dunn's pair-wise comparisons, through whole age range (years 5-20). AfA = African American; AsA = Asian American; EA = European American; His = Hispanic; Nat = Native American. 0.05 = significant at $\alpha = 0.05$; Bon = significant at Bonferroni corrected $\alpha = 0.000284$; Total n = total number of comparisons. Positive z-scores indicate the first group has higher developmental scores; negative z-scores indicate the second group has higher developmental scores. For example, the African American-Hispanic comparison indicates that African American developmental scores are higher in 5 cases (positive z-scores), while Hispanic developmental scores are higher in 6 cases (negative z-scores).

	AfA-AsA	AfA-EA	AfA-His	AfA-Nat	AsA-EA	AsA-His	AsA-Nat	EA-His	EA-Nat	His-Nat	Total
0.05	6	7	11	8	11	10	6	43	10	9	121
Bon	0	0	0	0	0	0	0	16	0	0	16
Positive z-scores	3	7	5	8	8	2	4	3	9	9	137
Negative z-scores	3	0	6	0	3	8	2	56	1	0	
Total n	196	197	197	160	211	211	161	215	161	161	1,870

In the overall ancestry comparison during childhood, the Kruskal-Wallis test identifies four teeth that exhibit significant differences (#12, 13, 19, and 20) (Table 5.5). Two pair-wise comparisons yield significant results. Overall, the European American sample has the lowest Demirjian et al. (1973) scores during childhood, followed by the Asian American and African American samples, respectively. The Hispanic sample has the highest developmental scores (Appendix A2.17.2). Separated by year, individuals at age five exhibit no significant differences between ancestry groups in the Kruskal-Wallis test, but five teeth demonstrate significance between ancestry groups during year six (#10, 12, 13, 19, and 20). The Hispanic sample exhibits the only significant differences during pair-wise comparisons in years five and six, demonstrating significantly higher developmental scores in as few as one tooth compared to the Asian American sample during both years and as many as nine teeth compared to the European American sample during year six (Appendices A2.1.2 and A2.2.2).

As was the case with sex, ancestry differences are most pronounced during the juvenile period (see Table 5.5). In the ancestry comparisons during the juvenile period, the Kruskal-Wallis test reveals seven teeth that demonstrate significant differences (#9, 10, 11, 14, 19, 22, and 23) and an additional five teeth that are significant at the Bonferroni corrected $\alpha = 0.000284$ (#12, 13, 18, 20, and 21). Five pair-wise comparisons yield statistically significant results for the juvenile period. Overall, the European American and Asian American samples have the lowest Demirjian et al. (1973) scores during the juvenile period, followed by the African American and Hispanic samples, respectively. The Native American sample has the highest developmental scores (Appendix A2.18.2).

Table 5.5: Ancestry comparison using Kruskal-Wallis and Dunn's post-hoc tests across age categories (Dunn 1964; Kruskal and Wallis 1952). The first column (Anc) includes the results from the overall ancestry K-W test, and all other columns are subsequent Dunn's tests. C = childhood; J = juvenile; A = adolescence; one asterisk (*) = 0.05 alpha level; two asterisks (**) = Bonferroni adjusted α = 0.000284; n = N/A, i.e., a comparison that could not be performed due to lack of information. Plus signs indicate positive z-scores in which Demirjian et al. (1973) scores of the first ancestry group are higher than the second; minus signs indicate negative z-scores in which developmental scores of the second group are higher than the first. For example, the negative z-score in the EA-His comparison at tooth 9 during childhood means that the European American childhood sample exhibits significantly lower developmental scores than the Hispanic childhood sample. / indicates no significant difference.

Tooth	Anc			AfA-AsA			AfA-EA			AfA-His			AfA-Nat			AsA-EA			AsA-His			AsA-Nat			EA-His			EA-Nat			His-Nat		
	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A
9: UI1	/	*	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	−*	−*	/	n	/	/	n	/	/
10: UI2	/	*	/	/	/	/	/	/	/	/	/	/	n	/	+*	/	/	/	/	/	/	n	−*	/	/	−*	/	n	−*	/	n	/	/
11: UC	/	*	*	/	/	/	/	/	/	/	/	+*	n	/	/	/	/	/	/	/	+*	n	/	/	/	−*	/	n	/	/	n	/	/
12: UP1	*	**	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	+*	n	/	/	−*	−**	/	n	/	/	n	/	/
13: UP2	*	**	*	/	/	/	/	/	/	/	/	+*	n	/	/	/	/	+*	/	/	+*	n	/	/	−*	−**	/	n	/	/	n	/	/
14: UM1	/	*	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	−*	−*	/	n	/	/	n	/	/
15: UM2	/	**	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	−*	/	n	−*	/	/	−**	+*	n	−*	/	n	/	/
16: UM3	/	/	*	n	/	/	n	/	/	n	/	+*	n	/	/	n	/	/	n	/	/	n	/	/	/	/	+*	n	/	/	n	/	/
17: LM3	/	/	*	n	/	/	n	/	/	n	/	+*	n	/	+*	n	/	/	n	/	/	n	/	/	/	/	+*	n	/	/	n	/	/
18: LM2	/	**	*	/	/	/	/	/	/	/	/	+*	n	/	/	/	/	/	/	/	+*	n	/	/	/	−**	+*	n	/	/	n	/	/

Tooth	Anc			AfA-AsA			AfA-EA			AfA-His			AfA-Nat			AsA-EA			AsA-His			AsA-Nat			EA-His			EA-Nat			His-Nat		
	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A
19: LM1	*	*	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	—*	—*	/	n	/	/	n	/	/
20: LP2	*	**	/	/	/	/	+*	+*	/	/	/	/	n	/	/	/	/	/	/	/	+*	n	/	+*	—*	—**	/	n	—*	/	n	/	/
21: LP1	/	**	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	—*	+*	n	—*	+*	/	—**	/	n	—*	/	n	/	/
22: LC	/	*	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	—*	—*	/	n	/	/	n	/	/
23: LI2	/	*	/	/	/	/	/	+*	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	—*	—**	/	n	/	/	n	/	/
24: LI1	/	/	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	—*	n	/	/	—*	—*	/	n	/	/	n	/	/

When years 7-11 are analyzed individually, each year yields significant results (Appendices A2.3.2-A2.7.2). Year seven yields the fewest significant results, with only two teeth exhibiting differences between ancestry groups (#20 and 21) (Appendix A2.3.2). Across the whole age range, the Kruskal-Wallis tests identify the most significant differences between ancestry groups at age eight. During year eight, there are 13 teeth that demonstrate significant differences between ancestry groups, with four teeth significant at $\alpha = 0.05$ (#9, 10, 19, and 24) and nine additional teeth significant at the Bonferroni corrected alpha level (#11, 12, 13, 15, 18, 20, 21, 22, and 23) (Appendix A2.4.2).

During years 7-11, the Hispanic sample again exhibits the most significant differences in developmental stages when compared to other ancestry groups. The Hispanic sample exhibits significantly higher developmental scores than the European American sample during each year, in as few as two teeth at age seven (Appendix A2.3.2) and as many as 14 teeth when $\alpha < 0.05$ at ages eight and 10 (Appendices A2.4.2 and A2.6.2). The Hispanic sample also exhibits significantly higher developmental scores in as many as five teeth compared to the African American sample at age 10 (Appendix A2.6.2) and two teeth compared to the Native American sample at age 11 (Appendix A2.7.2).

Other ancestry groups exhibit fewer significant differences during years 7-11 than the Hispanic sample. The African American sample exhibits significantly higher developmental scores, in at most four teeth compared to the European American sample at age eight (Appendix A2.4.2) and at least one tooth compared to the European American, Hispanic, and Native American samples (Appendices A2.4.2, A4.5.2, and

A2.7.2). The Asian American sample exhibits significantly higher developmental scores compared to all other ancestry groups at least once during years 7-11. Asian American developmental scores are significantly higher for as many as six teeth compared to the European American sample at age eight (Appendix A2.4.2) and as few as one tooth compared to the Hispanic and Native American samples (Appendices A2.4.2, A4.5.2, and A2.7.2). The European American sample only exhibits a significantly higher score in one pair-wise comparison, for a single tooth compared to the Native American sample at age 11 (Appendix A2.7.2).

The pattern observed in the sex comparisons again holds true in the ancestry tests. Sex and ancestry differences are most pronounced during the juvenile period, and these variables demonstrate fewer significant differences with the transition into the adolescent period (see Tables 5.2 and 5.5). When ages are considered individually, each year in the adolescent subset either demonstrates significant differences at one tooth or no teeth in the ancestry comparison. There are no significant differences between ancestry groups at ages 12, 16, or 17 (Appendices A2.8.2, A2.12.2, and A2.13.2). The Kruskal-Wallis test reveals five teeth that demonstrate significant differences between ancestry groups during the adolescent period (#11, 13, 16, 17, and 18) (Appendix A2.19.2). Six of the ten pair-wise comparisons for the adolescent sample yield significant results. Overall, the Hispanic sample has the lowest Demirjian et al. (1973) scores during adolescence, followed by the Native American and European American samples, respectively. Asian American and African American samples have the highest developmental scores (Appendix A2.19.2).

Contrary to the childhood and juvenile periods, both the African American and European American samples exhibit significantly higher developmental scores in more cases than the Hispanic sample during years 12-20. The African American sample exhibits significantly higher developmental scores compared to all other ancestry groups in at least one pair-wise comparison. African American developmental scores are significantly higher in at most two teeth, compared to the Hispanic, Asian American, and European American samples at age 14 (Appendix A2.10.2) and compared to the Native American sample at ages 16 and 19 (Appendices A2.12.2 and A2.15.2). The European American sample exhibits significantly higher developmental scores in as many as four teeth compared to the Native American sample at age 19 (Appendix A2.15.2) and as few as one tooth compared to the Asian American, Hispanic, and Native American samples (Appendices A2.8.2-A2.9.2, A2.11.2-A2.14.2, and A2.16.2).

During years 12-20, the Hispanic sample exhibits significantly higher developmental scores in as many as two teeth compared to the Native American sample at ages 16, 18, and 19 (Appendices A2.12.2 and A2.14.2-A2.15.2) and as few as one tooth compared to the Asian American, European American, and Native American samples (Appendices A2.8.2-A2.9.2 and A2.11.2). The Asian American and Native American samples exhibit significantly higher developmental scores in many fewer cases than the other ancestry groups during years 12-20. Neither group exhibits significantly higher scores in more than a single tooth per year. The Asian American sample has significantly higher developmental scores in one tooth compared to the Hispanic and Native American samples (Appendices A2.14.2-A2.16.2), while the Native American

sample exhibits significantly higher scores for one tooth compared to the Asian American and European American samples (Appendices A2.8.2 and A2.11.2).

Significant differences between ancestry groups are tallied by tooth across the whole age range in Table 5.6. Incisors exhibit the highest proportion of significant differences in developmental scores between ancestry groups (8.73% of total comparisons), while premolars exhibit significant differences slightly less often (8.56%). After incisors and premolars, molars exhibit the next highest proportion of significant differences between ancestry groups (6.61%), with canines exhibiting the lowest proportion of significant differences (4.89%). Although incisors exhibit the highest proportion of differences at $\alpha < 0.05$, these teeth yield no differences that are significant at the Bonferroni corrected $\alpha = 0.000284$. Premolars exhibit the highest proportion of Bonferroni significant differences (20.45% of differences), followed by canines (15.38%) and molars (10.64%).

The highest proportions of significant differences between ancestry groups are observed in the mandibular premolars; therefore, the age distribution for each Demirjian et al. (1973) score for these teeth has been visualized in Figures 5.3 and 5.4. Significant differences are most common between the European American and Hispanic samples, and this trend is evident in the box plots. The boxes representing the age distribution for the European American sample are consistently at higher ages than those representing the Hispanic sample, indicating that European American dental development is delayed relative to Hispanic development. The other pattern that is most evident in the box and whisker plots involves the Native American sample. The age distribution at each score for both mandibular premolars tends to be higher for the Native American sample relative

to other ancestry groups. This supports the conclusion that Native American dental development is delayed in the current sample.

Table 5.6: Number of significant differences in Dunn's (1964) pair-wise comparisons between total ancestry groups, by tooth. Bon = Bonferroni adjusted α = 0.000284. Total n = total number of comparisons. Since no differences are significant at the Bonferroni level during childhood, the Bonferroni column is not included.

Tooth	Childhood (5-6)		Juvenile (7-11)			Adolescence (12-20)			Total			
	0.05	Total n	0.05	Bon	Total n	0.05	Bon	Total n	0.05	Bon	All α	Total n
9: UI1	1	9	4	0	46	0	0	32	5	0	5	87
10: UI2	1	9	7	0	46	0	0	56	8	0	8	111
11: UC	2	9	2	1	46	1	0	86	5	1	6	141
12: UP1	1	7	1	3	46	4	0	62	6	3	9	115
13: UP2	1	7	6	2	46	0	0	86	7	2	9	139
14: UM1	1	9	2	0	43	3	0	30	6	0	6	82
15: UM2	0	9	3	3	46	6	0	83	9	3	12	138
16: UM3	0	0	1	0	42	3	0	90	4	0	4	132
17: LM3	0	0	2	0	39	5	0	90	7	0	7	129
18: LM2	0	9	5	2	46	7	0	90	12	2	14	145
19: LM1	1	9	3	0	46	0	0	30	4	0	4	85
20: LP2	1	9	5	2	46	5	0	90	11	2	13	145
21: LP1	0	9	6	2	46	5	0	60	11	2	13	115
22: LC	1	9	3	1	46	2	0	70	6	1	7	125
23: LI2	0	9	9	0	46	1	0	40	10	0	10	95
24: LI1	0	9	6	0	46	4	0	30	10	0	10	85
Total n	10	122	65	16	722	46	0	1,025	121	16	137	1,869

Overall, the majority of comparisons suggest no significant differences exist between developmental scores assigned to individuals from different ancestry groups. However, when significant differences do exist, the European American and Hispanic samples yield the greatest proportion of significant results, when alpha levels are combined and at the Bonferroni adjusted α = 0.000284. Nearly all significant differences show Hispanic developmental scores are higher than European American scores, indicating advanced dental development in the Hispanic sample (see Table 5.4). When

significant differences between total ancestry groups are tallied across the whole age range, the z-scores produced by the Dunn's tests indicate that Native American developmental scores are lowest, followed by the European American and Asian American samples, with the African American and Hispanic samples exhibiting the highest developmental scores.

Few significant differences exist between ancestry groups during childhood. The juvenile period yields the highest proportion of significant differences, while fewer differences exist between total ancestry groups during the adolescent period (see Table 5.5). Of the whole age range, year eight yields the highest number of significant differences between ancestry groups (see Appendix A2.4.2). Incisors exhibit significant differences between ancestry groups in a higher proportion than other tooth classes. However, the proportion of significant differences observed in premolars is comparable, and premolars yield the greatest proportion of differences that are significant at the Bonferroni corrected $\alpha = 0.000284$ (see Table 5.6).

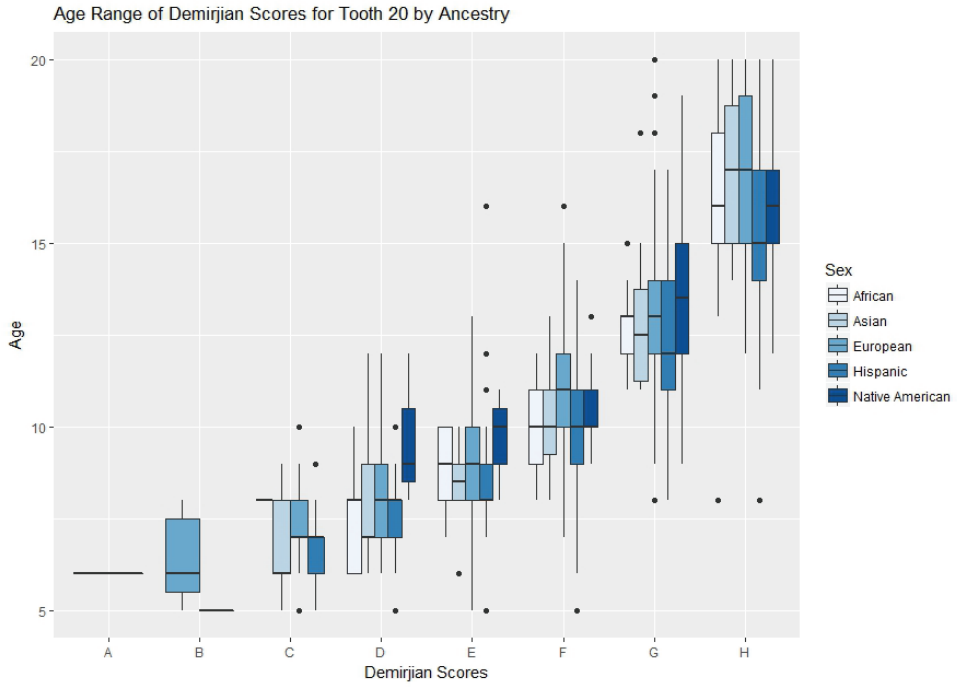


Figure 5.3: Box and whisker plots of age distribution for each Demirjian et al. (1973) score for tooth #20 (LP2), divided by ancestry.

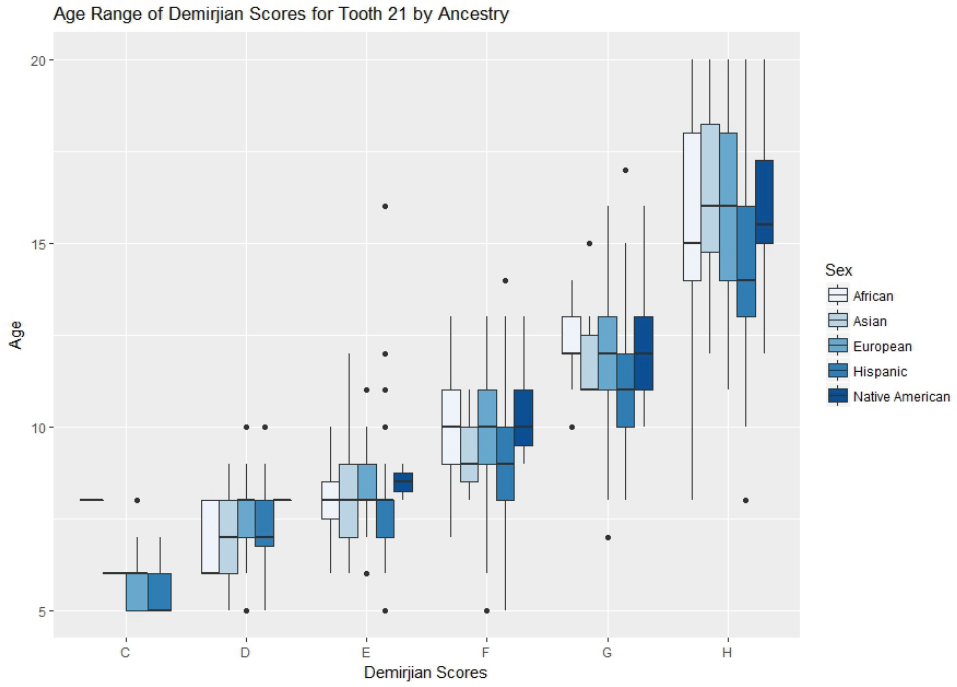


Figure 5.4: Box and whisker plots of age distribution for each Demirjian et al. (1973) score for tooth #21 (LP1), divided by ancestry.

5.2.3: Combined Sex and Ancestry Differences in Dental Development

5.2.3.1: Female Ancestry Differences

Across the whole age range, the Dunn's post-hoc tests could perform 1,379 pair-wise comparisons between female ancestry groups. While fewer comparisons were performed between female ancestry groups than total ancestry groups, a greater proportion yielded significant results. Of these 1,379 comparisons, 111 indicate that there are significant differences between female ancestry groups (8.05%); 105 of these differences are significant at $\alpha = 0.05$, and the remaining 6 differences are significant at the Bonferroni adjusted $\alpha = 0.000284$ (Table 5.7). The comparisons between European American and Hispanic females yield the highest number and proportion of significant results, with 48 of 200 total comparisons indicating that there are significant differences between these two samples (24.00%). The next highest number of significant differences occur in all pair-wise comparisons with the Native American female sample; compared to other female ancestry groups, significant differences exist in 6-11% of cases. The remaining pair-wise comparisons between female ancestry groups yield significant results in 2-5% of cases.

Comparing sex and ancestry groups simultaneously for the childhood period, the Kruskal-Wallis test identifies nine teeth that are significantly different between ancestry groups in the female sample (#12, 13, 14, 15, 19, 20, 21, 22, and 23) (Table 5.8 and Appendix A2.17.3). In the female sample during childhood, four pair-wise comparisons yield significant results. Overall for females, the Asian American sample exhibits the lowest Demirjian et al. (1973) scores during childhood, followed by the European

American and African American samples, respectively. The Hispanic female sample has the highest developmental scores (Appendix A2.17.3).

Table 5.7: Summary of significant differences between female ancestry groups from Dunn's pair-wise comparisons, through whole age range (years 5-20). 0.05 = significant at $\alpha = 0.05$; Bon = significant at Bonferroni corrected $\alpha = 0.000284$; Total n = total number of comparisons. Positive z-scores indicate the first group has higher developmental scores; negative z-scores indicate the second group has higher developmental scores.

	AfA-AsA	AfA-EA	AfA-His	AfA-Nat	AsA-Eur	AsA-His	AsA-Nat	EA-His	EA-Nat	His-Nat	Total
0.05	3	7	4	7	4	7	7	42	10	14	105
Bon	0	0	0	0	0	0	0	6	0	0	6
Positive z-scores	3	6	2	7	2	0	6	0	10	14	111
Negative z-scores	0	1	2	0	2	7	1	48	0	0	
Total n	116	149	149	90	162	162	107	200	122	122	1,379

When the childhood sample is separated by year, no significant differences are identified in the pair-wise comparisons between female ancestry groups at age five (Appendices A2.1.3 and A2.1.4). At age six, the Kruskal-Wallis test identifies eight teeth that demonstrate significant differences between ancestry groups in the female sample (Appendix A2.2.3). The European American female sample exhibits significantly lower Demirjian et al. (1973) scores for two teeth compared to the African American female sample and 11 teeth compared to the Hispanic female sample, indicating that European American female dental development is comparatively delayed during year six (Appendix A2.2.3).

Table 5.8: Ancestry comparison for females using Kruskal-Wallis and Dunn's post-hoc tests across age categories (Dunn 1964; Kruskal and Wallis 1952). One asterisk (*) = 0.05 alpha level; two asterisks (**) = Bonferroni adjusted α = 0.000284; n = N/A, i.e., a comparison that could not be performed due to lack of information. / indicates no significant difference. See Table 5.5 caption for more detail on abbreviations.

Tooth	Anc			AfA-AsA			AfA-EA			AfA-His			AfA-Nat			AsA-EA			AsA-His			AsA-Nat			EA-His			EA-Nat			His-Nat		
	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A
9: UI1	/	/	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	−*	/	/	n	/	/	n	/	/
10: UI2	/	*	/	/	/	/	/	/	/	/	/	/	n	/	+*	/	/	/	/	/	/	n	−*	/	−*	/	/	n	−*	/	n	−*	/
11: UC	/	/	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	−*	/	/	n	/	/	n	/	/
12: UP1	*	*	/	n	/	/	/	/	/	/	−*	/	n	−*	/	n	/	/	n	/	/	n	/	/	−*	−*	/	n	−*	/	n	/	/
13: UP2	*	*	*	n	/	/	/	/	/	/	/	+*	n	/	/	n	/	+*	n	/	+*	n	/	/	−*	−**	/	n	−*	/	n	/	/
14: UM1	*	/	/	/	/	/	/	/	/	/	/	/	n	−*	/	/	/	/	−*	/	/	n	/	/	−*	/	/	n	/	/	n	/	/
15: UM2	*	*	/	/	/	/	/	/	/	/	/	/	n	−*	/	/	/	/	−*	/	/	n	/	/	−*	−*	/	n	−*	/	n	/	/
16: UM3	n	/	/	n	/	/	n	−*	/	n	/	+*	n	/	/	n	/	/	n	/	/	n	/	/	n	/	/	n	/	/	n	/	/
17: LM3	n	/	*	n	/	/	n	/	/	n	/	/	n	/	/	n	/	/	n	/	+*	n	/	+*	n	+*	/	n	/	/	n	/	/
18: LM2	/	*	*	/	/	/	/	/	+*	/	/	+*	n	/	+*	/	/	+*	/	/	+*	n	/	+*	−*	−*	/	n	/	/	n	/	/
19: LM1	*	/	/	+*	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	−*	/	/	n	−*	/	n	/	/
20: LP2	*	*	/	/	/	/	+*	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	−*	–*	/	n	/	/	n	/	/

Tooth	Anc			AfA-AsA			AfA-EA			AfA-His			AfA-Nat			AsA-EA			AsA-His			AsA-Nat			EA-His			EA-Nat			His-Nat		
	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A
21: LP1	*	**	/	/	/	– *	/	/	/	/	/	/	n	– *	/	/	/	/	/	– *	+ *	n	– *	+ *	– *	– **	/	n	– *	/	n	/	/
22: LC	*	/	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	+ *	– *	/	/	n	/	/	n	/	/
23: LI2	*	/	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	– *	– *	/	n	/	/	n	/	/
24: LI1	/	/	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	– *	/	/	n	/	/	n	/	/

When analyzed separately, the juvenile period exhibits the most significant differences between sex and ancestry groups, and the same pattern holds true when these variables are analyzed simultaneously (see Tables 5.2 and 5.5 and Appendices A2.18.3 and A2.18.4). In the female sample during the juvenile period, the Kruskal-Wallis test identifies six teeth that demonstrate significant differences between ancestry groups (#10, 12, 13, 15, 18, and 20) and one additional tooth at the Bonferroni corrected $\alpha = 0.000284$ (#21). Eight of the ten pair-wise comparisons between female ancestry groups yield significant results for the juvenile subset. Overall in the female subset, the African American and Asian American samples exhibit the lowest Demirjian et al. (1973) scores during the juvenile period, followed by the European American and Hispanic samples, respectively. The Native American sample exhibits the highest developmental scores (see Appendix A2.18.3).

According to the Kruskal-Wallis tests, female ancestry groups exhibit significant differences during every year between ages 7-11. Tooth #19 exhibits significant differences between female ancestry groups at age seven (Appendix A2.3.3). As seen in the total ancestry comparisons, year eight exhibits the most significant differences between female ancestry groups across the whole age range. For the female sample at age eight, nine teeth demonstrate significant differences between ancestry groups (#10, 12, 15, 18, 19, 20, 21, 22, and 23) (Appendix A2.4.3). Six teeth demonstrate significant differences between female ancestry groups at age nine (Appendix A2.5.3), four teeth exhibit significant differences at age 10 (Appendix A2.6.3), and three teeth demonstrate significant differences between female ancestry groups at age 11 (Appendix A2.7.3).

During years 7-11, the Hispanic female sample exhibits significantly higher developmental scores compared to all other ancestry groups, indicating comparatively advanced dental development. Most of these differences are observed in the European American-Hispanic comparison, with Hispanic females exhibiting significantly higher developmental scores in as few as six teeth at age 11 (see Appendix A2.7.3) and as many as 13 teeth when $\alpha < 0.05$ at age eight (see Appendix A2.4.3). Hispanic females also exhibit significantly higher scores in as many as four teeth compared to the Asian American females at age nine and the Native American females at age 11 (Appendices A2.5.3 and A2.7.3).

Other female ancestry groups yield fewer significant differences during years 7-11. African American females exhibit significantly higher developmental scores compared to Asian American, European American, and Hispanic females. The greatest number of differences occurs in the African American-European American comparison, with African American females exhibiting significantly higher developmental scores for three teeth at age eight (Appendix A2.4.3). Asian American females exhibit significantly higher developmental scores compared to the European American and Native American female samples, in at most three teeth compared to Native American females at age 11 (Appendix A2.7.3). European American and Native American females exhibit significantly higher developmental scores compared to other female ancestry groups in no more than one tooth during years 7-11. European American females exhibit significantly higher scores in one tooth compared to Asian American and Native American females (Appendices A2.3.3, A2.5.3, and A2.7.3), while Native American

females exhibit significantly higher scores in one tooth compared to Asian American females (Appendix A2.5.3).

As with the individual sex and ancestry comparisons, fewer significant differences exist between ancestry groups in both the female and male samples in the adolescent period compared to the juvenile period (see Tables 5.2 and 5.5 and Appendices A2.19.3 and A2.19.4). Of the nine years this biological phase encompasses, the Kruskal-Wallis tests reveal significant differences in only two years for the female sample (ages 13 and 16). No Kruskal-Wallis tests in the adolescent period yield significant results at the Bonferroni adjusted $\alpha = 0.000284$, for either the female or male subsets (see Appendices A2.19.3 and A2.19.4).

In the female sample during the adolescent period, the Kruskal-Wallis test identifies three teeth that demonstrate significant differences between ancestry groups (#13, 17, and 18). Seven of the pair-wise comparisons yield significant results. Overall, in the female subset the Hispanic and Native American samples exhibit the lowest Demirjian et al. (1973) scores during the adolescent period, followed by the European American and African American samples, respectively. The Asian American sample exhibits the highest developmental scores (see Appendix A2.19.3).

As noted, when the adolescent period is divided by year, only ages 13 and 16 exhibit significant differences between female ancestry groups. Two teeth demonstrate significant differences between female ancestry groups during years 13 and 16 (Appendices A2.9.3 and A2.12.3). In addition to exhibiting no differences based on the Kruskal-Wallis tests, ages 15, 17, and 20 also yield no significant results from the Dunn's

pair-wise comparisons of female ancestry groups (Appendices A2.11.3, A2.13.3, and A2.16.3).

The Native American female sample exhibits the most significant differences compared to other female ancestry groups during years 12-20, which indicates Native American female dental development is comparatively delayed. The greatest number of differences occurs in the comparison of Native American females to Hispanic and African American females at age 16, with five teeth exhibiting significantly lower developmental scores compared to both groups (Appendix A2.12.3). The Native American female sample also exhibits significantly lower developmental scores in as many as four teeth compared to European American females (Appendix A2.12.3) and as many as two teeth compared to Asian American females (Appendix A2.15.3).

Other female ancestry groups exhibit fewer significant differences during years 12-20. Hispanic females exhibit significantly higher developmental scores in only two teeth compared to European American females and one tooth compared to African American and Asian American females (Appendices A2.9.3-A2.10.3). Excluding the comparisons to the Native American females already summarized, African American and European American females exhibit significantly higher developmental scores in no more than one tooth during years 12-20. African American females exhibit significantly higher developmental scores compared to Hispanic females (Appendix A2.15.3), and European American females exhibit significantly higher developmental scores compared to African American females (Appendix A2.8.3).

The number of significant differences between female ancestry groups, across the whole age range, are presented by tooth in Table 5.9. Premolars exhibit significant

differences between female ancestry groups more often than other tooth classes (11.17% of total comparisons), followed by incisors (8.50% of total comparisons). Molars and canines exhibit significant differences between female ancestry groups in a smaller proportion of comparisons (6.92% and 3.54%, respectively). In addition to exhibiting the highest proportion of significant differences when $\alpha < 0.05$, premolars yield the highest proportion of differences that are significant at the Bonferroni corrected $\alpha = 0.000284$ (13.95% of differences). Molars exhibit Bonferroni significance between female ancestry groups in fewer cases (2.63%), while incisors and canines yield no differences that are significant at the Bonferroni alpha level.

Since mandibular premolars exhibit the greatest proportion of significant differences between female ancestry groups, the age distribution of each Demirjian et al. (1973) score for these two teeth is presented in Figures 5.5 and 5.6. As was the case in the total ancestry comparisons, the most obvious trend in the box and whisker plots is the difference in age distributions between the European American and Hispanic female samples. Hispanic females consistently exhibit lower age ranges at every Demirjian et al. (1973) score for these two teeth, indicating that Hispanic female development is advanced relative to European American females. Apart from the Demirjian et al. (1973) score of H for tooth #20, the Native American female sample exhibits higher age ranges for developmental scores, indicating delayed development compared to other female ancestry groups, as seen in the total ancestry comparisons. Finally, while this pattern was less evident in the visualizations for the total ancestry comparisons, African American females tend to exhibit lower age ranges relative to most female ancestry groups, indicating advanced dental development in this sample.

Table 5.9: Number of significant differences in Dunn's (1964) pair-wise comparisons between female ancestry groups, by tooth. Bon = Bonferroni adjusted α = 0.000284. Total n = total number of comparisons. Since no differences are significant at the Bonferroni level during childhood, the Bonferroni column is not included.

Tooth	Childhood (5-6)		Juvenile (7-11)			Adolescence (12-20)			Total			
	0.05	Total n	0.05	Bon	Total n	0.05	Bon	Total n	0.05	Bon	All α	Total n
9: UI1	1	6	4	0	28	0	0	16	5	0	5	50
10: UI2	1	6	6	0	38	1	0	28	8	0	8	72
11: UC	1	6	1	0	38	2	0	56	4	0	4	100
12: UP1	1	4	3	1	31	3	0	38	7	1	8	73
13: UP2	1	4	4	1	38	1	0	64	6	1	7	106
14: UM1	0	6	1	0	28	1	0	6	2	0	2	40
15: UM2	1	6	2	1	38	6	0	73	9	1	10	117
16: UM3	0	0	0	0	28	2	0	71	2	0	2	99
17: LM3	0	0	0	0	29	1	0	78	1	0	1	107
18: LM2	1	6	6	0	38	8	0	78	15	0	15	122
19: LM1	2	6	6	0	38	0	0	20	8	0	8	64
20: LP2	2	6	6	1	38	3	0	74	11	1	12	118
21: LP1	1	6	6	3	38	6	0	44	13	3	16	88
22: LC	1	6	1	0	38	1	0	54	3	0	3	98
23: LI2	0	6	4	0	38	0	0	20	4	0	4	64
24: LI1	0	6	4	0	35	0	0	20	4	0	4	61
Total n	13	80	54	7	559	35	0	740	102	7	109	1,379

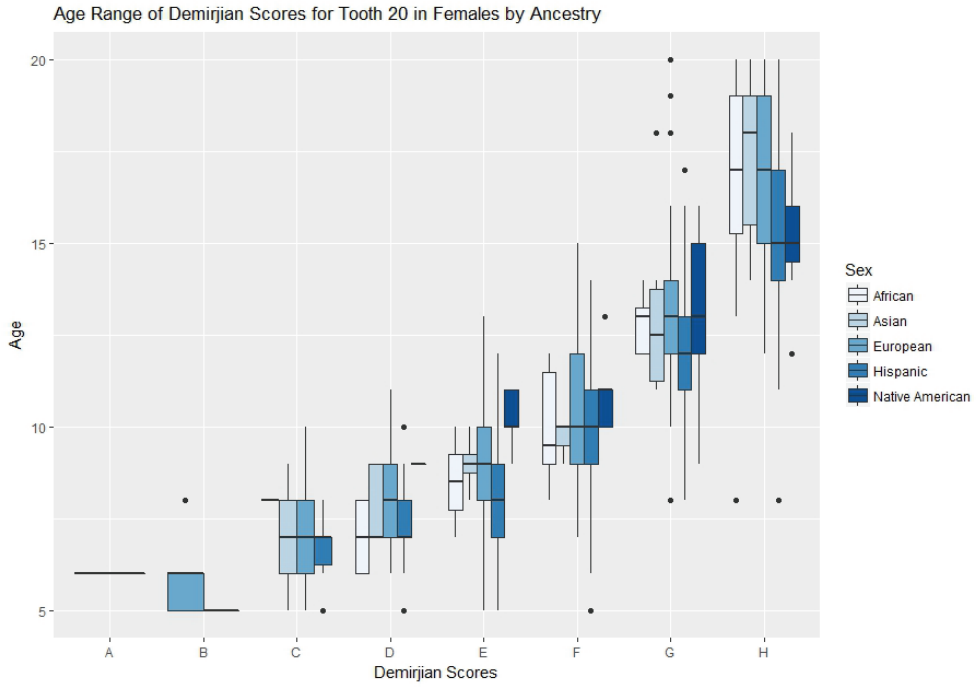


Figure 5.5: Box and whisker plots of age distribution for each Demirjian et al. (1973) score for tooth #20 (LP2) in female sample, divided by ancestry.

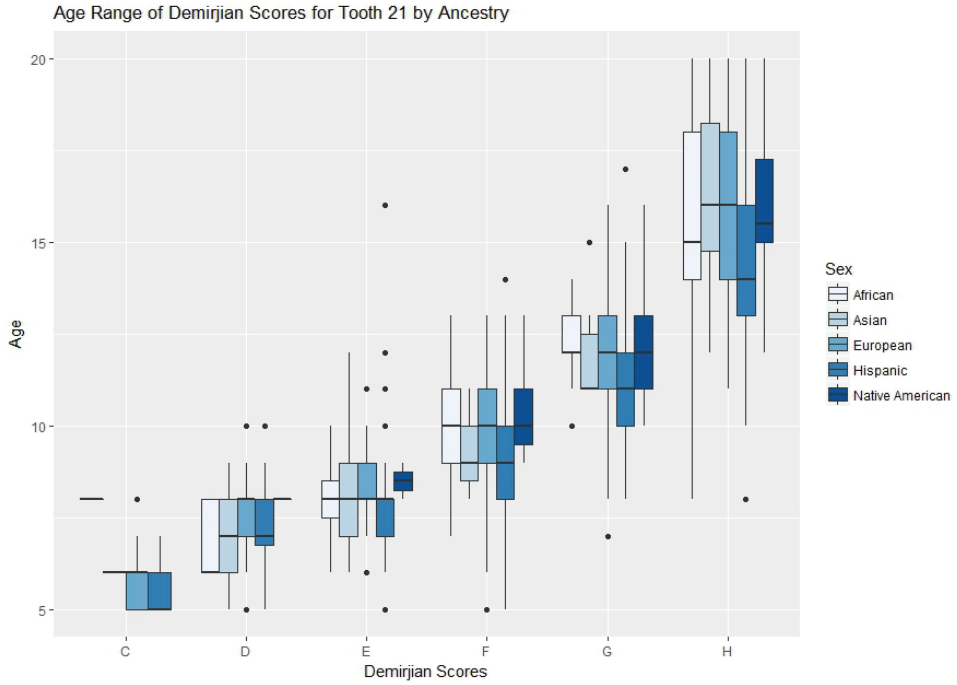


Figure 5.6: Box and whisker plots of age distribution for each Demirjian et al. (1973) score for tooth #21 (LP1) in female sample, divided by ancestry.

Overall, most of the comparisons between female ancestry groups yield no significant differences. However, when significant differences do exist, the European American and Hispanic female samples yield the highest number of significant results. In most cases, Hispanic female developmental scores are higher than European American female scores, indicating advanced dental development in the Hispanic female sample (see Table 5.7). Across the whole age range, z-scores produced during Dunn's pair-wise comparisons suggest Native American females exhibit the lowest developmental scores, followed by European American and Asian American females, with African American and Hispanic females exhibiting the highest developmental scores. This is the same general pattern observed during the comparison of total ancestry groups (see Table 5.4).

As with sex and total ancestry comparisons, female ancestry groups exhibit significant differences in developmental scores most often during the juvenile period. The adolescent period yields fewer significant results, with the lowest number of differences observed between female ancestry groups during childhood (see Table 5.8). Premolars exhibit the greatest proportion of significant differences between female ancestry groups, both when alpha levels are combined and at the Bonferroni corrected $\alpha = 0.000284$ (see Table 5.9). This result differs from the total ancestry comparisons, during which the proportion of significant differences was slightly higher for the incisors than the premolars (see Table 5.6).

5.2.3.2: Male Ancestry Differences

Across the whole age range, 1,525 pair-wise comparisons were performed between male ancestry groups. While a greater number of pair-wise comparisons could be performed between male ancestry groups than between female ancestry groups, fewer

comparisons yielded significant results, both absolutely and proportionally. Out of the 1,525 pair-wise comparisons, 96 indicate significant differences between male ancestry groups (6.30%); 91 of these differences are significant at $\alpha = 0.05$, and the remaining five are significant at the Bonferroni adjusted $\alpha = 0.000284$ (Table 5.10). As with the total ancestry and female ancestry tests, the comparisons between European American and Hispanic males yield the greatest number of significant results, with 39 of 200 comparisons indicating significant differences in developmental scores between these two samples (19.50%). While Native American females generated the next highest amount of significant results, comparisons to the European American male sample seem to be most significant, with 4-8% of cases indicating significant differences. The remaining pair-wise comparisons between male ancestry groups identify significant differences in between 2-6% of cases.

Table 5.10: Summary of significant differences between male ancestry groups from Dunn's pair-wise comparisons, through whole age range (years 5-20). 0.05 = significant at $\alpha = 0.05$; Bon = significant at Bonferroni corrected $\alpha = 0.000284$; Total n = total number of comparisons. Positive z-scores indicate the first group has higher developmental scores; negative z-scores indicate the second group has higher developmental scores.

	AfA-AsA	AfA-EA	AfA-His	AfA-Nat	AsA-EA	AsA-His	AsA-Nat	EA-His	EA-Nat	His-Nat	Total
0.05	8	7	4	4	14	6	4	34	6	4	91
Bon	0	0	0	0	0	0	0	5	0	0	5
Positive z-scores	7	7	2	4	9	1	3	2	3	3	96
Negative z-scores	1	0	2	0	5	5	1	37	3	1	
Total n	152	164	164	115	176	176	120	200	129	129	1,525

The Kruskal-Wallis test does not identify any significant differences between ancestry groups in the male sample during childhood, and none of the male pair-wise comparisons yield significant results (Table 5.11 and Appendix A2.17.4). For males during childhood, the Asian American and European American samples exhibit the lowest developmental scores, followed by the African American sample. As with the Hispanic female sample, the Hispanic male sample has the highest developmental scores during childhood (Appendix A2.17.4).

When the years are analyzed individually, no significant differences are identified between male ancestry groups by the Kruskal-Wallis tests at either age five or six (Appendix A2.1.4). Only one pair-wise comparison using the Dunn's test yields significant results, with the Hispanic male sample exhibiting significantly higher scores for one tooth compared to European American males (Appendix A2.2.4).

The Kruskal-Wallis tests identify the greatest number of significant differences between male ancestry groups during the juvenile period, as seen in the sex, ancestry, and female ancestry comparisons (see Tables 5.2, 5.5, 5.8, and 5.11). In the male sample during the juvenile period, ten teeth demonstrate significant differences between ancestry groups (#9, 10, 11, 13, 14, 15, 16, 18, 22, and 23) and another two teeth at the Bonferroni corrected $\alpha = 0.000284$ (#20 and 21). Four of the pair-wise comparisons yield significant results in the male sample. Overall in the male subset, the European American sample exhibits the lowest Demirjian et al. (1973) scores during the juvenile period, followed by the Asian American and Native American samples with similar scores, then the Hispanic sample. The African American male sample exhibits the highest developmental scores during the juvenile period (Appendix A2.18.4)

Table 5.11: Ancestry comparison for males using Kruskal-Wallis and Dunn's post-hoc tests across age categories (Dunn 1964; Kruskal and Wallis 1952). One asterisk (*) = 0.05 alpha level; two asterisks (**) = Bonferroni adjusted α = 0.000284; n = N/A, i.e., a comparison that could not be performed due to lack of information. / indicates no significant difference. See Table 5.5 caption for more detail on abbreviations.

Tooth	Anc			AfA-AsA			AfA-EA			AfA-His			AfA-Nat			AsA-EA			AsA-His			AsA-Nat			EA-His			EA-Nat			His-Nat		
	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A
9: UI1	/	*	/	n	/	/	n	/	/	n	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	— *	/	n	/	/	n	/	/
10: UI2	/	*	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	— *	/	n	/	/	n	/	/
11: UC	/	*	/	/	/	/	/	+ *	/	/	/	+ *	n	/	/	/	/	/	/	/	+ *	n	/	/	/	— *	/	n	/	/	n	/	/
12: UP1	/	/	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	— *	/	n	/	/	n	/	/
13: UP2	/	*	/	n	/	/	n	/	/	n	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	— *	/	n	/	/	n	/	/
14: UM1	/	*	/	n	/	/	n	/	/	n	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	— *	/	n	/	/	n	/	/
15: UM2	/	*	*	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	— **	+ *	n	/	/	n	/	/
16: UM3	/	*	/	n	+ *	/	n	+ *	/	n	/	/	n	/	/	n	/	/	n	/	/	n	/	/	/	— *	+ *	n	/	/	n	/	/
17: LM3	/	/	*	n	/	/	n	/	/	n	/	+ *	n	/	/	n	/	/	n	/	/	n	/	/	/	/	+ *	n	/	/	n	/	/
18: LM2	/	*	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	— **	+ *	n	/	/	n	/	/
19: LM1	/	/	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	— *	/	n	/	/	n	/	/
20: LP2	/	**	/	/	/	/	/	+ *	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	— **	/	n	— *	/	n	/	/

Tooth	Anc			AfA-AsA			AfA-EA			AfA-His			AfA-Nat			AsA-EA			AsA-His			AsA-Nat			EA-His			EA-Nat			His-Nat		
	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A	C	J	A
21: LP1	/	**	/	/	/	/	/	+ *	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	– **	/	n	/	/	n	/	/
22: LC	/	*	/	/	/	/	/	/	/	/	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	– **	/	n	/	/	n	/	/
23: LI2	/	*	/	n	/	/	n	/	/	n	/	/	n	/	/	/	/	/	/	/	/	n	/	/	/	– *	/	n	/	/	n	/	/
24: LI1	/	/	*	/	/	+ *	/	/	/	/	/	/	n	/	/	/	/	– **	/	/	– *	n	/	– *	/	– *	/	n	/	/	n	/	/

In the male ancestry comparisons, the Kruskal-Wallis tests do not identify significant differences during every year of the juvenile period. At ages seven and nine, male ancestry groups exhibit no significant differences (Appendices A2.3.4 and A2.5.4). Year eight yields the highest number of significant difference between male ancestry groups, as was the case in the total ancestry and female ancestry comparisons (Appendices A2.4.2 and A2.4.3). Six teeth demonstrate significant differences between male ancestry groups at age eight (#12, 13, 15, 18, 22, and 23), with another three teeth exhibiting Bonferroni significance (#11, 20, and 21) (Appendix A2.4.4). Six teeth demonstrate significant differences between male ancestry groups at age 10 (Appendix A2.6.4), and five teeth exhibit significant differences between male ancestry groups at age 11 (Appendix A2.7.4).

As with Hispanic females, the Hispanic male sample exhibits significantly higher developmental scores when compared to other ancestry groups during every year of the juvenile period, indicating advanced dental development. Compared to the European American male sample, Hispanic males exhibit significantly higher developmental scores in at most 11 teeth when alpha levels are combined at age eight (Appendix A2.4.4) and as few as one tooth at age seven (Appendix A2.3.4). The Hispanic male sample also exhibits significantly higher developmental scores in as many as two teeth compared to the Native American male sample (Appendix A2.6.4) and at most one tooth compared to the African American male sample (Appendices A2.6.4-A2.7.4).

Other male ancestry groups exhibit fewer significant differences during years 7-11. The Asian American male sample exhibits significantly higher developmental scores in as many as six teeth compared to European American males (Appendix A2.4.4) and at

most one tooth compared to African American and Native American males (Appendices A2.4.4 and A2.7.4). The African American male sample yields the next highest number of significant differences during years 7-11. African American males exhibit significantly higher developmental scores in as many as three teeth compared to the European American male sample (Appendix A2.7.4) and one tooth compared to Asian American and Native American males (Appendices A2.4.4-A2.5.4). The Native American male sample only exhibits significantly higher developmental scores compared to European American males, in at most one tooth (Appendices A2.6.4-A2.7.4).

Fewer significant differences are observed between male ancestry groups during the adolescent period, a pattern also observed in the sex, total ancestry, and female ancestry comparisons (see Table 5.11 and Appendix A2.19.4). During the adolescent period, the Kruskal-Wallis test identifies three teeth in the male sample that exhibit significant differences between ancestry groups (#15, 17, and 24), and six pair-wise comparisons yield significant results. Overall, in the male subset the Hispanic sample exhibits the lowest Demirjian et al. (1973) scores during the adolescent period, followed by the European American sample, the Asian American and Native American samples, and finally the African American sample with the highest developmental scores (see Appendix A2.19.4).

During years 12-20, the Kruskal-Wallis test only identifies significant differences between male ancestry groups in four years, ages 12, 14, 17, and 19, and a different tooth exhibits significance during each of these years (Appendices A2.8.4, A2.10.4, A2.13.4, and A2.15.4). Age 20 is the only year during which no pair-wise comparisons yield significant differences between male ancestry groups (Appendix A2.16.4).

No pair-wise comparisons between male ancestry groups during years 12-20 yield significant differences at more than two teeth. The African American male sample exhibits significantly higher developmental scores in more cases than any other ancestry group during years 12-20, in as many as two teeth compared to the Asian American and European American male samples and one tooth compared to the Native American male sample (Appendices A2.10.4 and A2.13.4). The European American male sample exhibits significantly higher developmental scores in as many as two teeth compared to Asian American and Native American males (Appendices A2.11.4 and A2.15.4) and one tooth compared to Hispanic males (Appendices A2.12.4 and A2.15.4). Hispanic males exhibit significantly higher developmental scores in as many as two teeth compared to the Asian American male sample (Appendix A2.11.4) and one tooth compared to the European American and Native American male samples (Appendices A2.9.4-A2.10.4 and A2.13.4).

The Asian American and Native American male samples only exhibit significant differences compared to other male ancestry groups in a single tooth during years 12-20. Asian American males exhibit significantly higher developmental scores compared to European American, Hispanic, and Native American males (Appendices A2.13.4-A2.15.4). The Native American male sample exhibits significantly higher scores compared to the Hispanic and European American male samples (Appendices A2.8.4 and A2.15.4).

The number of significant differences between male ancestry groups across the whole age range are tallied by tooth in Table 5.12. All tooth classes exhibit significant differences in nearly equal proportions. Molars demonstrate significant differences

between male ancestry groups in the highest proportion (6.33% of total comparisons), followed closely by premolars (6.27%), incisors (6.25%), and canines (6.22%). Although canines exhibit the lowest proportion of significant differences between male ancestry groups, these teeth exhibit the highest percentage of differences that are significant at the Bonferroni corrected $\alpha = 0.000284$ (14.29% of differences). Premolars exhibit differences significant at the Bonferroni alpha level in 7.69% of cases, while molars yield Bonferroni significant differences in only 2.63% of cases. Incisors exhibit no differences that are significant at the Bonferroni corrected alpha level.

Table 5.12: Number of significant differences in Dunn's (1964) pair-wise comparisons between male ancestry groups, by tooth. Bon = Bonferroni adjusted $\alpha = 0.000284$. Total n = total number of comparisons. Since no differences are significant at the Bonferroni level during childhood, the Bonferroni column is not included.

Tooth	Childhood (5-6)		Juvenile (7-11)			Adolescence (12-20)			Total			
	0.05	Total n	0.05	Bon	Total n	0.05	Bon	Total n	0.05	Bon	All α	Total n
9: UI1	0	3	4	0	35	0	0	29	4	0	4	67
10: UI2	0	6	2	0	42	0	0	42	2	0	2	90
11: UC	0	7	0	1	42	4	0	60	4	1	5	109
12: UP1	1	7	3	0	38	1	0	41	5	0	5	86
13: UP2	0	3	6	0	38	0	0	60	6	0	6	101
14: UM1	0	4	1	0	35	4	0	26	5	0	5	65
15: UM2	0	7	2	1	46	3	0	49	5	1	6	102
16: UM3	0	0	4	0	38	8	0	74	12	0	12	112
17: LM3	0	0	3	0	39	5	0	74	8	0	8	113
18: LM2	0	7	4	0	46	0	0	72	4	0	4	125
19: LM1	0	7	3	0	46	0	0	30	3	0	3	83
20: LP2	0	7	7	1	46	1	0	72	8	1	9	125
21: LP1	0	7	5	1	46	0	0	50	5	1	6	103
22: LC	0	7	2	1	43	6	0	66	8	1	9	116
23: LI2	0	4	7	0	42	2	0	33	9	0	9	79
24: LI1	0	7	0	0	35	3	0	10	3	0	3	52
Total n	1	83	53	5	657	37	0	788	91	5	96	1,528

Since molars exhibit the highest proportion of significant differences between male ancestry groups, the maxillary and mandibular third molars have been selected to visualize the age distribution for each Demirjian et al. (1973) score in the male sample, divided by ancestry (Figures 5.7 and 5.8). In the earliest developmental scores, trends are less evident. However, in Demirjian et al. (1973) scores of C and above, the same pattern that was observed between European American and Hispanic samples in the total ancestry and female ancestry comparisons is evident in the male ancestry groups. Hispanic males tend to exhibit lower age ranges for developmental scores compared to the European American males, indicating that Hispanic male dental development is relatively advanced. As evident in the female ancestry comparison, African American males tend to exhibit lower age ranges when compared to other male ancestry groups, supporting the conclusion that African American male dental development is advanced in the third molars. Although the trend of delayed development in the Native American samples was more obvious in the total and female ancestry comparisons, this pattern is still observed for third molar development in Native American males.

Overall, the majority of comparisons indicate no significant difference in developmental scores between male ancestry groups, and fewer significant results are observed between male ancestry groups than either the total ancestry or female ancestry comparisons. When significant differences are observed, the European American and Hispanic male samples yield the highest number of significant results, with most z-scores indicating Hispanic male developmental scores are higher and dental development is advanced (see Table 5.10). This pattern carries over from the total ancestry and female ancestry comparisons (see Tables 5.4 and 5.7).

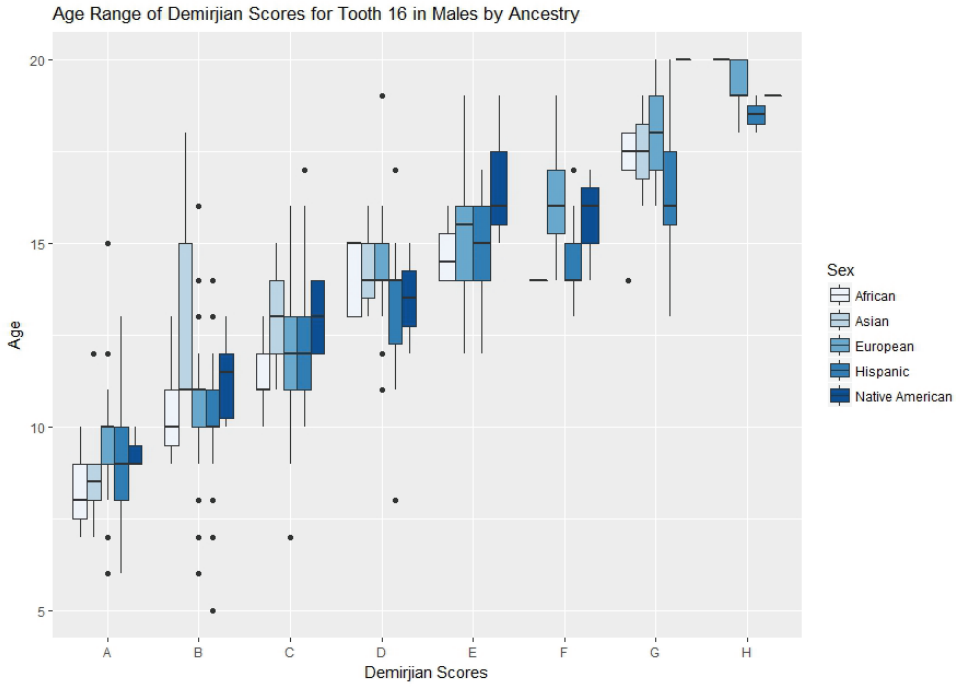


Figure 5.7: Box and whisker plots of age distribution for each Demirjian et al. (1973) score for tooth #16 (UM3) in male sample, divided by ancestry.

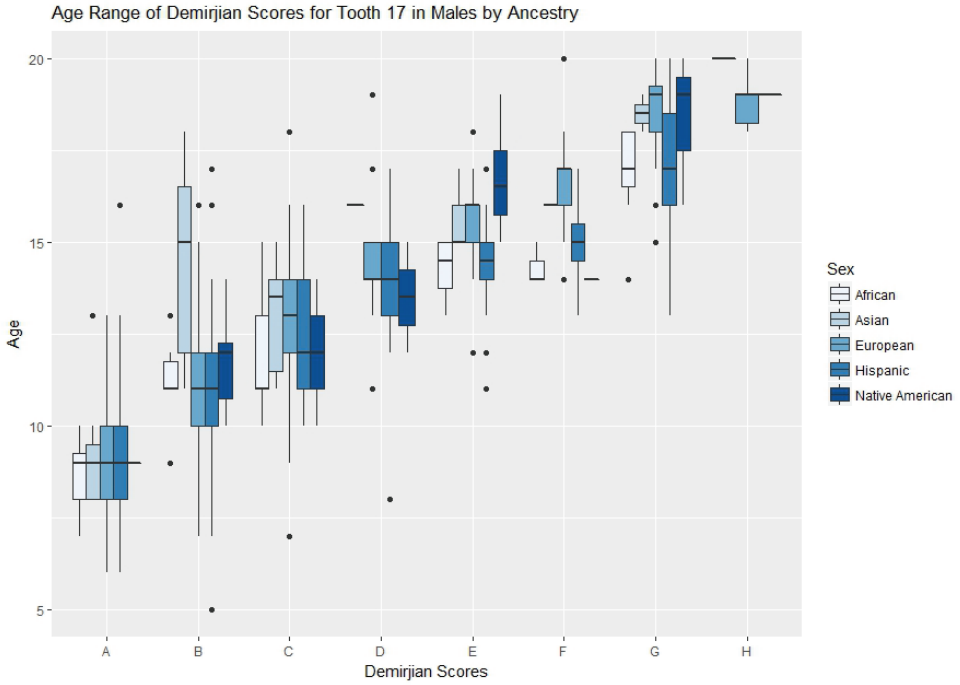


Figure 5.8: Box and whisker plots of age distribution for each Demirjian et al. (1973) score for tooth #17 (LM3) in male sample, divided by ancestry.

In addition to producing the lowest number of significant differences, the comparison between male ancestry groups exhibits a slight departure from the overall pattern observed among total or female ancestry groups. Based on the z-scores from significant differences produced by the Dunn's tests, European American and Native American males both exhibit the lowest developmental scores, as opposed to the total and female ancestry comparisons where scores were higher in the European American samples. Asian American male developmental scores are in the middle, while African American and Hispanic males exhibit the highest developmental scores (see Table 5.10). These three ancestry groups conform to the pattern observed in the total and female ancestry comparisons (see Tables 5.4 and 5.7).

No significant differences were observed between male ancestry groups during the childhood period. The juvenile period yields the highest number of significant differences, while male ancestry groups exhibit fewer significant differences during the adolescent period (see Table 5.11). This trend, where more differences are observed during the juvenile period, was also evident in the sex, total ancestry, and female ancestry comparisons (see Tables 5.2, 5.5, and 5.8). All tooth classes yield significant results between male ancestry groups in nearly equal proportions, but canines exhibit the greatest proportion of differences that are significant at the Bonferroni corrected $\alpha = 0.000284$ (see Table 5.12). This contrasts the total ancestry and female ancestry comparisons, in which premolars yield the highest proportion of Bonferroni significant differences (see Tables 5.6 and 5.9).

5.2.4: Summary of Ancestry Differences in Dental Development

The results of the total ancestry comparison and the ancestry comparisons divided by sex show some general patterns. Most comparisons indicate there are no significant differences between ancestry groups; 4,775 pair-wise comparisons were performed, and of this total, only 345 yield significant results (Table 5.13). However, while the percentage is small, the cases in which significant differences are observed generate meaningful patterns regarding which ancestry groups experience relatively advanced or delayed development.

Table 5.13: Summary of significant differences between ancestry groups (total and divided by sex) from Dunn's pair-wise comparisons, through whole age range (years 5-20). 0.05 = significant at $\alpha = 0.05$; Bon = significant at Bonferroni corrected $\alpha = 0.000284$; Total n = total number of comparisons. Positive z-scores indicate the first group has higher developmental scores; negative z-scores indicate the second group has higher developmental scores.

	AfA-AsA	AfA-EA	AfA-His	AfA-Nat	AsA-EA	AsA-His	AsA-Nat	EA-His	EA-Nat	His-Nat	Total
0.05	17	21	19	19	29	23	17	120	26	27	318
Bon	0	0	0	0	0	0	0	27	0	0	27
Positive z-scores	13	20	9	19	19	3	13	5	22	26	345
Negative z-scores	4	1	10	0	10	20	4	142	4	1	
Total n	464	510	510	365	549	549	388	615	412	412	4,775

Through the whole age range, the African American sample exhibits significantly higher Demirjian et al. (1973) scores compared to the Asian American, European American, and Native American samples (see Table 5.13). Significant differences between the African American and Hispanic samples are relatively evenly distributed between positive and negative z-scores (9 and 10 cases, respectively), suggesting that

neither group is consistently developmentally advanced or delayed. The Asian American sample exhibits significantly higher developmental scores compared to the Native American sample (13 of 16 total differences). Significant differences between the Asian American and European American samples are not as disparate, with Asian American samples exhibiting significantly higher scores in 19 cases and European American samples exhibiting significantly higher scores in 10 cases. The European American sample exhibits significantly higher developmental scores than the Native American sample (22 of 26 total differences).

Of all pair-wise ancestry comparisons, the European American and Hispanic samples exhibit the most significant differences (see Table 5.13). The differences between these two ancestry groups overwhelmingly show that the Hispanic sample exhibits higher developmental scores, i.e., advanced dental development, compared to the European American sample. The Hispanic sample also exhibits significantly higher developmental scores than both the Native American sample (26 of 27 total differences) and Asian American sample (20 of 23 total differences).

Significant differences in the Dunn's pair-wise comparisons at both the 0.05 alpha level and the Bonferroni adjusted $\alpha = 0.000284$ are most common during the total ancestry comparison, followed by the female ancestry groups and then the male ancestry groups. There are more years in which pair-wise comparisons cannot be conducted in the samples divided by sex and ancestry than the total ancestry groups, as these divisions leave fewer individuals in each sample. Based on the z-scores from significant differences across the whole age range, the Native American sample has the lowest developmental scores, followed by the European American and Asian American samples

respectively, with Hispanic and African American samples exhibiting the highest developmental scores (see Table 5.13).

The number of significant differences in all ancestry comparisons, total and divided by sex, have been summarized by tooth in Table 5.14. During ancestry comparisons overall, premolars exhibit the highest proportion of significant differences (8.60% of total comparisons), followed by incisors (7.89%). Molars and canines exhibit significant differences during ancestry comparisons in lower proportions (6.61% and 4.93%, respectively). In addition to exhibiting the highest proportion of differences when alpha levels are combined, premolars yield the most differences between ancestry groups that are significant at the Bonferroni corrected $\alpha = 0.000284$ (15% of differences). Though canines exhibit the smallest proportion of significant differences when all ancestry comparisons are combined, these teeth yield the next highest proportion of Bonferroni significant differences (11.76% of differences). Molars yield differences that are significant at the Bonferroni alpha level in 5.69% of cases, while no differences between incisors exhibit Bonferroni significance.

5.3: Confidence Intervals for Age Estimation

Confidence intervals (CIs) were created at 51% and 95% for every Demirjian et al. (1973) stage at every tooth for the training sample and for each subset divided by sex, ancestry, and sex/ancestry. These CIs are reported in Appendices A3.1-A3.17. The test set was then used to evaluate to accuracy of these CIs in estimating age. The proportion of teeth for which an individual's chronological age was within the 95% CI was calculated at every tooth, and these proportions were compared between the CIs based upon all individuals (i.e., general CIs) and the sex-, ancestry-, and sex-and-ancestry-

specific Cis (i.e., specific CIs). The results of these subsequent accuracy tests are reported in Appendices A4.1-A4.16. To evaluate whether the general CIs or the specific CIs are more precise, the width of the CI at each Demirjian et al. (1973) score was compared for every tooth.

Table 5.14: Number of significant differences in Dunn's (1964) pair-wise comparisons during all ancestry comparisons (total and divided by sex), by tooth. Bon = Bonferroni adjusted $\alpha = 0.000284$. Total n = total number of comparisons.

Tooth	Total			
	0.05	Bon	All α	Total n
9: UI1	14	0	14	204
10: UI2	18	0	18	273
11: UC	13	2	15	350
12: UP1	18	4	22	274
13: UP2	19	3	22	346
14: UM1	13	0	13	187
15: UM2	23	5	28	357
16: UM3	18	0	18	343
17: LM3	16	0	16	349
18: LM2	31	2	33	392
19: LM1	15	0	15	232
20: LP2	30	4	34	388
21: LP1	29	6	35	306
22: LC	17	2	19	339
23: LI2	23	0	23	238
24: LI1	17	0	17	198
Total n	314	28	342	4,776

5.3.1: Accuracy of General versus Specific Confidence Intervals

The test sample was randomly generated, and no Asian American females were selected. Therefore, the CIs created for this subset could not be tested, and only 16 comparisons were performed between the general CIs based on all individuals and the specific CIs based upon subsets (Appendices A4.1 to A4.16). The overwhelming trend is for no significant differences to exist between the accuracy rates of the set of CIs based

on all individuals compared to the sex-, ancestry-, and sex-and-ancestry-specific CIs (214 of 221 cases) (Table 5.15). When significant differences exist, the CIs based on subsets exhibit the higher accuracy rate more often than the CIs based on all individuals, but no differences reach significance at the Bonferroni adjusted $\alpha = 0.000173$. Of the 16 comparisons that could be performed, 12 of these exhibit no significant differences. Three comparisons yield significantly higher accuracy rates with the CIs based on subsets (Native American, Hispanic female, and Hispanic male), while the final comparison yields mixed results, with one tooth exhibiting higher accuracy using the set of CIs based on all individuals and one tooth using the specific set of CIs (Hispanic).

Table 5.15: Accuracy of confidence intervals based on all individuals versus confidence intervals based on subsets at 95% confidence, by group. For example, the Female row is comparing the accuracy of the CIs based on all individuals to the female-specific CIs when applied to the female portion of the test set. All differences are significant at $\alpha = 0.05$.

Subset Being Compared	CI Based on All Individuals More Accurate	CI Based on Subsets More Accurate	Not Significant	Total
Female	0	0	17	17
Male	0	0	17	17
African American	0	0	17	17
Asian American	0	0	12	12
European American	0	0	17	17
Hispanic	1	1	15	17
Native American	0	1	13	14
AfA Female	0	0	2	2
AfA Male	0	0	8	8
AsA Female	–	–	–	0
AsA Male	0	0	15	15
EA Female	0	0	17	17
EA Male	0	0	17	17
His Female	0	1	16	17
His Male	0	3	14	17
Nat Female	0	0	3	3
Nat Male	0	0	14	14
Total	1	6	214	221

The Native American sample exhibits higher accuracy using the specific CIs when the values for all teeth are combined. However, the Hispanic sample, as a whole and divided by sex, exhibits the greatest number of significant differences between the sets of CIs based on all individuals and the specific sets of CIs, most of which favor the specific sets (five of six cases). The total Hispanic comparison yields mixed results. The CI based on all individuals is more accurate for tooth #20, while the Hispanic-specific CI is more accurate for tooth #12. All remaining significant differences indicate that the Hispanic-specific CIs are more accurate. The Hispanic female CI is more accurate than the CI based on all individuals for tooth #12, while the Hispanic male CI is more accurate for teeth #17 and #18 and all teeth combined (see Table 5.15).

Since few differences exist between the CIs based on all individuals and those based on subsets, the same holds true across all teeth (Table 5.16). No real pattern can be discerned regarding which teeth exhibit the most differences; tooth #12 and all teeth combined yield significant results twice, while other teeth only generate one significant result (#17, 18, and 20), if any. However, a pattern can be observed by tooth class. The posterior teeth, i.e., premolars and molars, are the only teeth to yield significant differences, while the anterior teeth, i.e., incisors and canines, exhibit no significant differences between the CIs based on all individuals and the CIs based on subsets.

Table 5.16: Accuracy of confidence intervals based on all individuals versus confidence intervals based on subsets at 95% confidence, by tooth. All differences are significant at $\alpha = 0.05$.

Tooth	CI Based on All Individuals More Accurate	CIs Based on Subsets More Accurate	Not Significant	Total
9: UI1	0	0	11	11
10: UI2	0	0	13	13
11: UC	0	0	13	13
12: UP1	0	2	11	13
13: UP2	0	0	14	14
14: UM1	0	0	10	10
15: UM2	0	0	14	14
16: UM3	0	0	13	13
17: LM3	0	1	14	15
18: LM2	0	1	13	14
19: LM1	0	0	14	14
20: LP2	1	0	13	14
21: LP1	0	0	14	14
22: LC	0	0	12	12
23: LI2	0	0	12	12
24: LI1	0	0	9	9
All Combined	0	2	14	14
Total	1	6	214	221

5.3.2: Precision of General versus Specific Confidence Intervals

The width of the CI was calculated at every Demirjian et al. (1973) score for each tooth, and these values were compared between the CIs based on all individuals and the CIs based on subsets to assess the precision of the CI ranges. The results of these comparisons are summarized in Table 5.17. The values in this table represent the number of instances in which either the CI based on all individuals or the CI based on subsets was narrower, across eight Demirjian et al. (1973) scores and 16 teeth. The disparate total values are a product of differences in sample size and age distributions across the subdivisions. For example, the female sample comprises the greatest number of individuals (n = 931) and includes representatives at all years in the age range (see Table

4.2); therefore, the female sample has the highest number of CIs that can be compared to the CIs based on all individuals because the most variation is captured in this subset. The CIs created from the total training sample are narrower than the CIs based on subsamples in the clear majority of comparisons (98.48% of total), indicating that the CIs based on all individuals are more precise overall.

Table 5.17: Summarized comparisons of 95% CI widths between CIs based on all individuals and CIs based on subsets. Total values represent the number of CIs created across Demirjian et al. (1973) scores at every tooth in the subdivided samples.

Subset Being Compared	CI Based on All Individuals Narrower		CI Based on Subsets Narrower		No Difference		Total
	n	%	n	%	n	%	
Female	94	0.9307	1	0.0099	6	0.0594	101
Male	92	0.9787	2	0.0213	0	0.0000	94
African American	72	1.0000	0	0.0000	0	0.0000	72
Asian American	77	1.0000	0	0.0000	0	0.0000	77
European American	94	0.9592	1	0.0102	3	0.0306	98
Hispanic	90	1.0000	0	0.0000	0	0.0000	90
Native American	62	1.0000	0	0.0000	0	0.0000	62
AfA Female	64	1.0000	0	0.0000	0	0.0000	64
AfA Male	65	1.0000	0	0.0000	0	0.0000	65
AsA Female	62	1.0000	0	0.0000	0	0.0000	62
AsA Male	64	1.0000	0	0.0000	0	0.0000	64
EA Female	91	0.9381	3	0.0309	3	0.0309	97
EA Male	89	0.9889	1	0.0111	0	0.0000	90
His Female	87	1.0000	0	0.0000	0	0.0000	87
His Male	85	1.0000	0	0.0000	0	0.0000	85
Nat Female	51	1.0000	0	0.0000	0	0.0000	51
Nat Male	53	1.0000	0	0.0000	0	0.0000	53
Total	1,292	0.9848	8	0.0061	12	0.0091	1,312

5.4: Linear Models for Age Estimation

Thirteen linear models were devised using biological/taphonomic criteria (eight models) or statistical criteria (five models), and eight versions of each linear model were created. Each model was first developed using the entire training set (Table 5.18), and

then two sex-specific and five ancestry-specific versions of each linear model were created based on the appropriate subset of the training sample (Appendix 5). The linear models were then applied to the test set to evaluate accuracy of the models. When applied to the test set, each linear model produces a point estimate of the individual's age along with 51% and 95% prediction intervals (PIs).

Linear models based on all individuals are applied to the entire test set, and the total performance of each model is contained in Table 5.18. Since the models based on all individuals were applied to the entire test set, accuracy of these models can also be evaluated for subsets divided by sex, ancestry, and sex/ancestry. Alternatively, linear models based on subsets are applied to subsets of the test set. For example, female-specific linear models are based on the female portion of the training set and are subsequently tested on the female portion of the test set.

Table 5.18: Accuracy of linear models based on the whole training sample for age estimation from Demirjian et al. (1973) scores incorporating multiple teeth, as applied to the whole test set. Teeth chosen based on biological/taphonomic principles and statistical criteria (see Materials and Methods). The four models exhibiting the highest measures of performance are indicated with an asterisk (*).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Maxillary Polar – #9, 11, 12, 14	6	0.3750	6	0.3750	4	0.2500	2	0.1250	13	0.8125	1	0.0625	0	0.0000	15	0.9375	1	0.0625	16	83
Mandibular Polar – #19, 21, 22, 23	29	0.5577	9	0.1731	14	0.2692	12	0.2308	36	0.6923	4	0.0769	1	0.0192	50	0.9615	1	0.0192	52	48
Maxillary Forensic – #12, 13, 14, 15	8	0.4706	3	0.1765	6	0.3529	3	0.1765	12	0.7059	2	0.1176	0	0.0000	16	0.9412	1	0.0588	17	82
Mandibular Forensic – #18, 19, 20, 21	41	0.4659	31	0.3523	16	0.1818	21	0.2386	62	0.7045	5	0.0568	2	0.0227	84	0.9545	2	0.0227	88	12
Polar Forensic Both Jaws – #12, 14, 19, 21	9	0.4286	7	0.3333	5	0.2381	4	0.1905	14	0.6667	3	0.1429	0	0.0000	20	0.9524	1	0.0476	21	78
Molars Both Jaws – #14, 15, 18, 19	16	0.3810	12	0.2857	14	0.3333	5	0.1190	35	0.8333	2	0.0476	1	0.0238	40	0.9524	1	0.0238	42	57

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Maxillary 3 Molars – #14, 15, 16	12	0.4138	11	0.3793	6	0.2069	4	0.1379	22	0.7586	3	0.1034	1	0.0345	28	0.9655	0	0.0000	29	69
Mandibular 3 Molars – #17, 18, 19	29	0.4328	21	0.3134	17	0.2537	18	0.2687	46	0.6866	3	0.0448	1	0.0149	64	0.9552	2	0.0299	67	33
Narrow 4 Both Jaws – #21, 11, 22, 19	39	0.5270	15	0.2027	20	0.2703	19	0.2568	50	0.6757	5	0.0676	3	0.0405	70	0.9459	1	0.0135	74	26
Narrow 4 Posterior Both Jaws – #21, 19, 13, 20	34	0.5574	15	0.2459	12	0.1967	20	0.3279	36	0.5902	5	0.0820	2	0.0328	58	0.9508	1	0.0164	61	39
Narrow 4 Maxilla – #11, 9, 13, 10	11	0.3548	14	0.4516	6	0.1935	4	0.1290	25	0.8065	2	0.0645	0	0.0000	30	0.9677	1	0.0323	31	69
Narrow 3 Posterior Maxilla – #13, 12, 16	15	0.5172	8	0.2759	6	0.2069	8	0.2759	17	0.5862	4	0.1379	4	0.1379	23	0.7931	2	0.0690	29	68
Narrow 3 Posterior Mandible – #21, 19, 20	45	0.5000	23	0.2556	22	0.2444	22	0.2444	61	0.6778	7	0.0778	2	0.0222	87	0.9667	1	0.0111	90	10

Linear models based upon all individuals have been tested in three capacities: as applied to the entire test set; as applied to subsets of the test set divided by sex, ancestry, and sex/ancestry; and as applied to subsets of the test set divided into chronological age groups as defined by Bogin (1999). The first section evaluates the overall performance of the linear models based on all individuals to determine which models produce the best age estimates, while the subsequent tests evaluate sex, ancestry, and age differences in linear model performance. As with the CIs, discussion is limited to the 95% PIs. A PI is considered accurate if the chronological age of the individual is within the PI's upper and lower bounds. If an individual's chronological age is below the lower bound, the individual has been over-aged (i.e., the estimate is higher than the chronological age); conversely, if an individual's chronological age is above the upper bound, the individual has been under-aged (i.e., the estimate is lower than the chronological age).

5.4.1: Overall Performance of Linear Models based on All Individuals

Overall, models based on all individuals that incorporate teeth from just the mandible exhibit the highest accuracy rates, followed by models that incorporate teeth from both jaws, with the maxillary models exhibiting the lowest accuracy rates. However, the differences in accuracy rates are minimal, as these values are all between 93-97% with one exception: the model based on all individuals incorporating the three maxillary posterior teeth with the narrowest average CIs is only accurate for 79.31% of the individuals when applied to the entire test sample (see Table 5.18 and Appendix A5.12.1).

While the accuracy rates of most 95% PIs are comparable, mandibular models based on all individuals could consistently be applied to more individuals in the test

sample than the maxillary models based on all individuals focused on the same teeth. Models based on all individuals incorporating the teeth most frequently recovered in the forensic context (hereafter referred to as the "forensic teeth") can also be applied to more individuals than those models based on the polar teeth, though this difference is minimal in the maxilla (n = 17 and n = 16, respectively). The model based on all individuals incorporating two molars from both jaws can be applied to more individuals than the model incorporating the polar forensic teeth from both jaws (n = 42 and n = 21, respectively). However, the two linear models based on all individuals that incorporate the teeth from both jaws with the narrowest average CIs are more widely applicable than either biological/taphonomic model incorporating teeth from the maxilla and mandible (n = 74 and n = 61) (see Table 5.18).

Models based on all individuals that incorporate teeth from just the maxilla tend to exhibit narrower PIs, or higher precision, than the mandibular models based on all individuals (Table 5.19). Only the mandibular model based on all individuals incorporating polar teeth exhibits higher precision than the maxillary model based on all individuals. The maxillary polar model and the model based on the four maxillary teeth with the narrowest average CIs produce the 95% PIs that are least precise when applied to the entire test set, reaching 10.415 and 10.451 years in width, respectively. In general, models based on all individuals that are defined by statistical criteria yield narrower 95% PIs than the models based on all individuals that are defined by biological/taphonomic criteria.

Table 5.19: Precision of linear models based on entire training sample for age estimation from Demirjian et al. (1973) scores incorporating multiple teeth, as applied to the whole test set. All values are in years. The ranges include all individuals in the test sample.

Linear Model	51% Prediction Interval	95% Prediction Interval
Maxillary Polar	2.599 – 3.658	7.400 – 10.415
Mandibular Polar	2.416 – 2.579	6.897 – 7.329
Maxillary Forensic	2.245 – 2.638	6.388 – 7.506
Mandibular Forensic	2.097 – 2.132	5.958 – 6.161
Polar Forensic Both Jaws	2.488 – 3.029	7.077 – 8.615
Molars (No Third) Both Jaws	2.235 – 2.465	6.352 – 7.005
Maxillary 3 Molars	2.081 – 2.119	5.917 – 6.027
Mandibular 3 Molars	2.207 – 2.261	6.271 – 6.424
Narrowest 4 Both Jaws	2.156 – 2.366	6.126 – 6.721
Narrowest 4 Posterior Both Jaws	2.175 – 2.345	6.179 – 6.664
Narrowest 4 Maxillary	2.348 – 3.675	6.678 – 10.451
Narrowest 3 Posterior Maxillary	1.964 – 2.032	5.588 – 5.781
Narrowest 3 Posterior Mandibular	2.269 – 2.330	6.446 – 6.620

5.4.1.1: Best Performance of Linear Models based on All Individuals

Three variables are considered when evaluating linear model performance: accuracy of the prediction intervals, precision as measured by the width of the prediction interval, and applicability of the model to the test sample, i.e., the number of individuals to which the model can be applied. With these factors in mind, the four linear models based on all individuals that exhibit the best performance were selected for further evaluation. The overall performance of these four models based on all individuals are first, followed by sex and/or ancestry differences in model performance and differences in performance across chronological age groups. The four models that exhibit the highest

performance measures include two models based on biological/taphonomic principles, the mandibular forensic teeth (#18, 19, 20, and 21) and the three maxillary molars (#14, 15, and 16), and two models based on statistical criteria, the four maxillary teeth with the narrowest average CIs (#11, 9, 13, and 10) and the three posterior mandibular teeth with the narrowest average CIs (#21, 19, and 20) (see Tables 5.18-5.19 and Appendices A5.4, A5.7, A5.11, and A5.13).

Considering all measures of performance, the linear model based on all individuals that incorporates the three posterior teeth from the mandible with the narrowest CIs exhibits the best performance for age estimation. The 95% PIs produced by this model accurately estimate age in 87 of the 90 individuals to which the model could be applied (96.67%) (Appendix A5.13.1). Age could not be estimated for the remaining 10 individuals in the test sample, which is the lowest number of NAs produced by a linear model based on all individuals. The widths of the 95% prediction intervals range between 6.446 and 6.620 years (see Table 5.19).

The linear model based on all individuals that incorporates the mandibular forensic teeth exhibits comparable accuracy and applicability to the model based on all individuals using the narrowest three posterior teeth from the mandible. The 95% PIs accurately estimate age in 84 of the 88 individuals to which the mandibular forensic teeth model could be applied (95.45%) (Appendix A5.4.1). Prediction intervals could not be created for the remaining 12 individuals in the test sample, which is the second lowest number of NAs produced by the linear models based on all individuals. The precision of the model based on all individuals that uses the mandibular forensic teeth is slightly higher than the model based on all individuals that incorporates the three mandibular

posterior teeth with the narrowest CIs, with the 95% PIs ranging between 5.958 and 6.161 years.

Two linear models based on the entire training sample produce higher values for some measures of performance, but the applicability of these models is much lower than the two models already summarized. The linear model based on all individuals that uses the four maxillary teeth with the narrowest average CIs estimates age correctly for 30 of the 31 individuals to which the model could be applied (96.77%), which is the highest accuracy value produced by a linear model based on all individuals (Appendix A5.11.1). However, 69 of the 100 individuals in the test sample were not assigned an age estimate due to missing data at one or more teeth. The linear model based on all individuals that incorporates the three maxillary molars exhibits the highest precision of the linear models created from the entire training sample, with the 95% PIs ranging between 5.917 and 6.027 years wide. The maxillary three molar model based on all individuals exhibits even lower applicability, however, with 69 of the 98 individuals in the test sample missing data and subsequently lacking an age estimate (Appendix A5.7.1).

5.4.2: Performance of Linear Models based on All Individuals by Sex and Ancestry

All linear models built using the whole training sample were evaluated for performance on subsets of the test sample, divided by sex, ancestry, and sex/ancestry (Appendix 5). Those four models demonstrating the highest measures of performance will be presented in detail. More often than not, the models based on all individuals exhibit 100% accuracy when the 95% prediction intervals are applied to a subset of the test sample. However, certain sex and/or ancestry groups exhibit decreased accuracy across these four models: females, European American individuals, Hispanic individuals,

and some combination of these variables exhibit lower accuracy values using the four best linear models based on all individuals (Appendices A5.4.1, A5.7.1, A5.11.1, and A5.13.1).

In the model based on all individuals that incorporates the three posterior mandibular teeth with the narrowest average CIs, the female sample, total Hispanic sample, and Hispanic female sample exhibit both under- and over-aging, while the total European American and European American female samples exhibit under-aging (Appendix A5.13.1). In the mandibular forensic teeth model based on all individuals, the female, total European American, total Hispanic, and Hispanic female samples exhibit under- and over-aging. Additionally, the European American female sample exhibits under-aging, and the male and European American male samples exhibit over-aging (Appendix A5.4.1). In the model based on all individuals that uses the four maxillary teeth with the narrowest CIs, the female, total Hispanic, and Hispanic female samples exhibit over-aging (Appendix A5.11.1). The three maxillary molar model based on all individuals exhibits under-aging for the female, European American, and European American female samples (Appendix A5.7.1).

Overall, when the 95% PI produced by the model based on all individuals does not yield 100% accuracy, the Hispanic female sample tends to be over-aged, which contributes to the over-aging observed in the female and total Hispanic samples. Conversely, the European American female sample tends to be under-aged, which contributes to the under-aging observed in the female and total European American samples (Appendix 5). In the four models based on all individuals with the highest performance measures, European American males only exhibit over-aging in one model,

contributing to the over-aging of the male and total European American samples (Appendix A5.4.1).

5.4.3: Performance of Linear Models based on All Individuals by Chronological Age Group

After applying the linear models based on all individuals to sex and ancestry groups, the entire test sample was divided into age groups to evaluate performance across the age ranges (Bogin 1999). As with the sex and ancestry tests, the four models based on all individuals that demonstrate the best performance measures are discussed. The adolescent sample tends to exhibit the lowest accuracy rates for both models incorporating mandibular teeth that are based on all individuals, followed by the juvenile sample, with the childhood sample exhibiting the highest accuracy rates (Appendices A5.4.2 and A5.13.2). However, no pattern can be discerned in the performance of the maxillary models based on all individuals when applied to age groups. The 95% PIs produced by the model based on all individuals that uses the four maxillary teeth with the narrowest average CIs exhibits decreased accuracy on the juvenile sample (Appendix A5.11.2), while the three maxillary molar model based on all individuals exhibits decreased accuracy for the adolescent sample (Appendix A5.7.2).

The childhood sample does not yield any accuracy rates below 100% for the 95% PIs produced by the four best models based on all individuals. However, when the 51% PIs are incorrect, the childhood sample exhibits over-aging (Appendices A5.4.2 and A5.13.2). In the juvenile sample, the 95% PIs only exhibit 100% accuracy with one of the four best linear models based on all individuals (Appendix A5.7.2). With the other three linear models, the juvenile sample exhibits over-aging with the 95% PI (Appendices

A5.4.2, A5.11.2, and A5.13.2). The opposite is true of the adolescent sample. One of the four best linear models based on all individuals yields an accuracy rate of 100% with the 95% PIs (Appendix A5.11.2), but the remaining three models exhibit under-aging in the adolescent sample (Appendices A5.4.2, A5.7.2, and A5.13.2).

Although the 95% PIs produced from all four of the best models based on all individuals exhibit 100% accuracy for the childhood sample, individuals in the childhood subset are assigned age ranges that are wider than those produced for other age groups. In other words, the high accuracy for the 95% PIs for the childhood sample is accompanied by low precision (Appendices A5.4.3, A5.11.3, and A5.13.3). Precision for the 95% PIs created for the juvenile and adolescent samples is comparable in the four best linear models based on all individuals (Appendices A5.4.3, A5.7.3, A5.11.3, and A5.13.3).

Overall, the linear models based on all individuals exhibit over-aging in young individuals, i.e., the childhood and juvenile samples, while the older individuals experience under-aging, i.e., the adolescent sample. This indicates that the linear models based on all individuals produce age estimates that are too high for young individuals and too low for older individuals. The linear models based on all individuals produce the widest prediction intervals for individuals in the childhood sample, while those in the juvenile and adolescent periods exhibit comparable precision (Appendix 5).

5.4.4: Performance of Linear Models based on All Individuals vs. Linear Models based on Subsets

The four best linear models based on all individuals are those incorporating: 1) the three posterior mandibular teeth with the narrowest average CIs, 2) the mandibular

forensic teeth, 3) the four maxillary teeth with the narrowest average CIs, and 4) the three maxillary molars (see Tables 5.18-5.19). The performance measures of these four models based on all individuals have been evaluated on the entire test sample, on subsets divided by sex and/or ancestry, and on subsets divided by chronological age group (see Appendix 5). Having established the performance of these four models based on all individuals, the best version of each model based on a subset of the training sample will be presented, to compare the performance of a general method of age estimation to a specific method of age estimation.

5.4.4.1: Linear Models based on Sex and Ancestry Groups

Overall, two subsets exhibit the best performance measures of all the versions of linear models based on subsets of the training sample. Compared to other models based on subsets, the male-specific model exhibits the highest value for one or more measures of performance in eight of the 13 linear models, while the European-American-specific model exhibits the highest value for one or more performance measures in seven of the 13 linear models (Appendix 5). There is one instance in which the African-American-specific linear model exhibits the best performance of all the specific models. The African-American-specific model based on the three posterior maxillary teeth with the narrowest CIs (#13, 12, and 16) exhibits 100% accuracy, produces zero NAs, and creates the narrowest PIs of all the linear models, ranging between 4.407 years wide and 5.920 years wide (Appendix A5.11.4). However, this linear model could only be tested on two individuals; therefore, the high values in these performance measures may be misleading.

When the four best linear models are considered, the male-specific model exhibits the highest values for one or more measure of performance in three cases, and the

European-American-specific model exhibits the highest values in two cases (Table 5.20). The male-specific version of the linear model based on the three mandibular posterior teeth with the narrowest average CIs performs best of all seven specific models when applied to the male test set. This model estimates age correctly for 45 of the 45 individuals to which the model could be applied (100%). The remaining six males could not be assigned age estimates due to missing data. The male-specific version of this model produces 95% PIs that range between 6.303 years wide and 6.552 years wide.

The second linear model based on all individuals that exhibits the best overall performance is the model based on the mandibular forensic teeth, and both the male- and European American-specific versions of this linear model exhibit the highest value for at least one performance measure (see Table 5.20). Of all the specific versions of this model, the male version exhibits the highest accuracy value, with correct age estimates assigned to 43 of the 44 individuals to which the model could be applied (97.73%). The European American version of this model produces the most precise age estimates. The 95% PIs produced by the European-American-specific mandibular forensic teeth model range between 5.544 years wide and 5.749 years wide. Both specific versions of this linear model exhibit comparable applicability, with the male-specific model unable to assign age to seven of the 51 individuals tested and the European-American-specific model unable to assign age to six of the 46 individuals tested.

Table 5.20: Performance of the linear model based on all individuals as applied to the whole test set and linear models based on subsets of the training set as applied to subsets of the test set. The four linear models presented are those that exhibit the highest measures of performance when based on the entire training set and applied to the entire test set.

Linear Model	Performance Measure	Based on All Individuals	Female-Specific	Male-Specific	AfA-Specific	AsA-Specific	EA-Specific	His-Specific	Nat-Specific
Narrowest 3 Posterior Mandibular	Accuracy of 95% PI	96.67%	93.33%	100.00%	100.00%	100.00%	97.56%	94.59%	66.67%
	Width of 95% PI	6.446 – 6.620 yrs	6.599 – 6.796 yrs	6.303 – 6.552 yrs	7.557 – 8.445 yrs	6.933 – 9.513 yrs	6.286 – 6.435 yrs	6.109 – 6.312 yrs	6.289 – 9.055 yrs
	Unusual PI Values*	–	–	–	–	–	–	–	–
	NAs	10 of 100	4 of 49	6 of 51	1 of 3	0 of 4	5 of 46	2 of 39	0 of 3
Mandibular Forensic	Accuracy of 95% PI	95.45%	93.18%	97.73%	100.00%	100.00%	95.00%	94.44%	66.67%
	Width of 95% PI	5.958 – 6.161 yrs	6.014 – 6.259 yrs	5.909 – 6.231 yrs	7.817 – 8.989 yrs	6.329 – 9.927 yrs	5.544 – 5.759 yrs	5.886 – 5.966 yrs	6.055 – 9.510 yrs
	Unusual PI Values*	–	–	–	–	73.819 yrs	–	–	–
	NAs	12 of 100	5 of 49	7 of 51	1 of 3	0 of 4	6 of 46	3 of 39	0 of 3
Narrowest 4 Maxillary	Accuracy of 95% PI	96.77%	87.50%	100.00%	100.00%	N/A	100.00%	87.50%	100.00%
	Width of 95% PI	6.678 – 10.451 yrs	6.635 – 7.447 yrs	6.874 – 12.301 yrs	23.364 yrs	N/A	6.488 – 6.861 yrs	6.551 – 8.040 yrs	12.704 yrs
	Unusual PI Values*	–	–	–	–	N/A	–	–	–
	NAs	69 of 100	26 of 42	36 of 51	1 of 2	2 of 2	35 of 46	18 of 34	2 of 3
Maxillary 3 Molars	Accuracy of 95% PI	96.55%	91.67%	100.00%	100.00%	N/A	90.91%	100.00%	100.00%
	Width of 95% PI	5.917 – 6.027 yrs	6.459 – 6.547 yrs	5.456 – 5.590 yrs	6.411 – 6.800 yrs	N/A	5.730 – 5.869 yrs	6.334 – 6.505 yrs	9.371 yrs
	Unusual PI Values*	–	–	–	–	N/A	–	–	–
	NAs	69 of 98	10 of 21	34 of 51	0 of 2	0 of 0	34 of 45	11 of 23	0 of 1

*Unusual PI Value refers to cases in which the 95% PI for an individual was more than double the highest value in the usual range of 95% PIs.

The linear model based on the four maxillary teeth with the narrowest CIs exhibits the highest accuracy of all the linear models based on all individuals, and the European American-specific version of this model performs best overall (see Table 5.20). Age was correctly estimated for nine of the nine individuals to which the model could be applied (100%), and the 95% prediction intervals exhibit comparable precision, ranging between 6.488 years wide and 6.861 years wide. The linear model based on all individuals with the most precise prediction intervals is the model based on the three maxillary molars, and the male-specific version of this model performs best (see Table 5.20). Age was correctly estimated for 17 of the 17 individuals to which the model could be applied (100%), and the width of the 95% prediction intervals is between 5.456 years wide and 5.590 years wide. However, as was the case when these two models were based on all individuals, the specific versions do not demonstrate high applicability. Using the European-American-specific version of the narrowest four maxillary teeth model, age could not be estimated for 35 of the 46 individuals tested, while the male-specific version of the maxillary three molar model could not produce age estimates for 34 of the 51 individuals tested.

Overall, linear models based on ancestry groups with small sample sizes, i.e., African American, Asian American, and Native American samples, produce comparable accuracy and applicability to the linear models based on all individuals, but measures of precision tend to be lower with these specific versions. However, compared to the linear models based on all individuals, the sex-specific and the European-American- and Hispanic-specific linear models can be applied to a similar proportion of individuals in the test sample, while the accuracy and precision values produced by these specific linear

models are either comparable to or slightly higher than those produced by the linear models based on all individuals (see Table 5.20 and Appendix 5).

5.5: Summary of Results

The intraobserver error tests suggest that the application of both the Moorrees et al. (1963) and Demirjian et al. (1973) systems is internally consistent (see Appendix 1). However, since the Cohen's weighted Kappa values are typically higher using the Demirjian et al. (1973) scoring system, these values were used in all other analyses (Cohen 1968).

Using the Kruskal-Wallis and Dunn's tests, most comparisons between females and males in this study suggest that developmental scores are not significantly different (173 out of 214 total comparisons) (Dunn 1964; Kruskal and Wallis 1952). When significant differences exist, nearly all cases indicate female dental development is advanced relative to male development (see Table 5.1). As was the case for the sex comparisons, most comparisons among ancestry groups, both as a whole and divided by sex, suggest that there are no significant differences (see Tables 5.4, 5.7, and 5.10). The comparisons between the European American and Hispanic samples exhibit the highest proportion of significant differences (23.90% of all comparisons), most of which indicate that Hispanic dental development is advanced compared to European American development. When significant differences are considered across all ancestry comparisons, the Native American sample exhibits the lowest developmental scores, followed by the European American and Asian American samples respectively, while the African American and Hispanic samples exhibit the highest developmental scores (see Table 5.13).

Overall, there are no significant differences when the accuracy rates of the CIs based on the entire training sample are compared to the specific CIs created from subsets divided by sex, ancestry, and sex/ancestry (see Table 5.15). When accuracy rates are significantly different, the CIs based on subsets are more accurate than the CIs based on all individuals. However, CIs created from the entire training sample are more precise than the CIs based on subsamples in nearly all comparisons (see Table 5.17).

The 95% prediction intervals produced by the linear models based on all individuals typically yield high accuracy rates (see Table 5.18). When linear models based on all individuals were compared to those based on sexes or ancestry groups, the female-, male-, European-American-, and Hispanic-specific models yield slightly higher accuracy and better precision (see Table 5.20). However, the linear models based on the African American, Asian American, and Native American subsets tend to be comparable to the linear models based on all individuals.

Chapter 6: Age Estimation Example

One individual from the test sample was selected to demonstrate the entire process of age estimation presented in this research, from assigning developmental scores and evaluating confidence intervals to using linear models to create point estimates and prediction intervals. For the purposes of this demonstration, this individual is referred to as "Subject A" (Figure 6.1). This orthopantomogram is from the UT sample, and permission for its use has been granted by Dr. Hassem Geha (personal communication, Geha 2018). Subject A is a European American female at eight years of age; knowing sex and ancestry allows the appropriate sex- and/or ancestry-specific methods of age estimation to be utilized during this demonstration, while the chronological age must be compared to the estimated ages to evaluate the performance of the methods.

6.1: Assigning Developmental Scores

Since the Demirjian et al. (1973) scoring system produced better intraobserver agreement values overall (see Appendix 1), the developmental scores from this system were utilized in the creation of age estimation methods. Demirjian et al. (1973) scores assigned to Subject A are presented in Table 6.1. Developmental scores were collected using a graphical user interface (GUI) in Microsoft Excel designed by the author, pictured in Figure 6.2. To prevent collinearity of variables in the age estimation methods, only scores from the left sides were used. When a tooth on the left could not be scored, the score assigned to its antimere would be substituted. However, in the case of Subject A, the teeth that could not be assigned a developmental score on the left side (#10, 12, 13, and 14) were also not scorable on the right side (#7, 5, 4, and 3, respectively). Therefore, no antimere scores were substituted, and the scores used for estimating chronological age

for Subject A are those for teeth #9-24 using the Demirjian et al. (1973) scoring system (see Table 6.1).

6.2: Age Estimation from Confidence Intervals

After developmental scores were assigned, the chronological age for each individual in the test sample was compared to the CIs based on all individuals and the applicable CIs based on subsets of the training set (see Appendix 3). Since Subject A is a female of European American ancestry, her age was estimated using the CIs based on all individuals, the female-specific CIs, the European-American-specific CIs, and the European-American-female-specific CIs (Table 6.2). Chronological age is presented as an integer; in other words, if Subject A were 8 years and 9 months old, her age would be listed as 8 years, rather than 8.75 years. Therefore, the upper and lower bounds of each CI were rounded down to the nearest whole number. Confidence intervals were considered accurate if the chronological age was either equal to or contained within the bounds.

The European-American-specific CIs perform worst on Subject A, only correctly estimating chronological age from two of the 12 teeth assigned developmental scores (16.67% correct). The female-specific and European-American-female-specific CIs are the most accurate, with six of 12 teeth estimating age correctly (50.00% correct). The accuracy of the CIs based on all individuals is only slightly lower, with five of 12 teeth correctly estimating age (41.67% correct). In all cases where the 95% CI was not accurate, Subject A was over-aged. Almost half of the inaccurate age estimates are only one year too high (14 of 29 cases across all CIs), while the worst estimates are between three and four years over Subject A's chronological age (see Table 6.2).

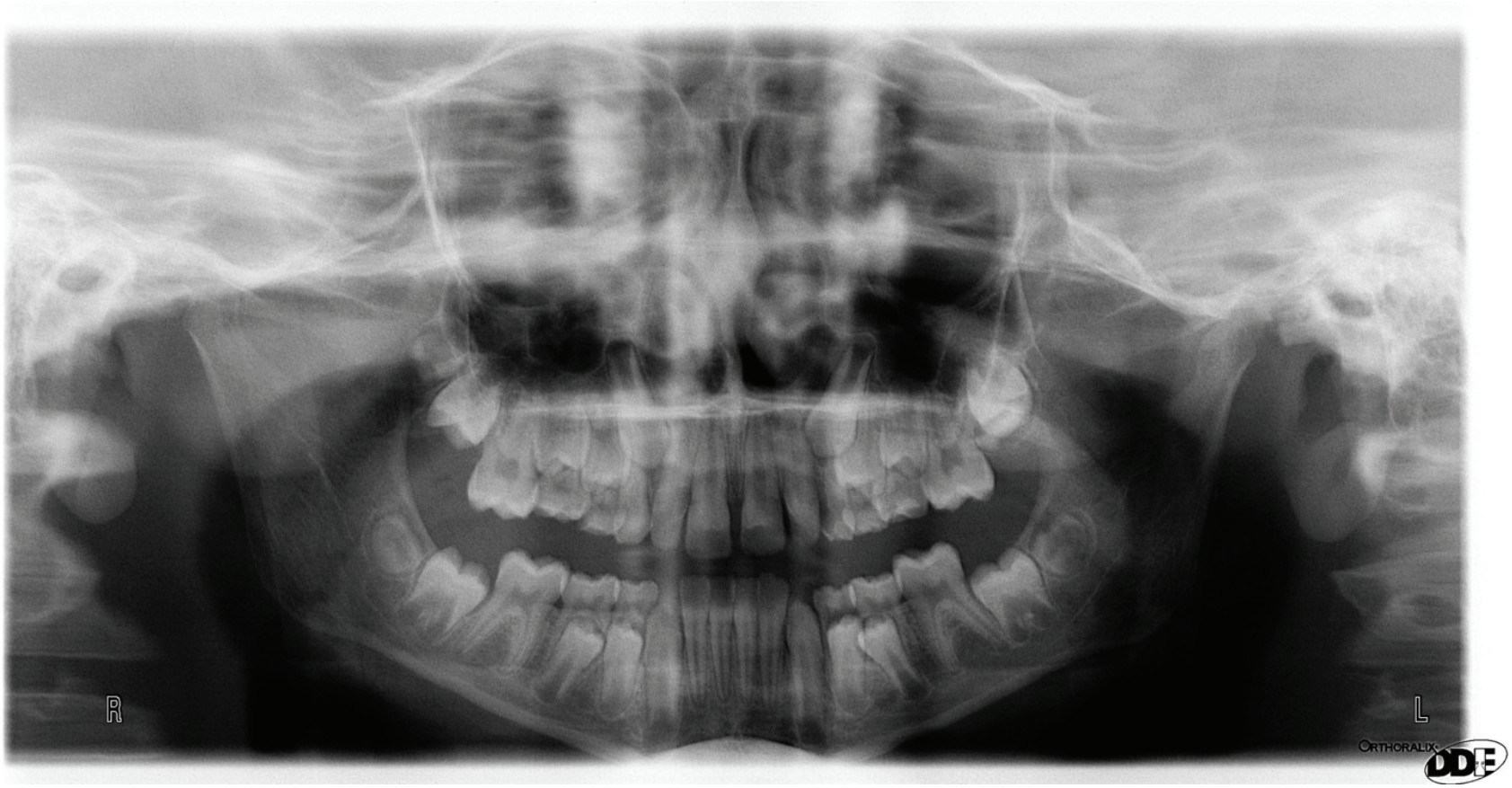


Figure 6.1: Orthopantomogram for Subject A. Radiograph printed with permission of Dr. Hassem Geha (personal communication, Geha 2018).

Table 6.1: Developmental scores assigned to Subject A using the Demirjian et al. (1973) scoring system. NS = not scorable, i.e., the tooth is present, but a developmental score cannot be assigned due to difficulty observing the apical end.

Side	Maxillae		Mandible	
	Tooth	Score	Tooth	Score
Right	1: M3	B	32: M3	B
	2: M2	E	31: M2	E
	3: M1	NS	30: M1	G
	4: P2	NS	29: P2	F
	5: P1	NS	28: P1	F
	6: C	F	27: C	F
	7: I2	NS	26: I2	G
	8: I1	G	25: I1	H
Left	9: I1	G	24: I1	H
	10: I2	NS	23: I2	G
	11: C	F	22: C	G
	12: P1	NS	21: P1	F
	13: P2	NS	20: P2	F
	14: M1	NS	19: M1	G
	15: M2	D	18: M2	E
	16: M3	A	17: M3	B

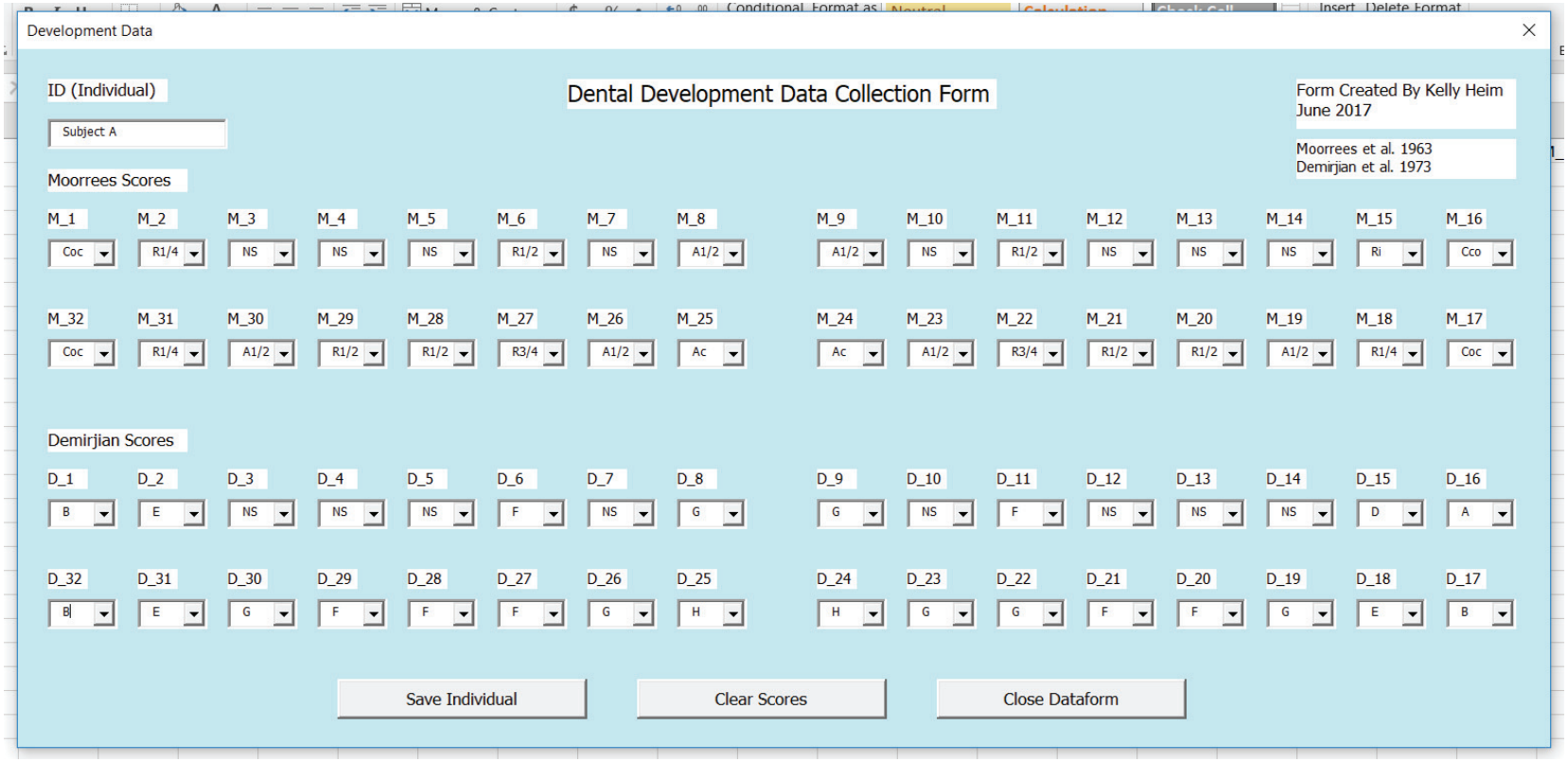


Figure 6.2: Graphical user interface (GUI) in Microsoft Excel for data collection. The scores for the Moorrees et al. (1963) system and the Demirjian et al. (1973) system have been recorded for Subject A.

Table 6.2: Age estimates from 95% confidence intervals created for Subject A based on Demirjian et al. (1973) scores for every tooth. The chronological age for Subject A is eight years. Therefore, any CI with an asterisk (*) correctly estimates age. The width of each CI is presented below the range. All values are in years.

Tooth	Demirjian Score	95% CI Based on All Individuals	Female 95% CI	EA 95% CI	EA Fem 95% CI
9: UI1	G	8.954 – 9.358* 0.404	8.536 – 9.071* 0.535	9.170 – 9.768 0.598	8.604 – 9.396* 0.792
10: UI2	NS	–	–	–	–
11: UC	F	9.236 – 9.492 0.256	8.854 – 9.205* 0.351	9.398 – 9.772 0.374	8.929 – 9.449* 0.520
12: UP1	NS	–	–	–	–
13: UP2	NS	–	–	–	–
14: UM1	NS	–	–	–	–
15: UM2	D	8.289 – 8.554* 0.265	8.007 – 8.411* 0.404	8.286 – 8.693* 0.407	7.960 – 8.660* 0.507
16: UM3	A	8.957 – 9.450* 0.493	8.725 – 9.420* 0.695	9.100 – 9.786 0.686	8.811 – 10.000* 1.189
17: LM3	B	10.930 – 11.360 0.430	10.700 – 11.220 0.520	10.940 – 11.500 0.560	10.740 – 11.430 0.690
18: LM2	E	9.170 – 9.464 0.294	9.031 – 9.453 0.422	9.429 – 9.831 0.402	9.260 – 9.876 0.616
19: LM1	G	8.380 – 8.614* 0.234	8.145 – 8.452* 0.307	8.500 – 8.824* 0.324	8.284 – 8.773* 0.489
20: LP2	F	10.150 – 10.460 0.310	9.950 – 10.350 0.400	10.480 – 10.930 0.450	10.220 – 10.860 0.640
21: LP1	F	9.411 – 9.694 0.283	9.156 – 9.522 0.366	9.709 – 10.070 0.361	9.392 – 9.897 0.505
22: LC	G	11.540 – 12.000 0.460	10.980 – 11.600 0.620	11.660 – 12.320 0.660	11.080 – 11.960 0.880
23: LI2	G	8.824 – 9.218* 0.394	8.369 – 8.902* 0.533	9.000 – 9.554 0.554	8.525 – 9.230* 0.705
24: LI1	H	11.410 – 11.820 0.410	11.180 – 11.760 0.580	11.870 – 12.470 0.600	11.770 – 12.540 0.770

Although the European-American-female-specific CIs produce one of the highest accuracy rates for Subject A, these CIs are also the widest, indicating the lowest degree of precision (see Table 6.2). The 95% CIs get wider with each subdivision of the data. The margin of error is added to and subtracted from the bootstrapped mean to create the CI, and the denominator of the margin of error is the square root of the sample size.

Therefore, the general CIs are narrowest, as they are informed by the entire training sample (n = 1,657); a larger sample size translates into a larger number in the denominator and a smaller value for the margin of error. The female sample has the next highest sample size (n = 931) followed by the European American sample (n = 865). Female-specific CIs are narrower than European American-specific CIs in nine of the 12 teeth that were assigned developmental scores for Subject A. The 95% CIs are least precise from the European-American-female-specific CIs, as this is the smallest sample size under consideration (n = 454) (see Table 4.2).

The 95% confidence intervals, either those created from the entire training sample or those created from subsets of the data, could be utilized to estimate age from a single tooth in the forensic context. Confidence intervals based on all individuals or based on subsets may be preferable depending on the goal of the researcher. The CIs based on all individuals are more precise, while the CIs based on subsets tend are more accurate when significant differences exist. However, differences in performance between CIs based on all individuals and those based on subsets tend not to demonstrate statistical significance (see Tables 5.15 and 5.17).

6.3: Age Estimation from Linear Models

Since confidence intervals derived from multiple teeth cannot be combined without introducing statistical error, linear models were created so that more than one tooth could be considered during the process of age estimation. Developmental scores for each individual in the test sample are contained in a Microsoft Excel sheet, which is read into the statistical software R (R Core Team 2017). Linear models are created from the training sample, and base functions in R can use these linear models to create point

estimates and prediction intervals for each individual in the test sample. The math behind these models will be illustrated momentarily. Every linear model creates both a 51% and 95% PI, for increased applicability across forensic contexts. However, as the Results chapter focused on the 95% PIs, these are the values that will be presented for Subject A.

Of the 13 linear models that were devised, five models can be applied to Subject A: mandibular polar teeth, mandibular forensic teeth, mandibular three molars, four teeth with narrowest average CIs in both jaws, and three posterior teeth with narrowest average CIs in the mandible. The remaining eight models cannot be run due to missing data at one or more teeth (see Appendix 5). Two of these five models, the models based on the mandibular forensic teeth and the three posterior mandibular teeth with the narrowest average CIs, exhibit the highest measures of performance across the linear models based on all individuals (see Tables 5.18-5.19 and Appendices A5.4 and A5.13). Therefore, the versions based on all individuals, and the female- and European-American-specific versions, of these two linear models have been applied to Subject A in Table 6.3.

Table 6.3: Age estimation for Subject A from linear models. Point Est = point estimate of chronological age. PIs with an asterisk (*) correctly estimate Subject A's chronological age. The width of each PI is presented below the range. All values are in years.

Linear Model	Demirjian Scores	Models Based on All Individuals		Female-Specific Models		European-American-Specific Models	
		Point Est	95% PI	Point Est	95% PI	Point Est	95% PI
Mandibular Forensic	#18 = E #19 = G #20 = F #21 = F	9.260	6.278 – 12.242* 5.964	9.130	6.117 – 12.142* 6.025	9.643	6.860 – 12.426* 5.566
Narrowest 3 Posterior Mandibular	#21 = F #19 = G #20 = F	9.344	6.118 – 12.571* 6.454	9.146	5.859 – 12.432* 6.573	9.693	6.540 – 12.847* 6.307

The point estimates of chronological age produced for Subject A are too high by one year, from the linear models based on all individuals and those based on subsets on the training sample. All 95% PIs contain Subject A's chronological age, meaning the prediction intervals are accurate. However, the precision of the models based on all individuals compared to the specific models yields mixed results. The models based on all individuals produce PIs for Subject A that are narrower than those produced by the female-specific versions of the models, while the opposite is true of the European American-specific models.

In the case of Subject A, the linear models based on all individuals and the models based on subsets of the training sample all estimate chronological age accurately with the 95% PI. Though there are differences in the widths of the 95% PI between the linear models based on all individuals and the specific linear models, the values are comparable, suggesting that precision does not change drastically with the introduction of sex or ancestry into the linear model (see Table 6.3). The linear models presented here allow age estimates to account for more than a single tooth. With 13 different models from which to choose, most of which exhibit comparable accuracy and precision (see Tables 5.18-5.19 and Appendix 5), this method of age estimation should be applicable in a wide variety of situations in the forensic context.

6.4: Calculating Point Estimates from Linear Models

Having presented the point estimates of chronological age calculated for Subject A using the statistical software R, a discussion of the background processes is in order. The developmental scores used in this research are ordinal variables, and R is treating the data as ordered factors, i.e., a Demirjian et al. (1973) score of A always comes before B,

which always comes before C, etc. With the ordered factor transformation, the letters associated with each developmental score are instead treated as integers. Linear models created from ordinal data must perform data transformations in the background to function. Instead of simply plugging the appropriate developmental score into the equation, i.e., inserting the number 6 for a Demirjian et al. (1973) score of F, R is instead transforming the developmental scores using orthogonal polynomial contrast tables (Table 6.4). These tables are generated by R, and the table presented here represents the values that are substituted in a linear model when the ordinal variable in question has eight potential scores, e.g., developmental scores of A-H defined by Demirjian et al. (1973).

Table 6.4: Orthogonal polynomial contrast table for an ordinal variable with eight potential scores for use in linear models, i.e., table of seven contrasts, generated by R (R Core Team 2017). Ordinal variable values translate into developmental scores A-H as defined by Demirjian et al. (1973). Values have been rounded to four decimal places.

Ordinal Variable Value	.L (Linear)	.Q (Quadratic)	.C (Cubic)	^4 (Fourth Order)	^5 (Fifth Order)	^6 (Sixth Order)	^7 (Seventh Order)
1st Score (A)	-0.5401	0.5401	-0.4308	0.2820	-0.1498	0.0615	-0.0171
2nd Score (B)	-0.3858	0.0772	0.3077	-0.5238	0.4922	-0.3077	0.1195
3rd Score (C)	-0.2315	-0.2315	0.4308	-0.1209	-0.3638	0.5539	-0.3585
4th Score (D)	-0.0772	-0.3858	0.1846	0.3626	-0.3210	-0.3077	0.5974
5th Score (E)	0.0772	-0.3858	-0.1846	0.3626	0.3210	-0.3077	-0.5974
6th Score (F)	0.2315	-0.2315	-0.4308	-0.1209	0.3638	0.5539	0.3585
7th Score (G)	0.3858	0.0772	-0.3077	-0.5238	-0.4922	-0.3077	-0.1195
8th Score (H)	0.5401	0.5401	0.4308	0.2820	0.1498	0.0615	0.0171

However, not every developmental score is represented for each tooth in the training sample. This fact can be confirmed by looking at the scores for which confidence intervals could be created from the total training sample in Appendix A3.1. Scores A-H are present in the training sample for tooth #18, but not for the remaining teeth being utilized in this demonstration. There is a single individual with a Demirjian et al. (1973) score of D for tooth #19, but the remainder of the training sample exhibits scores E-H. There is also one individual with a Demirjian et al. (1973) score of A for tooth #20, while the rest of the individuals in the training sample were assigned scores B-H. Finally, individuals in the training sample only exhibit scores C-H for tooth #21. While there are eight potential Demirjian et al. (1973) developmental scores, the age distribution of the dataset means that not every score is represented for every tooth. Therefore, a different orthogonal polynomial contrasts table would be required for each tooth based on the number of developmental scores actually present in the training sample. All potential orthogonal polynomial contrasts tables that could be used to transform Demirjian et al. (1973) developmental scores have been included in Appendix A5.14.

To transform the ordinal developmental scores for use in the linear models, R must take three steps. First, the correct orthogonal polynomial contrasts tables must be selected, based on the number of developmental scores represented for the tooth in question in the sample from which each model was derived. Next, R must determine the row from which to pull values based on the developmental score assigned to that tooth for a specific individual, in this case Subject A. If a tooth does not exhibit all eight developmental scores, the row must change accordingly. For example, a Demirjian et al.

(1973) score of F would be the sixth row in a table of seven contrasts. However, if a score of A is not present in the sample, then a table of six contrasts will be used, and F will subsequently be assigned the fifth row. Finally, R determines the correct column based on the order of the term in the linear model equation. The use of these contrast tables, and the calculation of the point estimate of age, will be illustrated with the two best linear models based on all individuals, as applied to Subject A.

The formula for the mandibular forensic teeth model based on all individuals is as follows (Appendix A5.4):

> Age = 9.3688 + 2.5429(#21.L) + 0.4202(#21.Q) + 0.4561(#21.C) + 0.0436(#21^4) + 0.1681(#21^5) + 0.7733(#20.L) + 1.1052(#20.Q) + 0.2532(#20.C) + 0.3342(#20^4) – 0.0751(#20^5) – 0.0045(#20^6) – 0.0018(#20^7) + 1.0480(#19.L) + 0.4992(#19.Q) – 0.2615(#19.C) + N/A(#19^4) + 4.1286(#18.L) + 1.9800(#18.Q) + 0.3524(#18.C) + 0.5917(#18^4) – 0.1202(#18^5) + 0.1701(#18^6) – 0.1114(#18^7)

Tooth #21 has six Demirjian et al. (1973) scores represented in the sample on which this model was built, which explains why terms for tooth #21 go to the fifth order in this equation. Since there are six potential scores, R must utilize a table of five contrasts. One of the coefficients for tooth #19 is N/A; this means that although tooth #19 exhibits five developmental scores in the sample informing this model, the fourth order term is not informing the equation. Therefore, the fourth order term for tooth #19 can be ignored in calculations, but a table of four contrasts should still be used since tooth #19 has five potential Demirjian et al. (1973) scores in the sample. Finally, teeth #18 and #20 exhibit all eight developmental scores in the sample for this model, which means R will use a table of seven contrasts.

Subject A was assigned Demirjian et al. (1973) scores of F for teeth #21 and #20, G for tooth #19, and E for tooth #18. Based on the scores present in the sample used to create this linear model, and the scores assigned to Subject A, R will pull values for tooth #21 from the fourth row of the table of five contrasts, values for tooth #20 from the sixth row of the table of seven contrasts, values for tooth #19 from the fourth row of the table of four contrasts, and values for tooth #18 from the fifth row of the table of seven contrasts (Appendix A5.14). To use tooth #20 as an example, the values substituted in the equation will be the values from the sixth row in the first through the seventh columns, in order (#20.L = 0.2315; #20.Q = -0.2315; #20.C = -0.4308; #20^4 = -0.1209; #20^5 = 0.3638; #20^6 = 0.5539; #20^7 = 0.3585) (see Table 6.4). With all of the substituted values, the equation for the point estimate of Subject A's chronological age from the mandibular forensic teeth model based on all individuals becomes:

> Age = 9.3688 + 2.5429(0.1195) + 0.4202(-0.4364) + 0.4561(-0.2981) + 0.0436(0.3780) + 0.1681(0.6299) + 0.7733(0.2315) + 1.1052(-0.2315) + 0.2532(-0.4308) + 0.3342(-0.1209) – 0.0751(0.3638) – 0.0045(0.5539) – 0.0018(0.3585) + 1.0480(0.3162) + 0.4992(-0.2673) – 0.2615(0.0000) + 4.1286(0.0772) + 1.9800(-0.3858) + 0.3524(-0.1846) + 0.5917(0.3626) – 0.1202(0.3210) + 0.1701(-0.3077) – 0.1114(-0.5974)

With the transformed values from the orthogonal polynomial contrasts tables, the point estimate of Subject A's chronological age from the mandibular forensic teeth model based on all individuals is 9.251 years.

The second model based on all individuals that was applied to Subject A is the model based on the three posterior mandibular teeth with the narrowest average CIs, and the equation for this linear model is as follows (Appendix A5.13):

Age = 8.9289 + 3.8201(#21.L) + 0.6719(#21.Q) + 0.5376(#21.C) – 0.0238(#21^4) + 0.0652(#21^5) + 2.6444(#19.L) – 0.2759(#19.Q) + 0.3831(#19.C) – 0.2215(#19^4) + 1.6853(#20.L) + 3.0750(#20.Q) – 0.1366(#20.C) + 1.0318(#20^4) – 0.3382(#20^5) + 0.2117(#20^6) + N/A(#20^7)

In the sample that informed this model, teeth #19-21 exhibit the same number of developmental scores previously mentioned (five, eight, and six, respectively), and the developmental scores assigned to Subject A remain the same. Therefore, the rows and tables of contrasts previously listed can also be used in the calculation of chronological age from the model based on all individuals using the three posterior mandibular teeth with the narrowest average CIs. However, in this linear model, the fourth order term for tooth #19 will be used, while the seventh order term for tooth #20 will not be considered in calculations. With all of the substituted values, the equation for the point estimate of Subject A's chronological age becomes:

Age = 8.9289 + 3.8201(0.1195) + 0.6719(-0.4364) + 0.5376(-0.2981) – 0.0238(0.3780) + 0.0652(0.6299) + 2.6444(0.3162) – 0.2759(-0.2673) + 0.3831(-0.6325) – 0.2215(-0.4781) + 1.6853(0.2315) + 3.0750(-0.2315) – 0.1366(-0.4308) + 1.0318(-0.1209) – 0.3382(0.3638) + 0.2117(0.5539)

With the transformed values from the orthogonal polynomial contrasts tables, the point estimate of Subject A's chronological age from the model based on all individuals incorporating the three posterior mandibular teeth with the narrowest average CIs is 9.344 years.

Having performed the calculations by hand, it is apparent that the values for the point estimate of Subject A's chronological age produced by manual calculation may not match the values produced by the statistical software R exactly. When the mandibular forensic teeth model based on all individuals is applied in R, the point estimate for Subject A's chronological age is 9.260 years, while the value produced by manual

calculation is 9.251 years. However, the point estimate for Subject A's chronological age calculated when R applies the linear model based on all individuals incorporating the three posterior mandibular teeth with the narrowest average CIs and the value produced by hand are both 9.344 years. The discrepancy between values produced by the mandibular forensic teeth model based on all individuals is likely a product of rounding the numbers in each equation. The intercepts, coefficients, and values from the orthogonal polynomial contrast tables have all been rounded to four decimal places, which could explain the disparate values.

It is also apparent that the calculations to create the prediction intervals for Subject A's chronological age have not been presented. Their absence is due to the fact that creating a prediction interval from a linear model using ordinal data requires matrix algebra, due to the presence of multiple variables with multiple potential scores. While this math could be done by hand, it is far more practical to perform these calculations using the statistical software R.

Linear models have been created to estimate age from multiple teeth, and the equations and orthogonal polynomial contrast tables have been presented in Appendix 5 and their use illustrated in this example. However, these calculations are easier to perform, and less subject to human error, with the use of a statistical software. Currently, the application of these models requires both Microsoft Excel for data management and R for calculations, in addition to the raw data and the code written during the course of this research in order to create the linear model functions. Future directions for this research include creating a user-friendly means of applying the linear models for age estimation, such as a web-based application in the statistical software R (R Core Team 2017).

Chapter 7: Discussion

7.1: Intraobserver Error

The teeth that exhibit differences between the Moorrees et al. (1963) and Demirjian et al. (1973) scoring systems, and the disparate scores between the maxilla and mandible, could be explained by the orthopantomograms themselves (see Appendix 1). Orthopantomograms are produced with an X-ray apparatus that rotates around the patient's head. The radiation source is on one side of the patient, and the film or sensor is positioned on the other side. This apparatus then rotates, essentially producing a single image that contains the same information as one anterior-posterior view and two lateral views of the skull (Perschbacher 2012). This radiograph format contrasts a lateral or bite-wing dental radiograph, where the sensor is positioned immediately behind the teeth of interest. In an orthopantomogram, the radiation must pass through not only the dentition to reach the sensor, but also the surrounding soft tissue and bone. For this reason, orthopantomograms are subject to interpretive errors related to anatomical structures of the head and neck, as well as associated air spaces (Peretz et al. 2012; Perschbacher 2012).

In a high-quality orthopantomogram, practitioners can avoid many interpretive errors through an understanding of cranial anatomy and its effect on the radiographic image (e.g., Peretz et al. 2012; Perschbacher 2012; Rondon et al. 2014). However, difficulty of interpretation is compounded when the patient is not properly positioned relative to the radiograph apparatus. In a literature review on panoramic radiograph errors, Rondon and colleagues (2014) found the most common source of error in orthopantomograms stems from improper patient positioning. In fact, in a study of

common errors in panoramic radiography, Peretz and colleagues (2012: 3) encountered only four radiographs in the whole sample (n = 289) that were error-free, and all errors were a product of the patient's position. This is not to suggest that orthopantomograms are not of use, especially for age estimation. In a clinical setting for disease diagnosis or treatment planning, additional radiographs should be obtained to ensure that doctors make the most informed decision for the patient's health (Peretz et al. 2012). However, for the purposes of age estimation, many of the imaging errors will not affect the ability to assign developmental scores, and those errors that do affect age estimation will likely not affect all teeth equally. It is important to understand that errors can, and do, occur and to recognize the effects of these positioning errors on the subsequent images.

During the imaging process, the tongue should be kept against the palate (Granlund et al. 2011; Peretz et al. 2012; Rondon et al. 2014). When the tongue is not properly positioned, the air in the oral cavity produces a radiolucent artifact on the orthopantomogram, appearing as a dark stripe across the apices of the maxillary teeth (Figure 7.1). Depending on the amount of space between the tongue and the palate, this darkened area can overlap the posterior teeth and incisors (Figure 7.1a), or at its most extreme, all the maxillary teeth (Figure 7.1b).

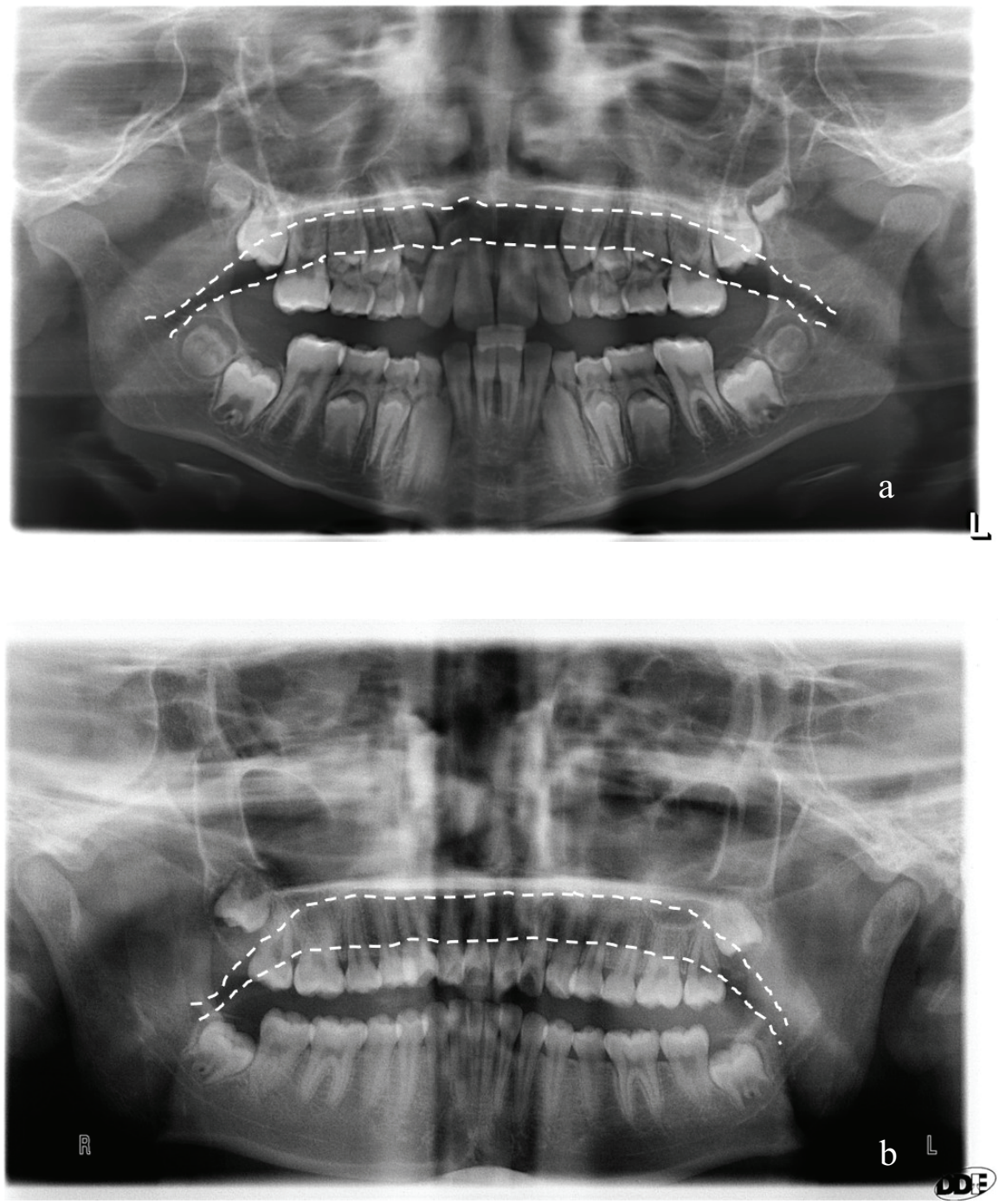


Figure 7.1: Orthopantomograms illustrating radiolucent palatoglossal air space, outlined with white dashed lines. The air space is positioned more superiorly on 7.1b, which obscures the apices of more maxillary teeth than observed in 7.1a. Radiographs printed with permission of Dr. Hassem Geha (personal communication, Geha 2018).

An additional source of distortion in maxillary teeth occurs when the patient's chin is tilted anteriorly. When the chin is properly positioned, the occlusal plane of the teeth forms what is referred to as a "smile" line, i.e., an upwards curve that resembles a smile (Figure 7.2) (Peretz et al. 2012: 2). When the chin is too high relative to the radiograph apparatus, the "smile" line either is flattened or is reversed into a downward curve (Figure 7.3). Because of this improper position, the palatine bones appear wider, resulting in a distinct radiopaque line across the apices of the maxillary teeth.

These two imaging artifacts, the radiolucent palatoglossal air space and the radiopaque palatine bones, can explain why developmental scores for mandibular teeth are more consistent in the intraobserver error tests. Some of the most common imaging errors in panoramic radiography affect the apices of the maxillary teeth, leading to inconsistency in assigning developmental scores. This error could also explain why the Moorrees et al. (1963) method produces higher Kappa values in the intraobserver error test than the Demirjian et al. (1973) system for teeth #9, 14, 15, and 16. Using the Liversidge and Molleson (2018) modification of the Moorrees et al. (1963) system, root length is determined relative to crown height (see Figure 4.8). For this reason, the Moorrees et al. (1963) system may be easier to apply to maxillary teeth than the Demirjian et al. (1973) system. The Demirjian et al. (1973) system requires determining the shape of the apical foramen to assign a score (see Figures 4.6 and 4.7). For example, if the opening is funnel-shaped, a tooth is assigned a score of F; however, if the walls of the root have begun to close and are parallel to one another, that tooth is assigned a score of G (Demirjian et al. 1973: 223-226). Once the root has reached its full length, the Moorrees et al. (1963) system allows for only two possible scores: apex half closed and

apex closed (see Figures 4.4 and 4.5). Determining whether the apical end of the root remains open or not is a simpler task than determining the shape of that opening, which may explain why the Moorrees et al. (1963) system can be more consistently applied to the maxillary first incisor and molars than the Demirjian et al. (1973) system.

While the previous positioning errors affect an entire jaw, some errors are unique to tooth classes. Images of the anterior teeth, i.e., the incisors and canines, are produced while the X-ray apparatus is in an anterior-posterior position relative to the head; this imaging position means that the cervical vertebrae are in line with the anterior teeth. When the patient is positioned properly, the cervical vertebrae do not obscure the dentition (see Figure 7.1). However, if the patient does not stand straight, the cervical vertebrae block the radiation as it moves anteriorly toward the sensor. This error causes the vertebrae to become more radiopaque, resulting in a wide, bright band across the anterior teeth called a ghost image (Figure 7.4) (Peretz et al. 2012; Perschbacher 2012).

Tooth #24, the mandibular central incisor, produces the lowest Kappa values in the intraobserver error test using the Demirjian et al. (1973) scoring system. While the Moorrees et al. (1963) system exhibits a higher Kappa value for this tooth than the Demirjian et al. (1973) system, the value is still one of the lowest in the intraobserver error test (see Appendix 1). As illustrated in Figure 7.4, the ghost image of the cervical vertebrae completely obscures the roots of the mandibular central incisors, additionally affecting the clarity of the remaining anterior teeth in both the maxillae and mandible. These results are in accordance with previous research that suggests the anterior teeth are the most frequently affected by radiographic errors and are the least diagnostic teeth in orthopantomograms (Peretz et al. 2012).

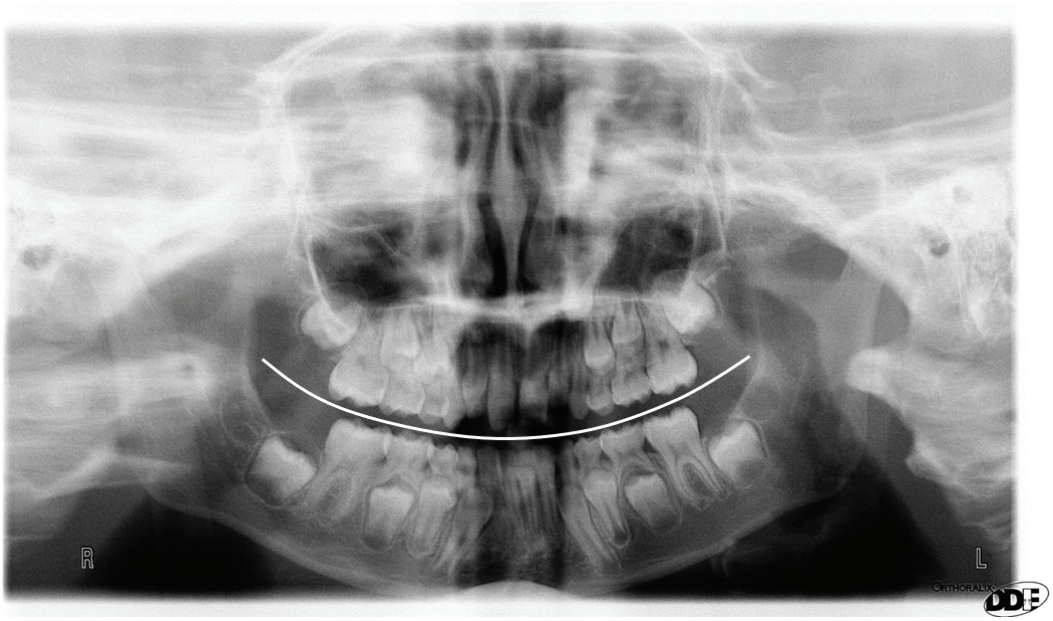


Figure 7.2: Orthopantomogram illustrating proper chin position relative to the radiograph apparatus, creating the "smile" line, outlined in white (Peretz et al. 2012: 2). Radiograph printed with permission of Dr. Hassem Geha (personal communication, Geha 2018).

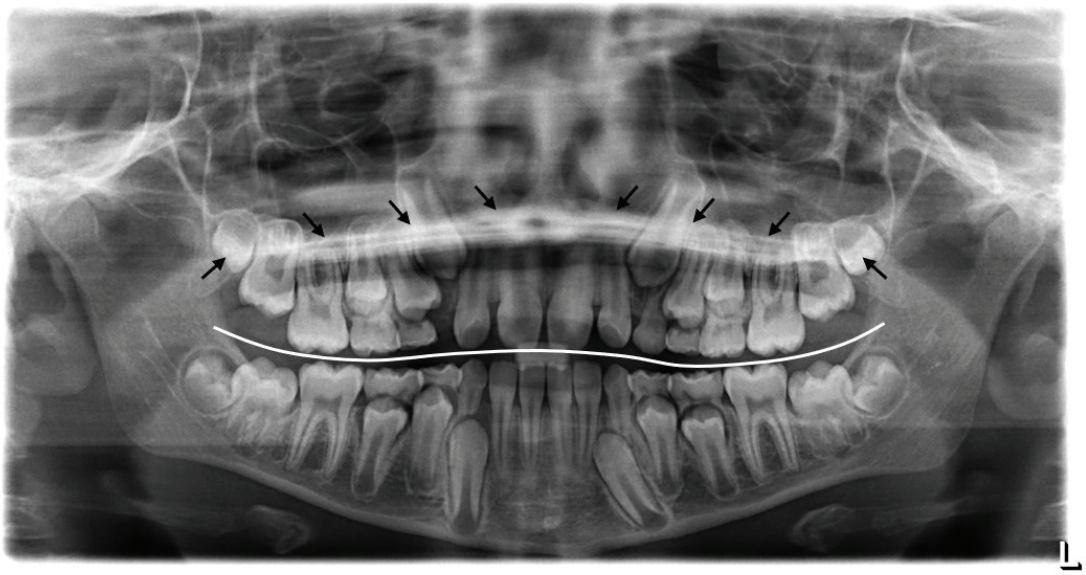


Figure 7.3: Orthopantomogram illustrating improper chin position relative to the radiograph apparatus. The "smile" line is now flattened, outlined in white (Peretz et al. 2012: 2). Additionally, the palatine bones are wider, appearing as a radiopaque white band, highlighted with black arrows. Radiograph printed with permission of Dr. Hassem Geha (personal communication, Geha 2018).

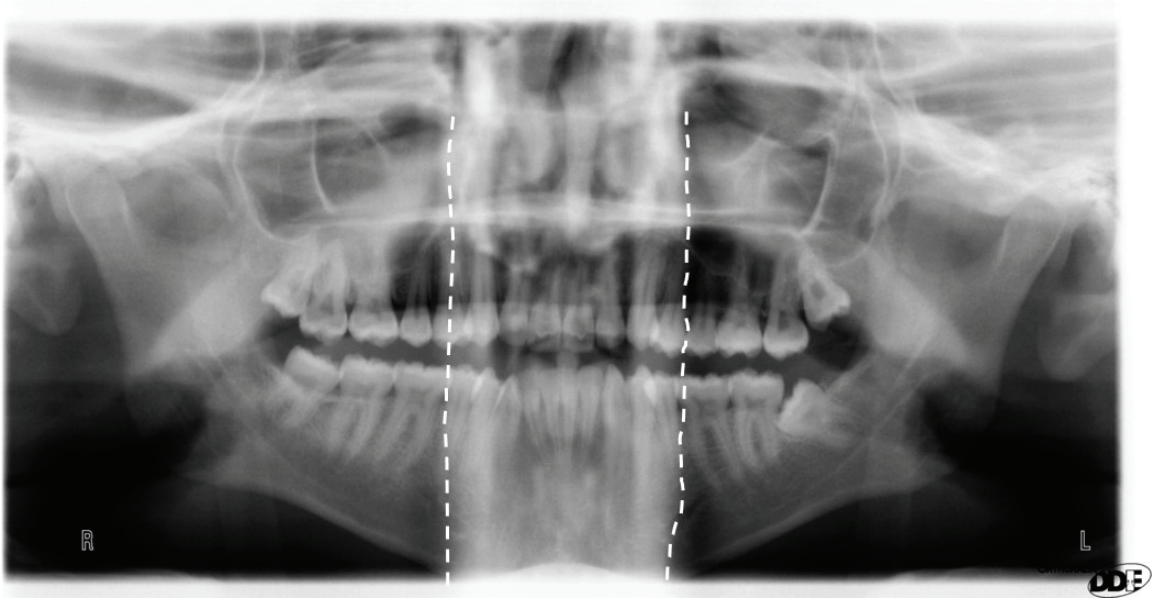


Figure 7.4: Orthopantomogram illustrating the ghost image of cervical vertebrae, outlined with white dashed lines, as a product of not standing straight during orthopantomogram production. Radiograph printed with permission of Dr. Hassem Geha (personal communication, Geha 2018).

Overall, the results of the intraobserver error test suggest that the Demirjian et al. (1973) system can be more consistently applied than the Moorrees et al. (1963) system. For this reason, all subsequent tests were performed using the Demirjian at al. (1973) scores. This system is one of the most widely applied for scoring dental development (Yan et al. 2013); therefore, the age estimation methods to follow can easily be adopted into a forensic context. It is additionally important to note that Kappa values are higher in the mandibular teeth using the Demirjian et al. (1973) system, as this finding may apply to later results.

7.2: Sex and Ancestry Differences Measured by Kruskal-Wallis and Dunn's Tests

While results of the Kruskal-Wallis and Dunn's tests were presented by separating sex, ancestry, and sex/ancestry, the discussion considers these variables

together (Dunn 1964; Kruskal and Wallis 1952). Additionally, rather than discussing results in order of variable, discussion proceeds by chronological age categories, as defined by Bogin (1999). This discussion not only allows the interplay between sex and ancestry to be considered, but patterns in the prevalence of differences across the developmental span can be noted as well. After discussing sex and ancestry differences by biological periods, differences are summarized across the whole age range.

7.2.1: Sex and Ancestry Differences during the Childhood Period (Years 5-6)

Females and males exhibit no significant differences during childhood (see Table 5.2). In fact, females and males exhibit higher developmental scores in relatively equal proportions in the childhood subset (see Appendix A2.17.1), suggesting that sex differences in the rate of dental development have not yet appeared. Liversidge (2010) suggests that sex differences are most pronounced during the root stages of dental development. At ages five and six, the permanent canines, premolars, and molars exhibit a mixture of crown and root developmental stages[5]. Any sex differences in the root stages during childhood may be lessened by the presence of crown stages exhibiting lower levels of sexual dimorphism.

Individuals during childhood also exhibit the fewest significant differences between ancestry groups, both in total and divided by sex (see Appendices A2.17.2-A2.17.4). Overall, European American developmental scores are lowest during childhood, followed by the Asian American and African American samples, while the Hispanic sample exhibits the highest Demirjian et al. (1973) scores (see Appendix

[5] In the Demirjian et al. (1973) scoring system, stages A-D focus on changes in the tooth crown, while stages E-H are concerned with root development.

A2.17.2). This pattern generally agrees with the pattern of dental development observed across the entire age range (see Table 5.13), though the Hispanic sample is narrowly surpassed by the African American sample when all ages are considered. No comparisons could be made to the Native American sample during childhood, as this ancestry group comprises no individuals below the age of eight years (see Table 4.2).

7.2.2: Sex and Ancestry Differences during the Juvenile Period (Years 7-11)

Differences are most pronounced during the juvenile period at all levels of comparison: sex, ancestry, and sex/ancestry (see Tables 5.2, 5.5, 5.8, and 5.11). Females in the juvenile period exhibit advanced dental development (see Appendix A2.18.1). The canines demonstrate the greatest level of sexual dimorphism, which is consistent with other studies (e.g., Anderson et al. 1976; Liversidge 2010, 2016a).

In this study, the female sample exhibits higher scores for tooth #16 during the juvenile period (see Appendix A2.18.1). The juvenile period is the first time the third molar is recorded as present in this dataset, which means this tooth is in its earliest developmental stages during these years. As previously stated, sex differences are most extreme in root stages (Liversidge 2010), and for the third molar specifically, researchers have found that female development is either ahead of or like males in the early developmental stages (e.g., AlQahtani et al. 2010; Anderson et al. 1976; Levesque et al. 1981; Prieto et al. 2005).

During the juvenile period, European American and Asian American samples exhibit the lowest Demirjian et al. (1973) scores, followed by African American and Hispanic samples respectively, with the Native American sample exhibiting the highest developmental scores (see Appendix A2.18.2). As these results are not consistent with

the overall pattern of dental development by ancestry group (see Table 5.13), it is worth discussing the statistical methods in use. Kruskal-Wallis and Dunn's tests are designed to compare samples to find significant differences in the variable under consideration, in this case, developmental scores (Dunn 1964; Kruskal and Wallis 1952). Since the juvenile period covers a range of five years, the Kruskal-Wallis and Dunn's tests may be tuning into differences in the age distribution of the ancestry groups, rather than true population differences.

As a practical example, consider the Native American sample. When all significant differences are considered across the whole age range, the Native American sample exhibits the lowest developmental scores (see Table 5.13), but the scores for this ancestry group are highest during the juvenile period (see Appendix A2.18.2). This disparate result can be explained by a difference in age distribution (Figure 7.5). The Native American sample includes no individuals below the age of eight, and at year eight, there are only two male individuals (see Table 4.2). Conversely, the other four ancestry groups under comparison include representatives at all five years of the juvenile period. In fact, year eight has the highest number of individuals in the whole range (see Table 4.2). Therefore, the Native American sample appears to exhibit the highest developmental scores during the juvenile period because the Kruskal-Wallis and Dunn's tests are essentially comparing years 9-11 for the Native American sample to years 7-11 for the other ancestry groups.

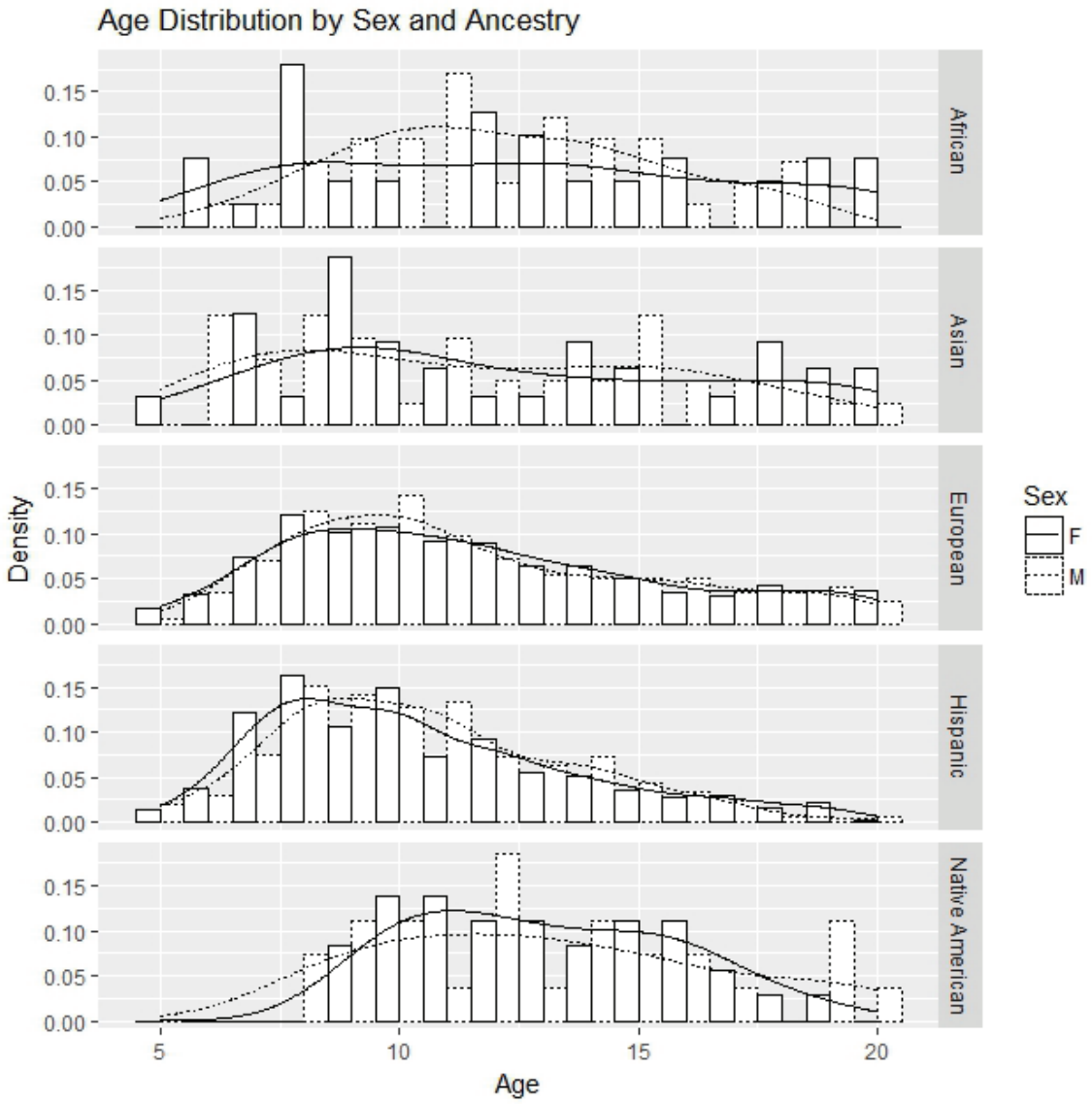


Figure 7.5: Age distribution of ancestry groups in total sample, divided by sex.

The remainder of the ancestry groups exhibit a pattern of developmental scores consistent with the results from the whole age range (i.e., European American and Asian American samples exhibit the lowest scores, followed by African American and Hispanic samples) (see Table 5.13). However, the result of the Native American sample during the

juvenile period is likely a product of sample distribution, rather than true population differences.

During the juvenile period, Asian American and African American female samples exhibit the lowest Demirjian et al. (1973) scores, followed by the European American and Hispanic female samples, with Native American females exhibiting the highest developmental scores (see Appendix A2.18.3). The results of the Native American female sample can again be explained by the age distribution (see Figure 7.5). Overall, the European American male sample exhibits the lowest developmental scores during the juvenile period, followed by the Asian American and Native American male samples with similar scores, then the Hispanic male sample, and finally the African American male sample exhibits the highest Demirjian et al. (1973) scores. The male ancestry pattern more closely reflects the pattern observed across the whole age range (see Table 5.13). The age distribution of the male ancestry groups may be less of a confounding variable during the juvenile period than that of the female ancestry groups (see Table 4.2).

Two years during the juvenile period yield noteworthy results. Of the whole age range, year eight produces the most significant differences between ancestry groups and sex/ancestry groups. The Kruskal-Wallis tests identify 13 teeth that demonstrate significant differences ($\alpha < 0.05$) between total ancestry groups (see Appendix A2.4.2) and nine teeth that demonstrate significant differences during both sex/ancestry comparisons (see Appendices A2.4.3-A2.4.4). The second noteworthy year is age nine, as this year has the greatest number of significant differences between females and males

of the whole age range. At nine years, nine teeth exhibit significantly different developmental scores between the sexes when ($\alpha < 0.05$) (see Appendix A2.5.1).

The increase in significant differences during years eight and nine may be related. As is the case for epiphyseal fusion (e.g., Cunningham et al. 2016; Cutler 1997; Grumbach 2000; Shapland and Lewis 2014), a link has been suggested between the emergence of the dentition and somatic development (e.g., Garn et al. 1965; Helm 1969; Liversidge 2016a; Maj et al. 1964), though some researchers disagree with this conclusion (e.g., Demirjian et al. 1986). The active eruption phase of the dentition is initiated shortly after root development has begun (Liversidge 2016b); therefore, the processes of emergence and development should be closely related.

Age nine demonstrates the highest number of significant differences between the female and male samples (see Appendix A2.5.1). According to Bogin (1999), the end of the juvenile period is the point at which puberty begins. In females, the juvenile period ends at age 10, while this cut-off is age 12 for males (Bogin 1999). If dental emergence, and by extension development, is linked to somatic development, then sexual differences in dental development should be most apparent during puberty. However, hormonal changes do not suddenly occur with the onset of puberty; hormone levels increase gradually, as evidenced in the process of adrenarche (Parker 1991; Parker et al. 1978).

Adrenarche is a period during which the production of androgen hormones gradually increases in the adrenal cortex, in both females and males, and this process occurs between ages six and eight. Adrenarche and puberty are related processes, though the increase in androgen hormones occurs before the increase in gonadotropin hormones associated with puberty (Parker 1991). Androgen hormones stimulate osteoblastic

activity in both sexes, contributing to the increase in bone length during puberty (e.g., Demirjian et al. 1986; Parker 1991; Stull 2013). Age nine is the year before the juvenile period should end in females and the year after which the process of adrenarche should be complete (Bogin 1999; Parker 1991). Therefore, androgen hormones being released prior to the hormonal changes associated with puberty may contribute to the high number of significant differences in developmental scores during this year. Adrenarche and puberty are not causally related (Parker 1991), but this increase in hormones may still be contributing to the increase in differences between females and males at age nine (see Appendix A2.5.1).

Age eight exhibits the most significant differences between ancestry groups, in the total comparison and in the female and male ancestry comparisons (see Appendices A2.4.2-A2.4.4). Differences in the rates of dental development between ancestry groups in the United States have been suggested by previous research (e.g., Blankenship et al. 2007; Garn et al. 1972; Garn et al. 1973b; Harris 2007; Harris and McKee 1990; Kaiser and Senn 2004; Kasper et al. 2009; Lewis and Senn 2010; Solari and Abramovitch 2002), and ancestry differences are acknowledged in the rate of skeletal development (e.g., Eveleth and Tanner 1990; Lewis et al. 2002; Spradley et al. 2008; Steyn and İşcan 1998). If adrenarche and the increase in androgen hormones contribute to the increase in sex differences observed in year nine, it is possible the same process can explain the highest number of significant differences between ancestry groups in year eight. Variation exists in the rates of dental and skeletal development between ancestry groups; if these populations also reach puberty at different rates, then adrenarche initiates at different ages. The ancestry differences at age eight suggest that the African American, Asian

American, and Hispanic samples exhibit significantly higher developmental scores, i.e., advanced dental development, compared to the European American samples (see Appendix A2.4.2). If European American populations reach puberty at later ages than other ancestry groups, this could explain the ancestry differences at age eight. The effects of adrenarche may not have contributed to meaningful changes in the dental development of the European American sample at this age, while the other ancestry groups may have initiated adrenarche at an earlier age, thereby spending extra years accumulating increased androgen hormones.

7.2.3: Sex and Ancestry Differences during the Adolescent Period (Years 12-20)

The Kruskal-Wallis and Dunn's tests identify fewer significant differences during the adolescent period in all levels of comparison than were identified in the juvenile sample, even though the adolescent period covers a nine-year range compared to the five years of the juvenile period (see Tables 5.2, 5.5, 5.8, and 5.11). In the mandible, most permanent teeth have completed the developmental process either before the adolescent period (e.g., incisors and first molars) or shortly after this period begins (e.g., canines, premolars, and second molars) (Liversidge 2009). Aside from Demirjian et al. (1973) scores of D recorded for P2 and M2 (which occur only in years 12 and 13, respectively), all teeth excluding the third molar exhibit only root stages of development during adolescence. With nearly all teeth having completed crown formation, fewer differences exist between the developmental scores assigned to individuals during the adolescent period, which inherently means there are fewer differences to be found.

Care should be taken when interpreting results from the adolescent period. The sample distribution is heavily skewed toward the juvenile period (n = 83 in childhood; n

= 955 in juvenile period; n = 719 in adolescence) (see Table 4.2). Not only are there fewer total individuals in the adolescent period, but this number is spread across a longer time span; starting at age 15, there are fewer than 100 individuals in the total sample for each year. As the sample is further divided into sex, ancestry, and sex/ancestry groups, significant differences should be approached with caution, as the number of individuals under comparison may be too small to generate meaningful results.

In the adolescent sample, male developmental scores are higher than female scores for four teeth, including both third molars (see Appendix A2.19.1). Though this result is not of statistical significance, advanced male development in the third molar is in agreement with previous research (e.g., Anderson et al. 1976; Arany et al. 2004; Engström et al. 1983; Garn et al. 1962; Gunst et al. 2003; Harris 2007; Kasper et al. 2009; Knell et al. 2009; Kullman et al. 1992; McGettigan et al. 2011; Mesotten et al. 2002; Mincer et al. 1993; Prieto et al. 2005; Sisman et al. 2007; Solari and Abramovitch 2002). The lack of significant male advancement may be due to the wide age range represented by the adolescent period. Female developmental scores may be higher in the third molar during earlier stages of development, which would occur during the beginning of adolescence (Liversidge 2010). Therefore, the magnitude to which male development is advanced relative to females during later stages of the third molar may be dampened in the analysis of the entire adolescent sample.

Overall, the Hispanic sample exhibits the lowest Demirjian et al. (1973) scores during adolescence, followed by Native American and European American samples, with African American and Asian American samples exhibiting the highest developmental scores (see Appendix A2.19.2). As was the case in the juvenile period, this pattern does

not agree with the overall pattern of dental development observed across the entire age range (see Table 5.13), and the adolescent departures from the overall pattern are likely a product of differing sample sizes. The Hispanic sample, particularly the males, have very few individuals in the top of the age range (n = 20 total for years 18-20, n = 5 for Hispanic males in the same range) (see Table 4.2). During these three years, all teeth but the third molars should have finished development, i.e., should exhibit a Demirjian et al. (1973) score of H. With very little representation during these three years, the average developmental score of the Hispanic sample is likely decreased relative to the other ancestry groups.

The African American and Asian American samples both exhibit the highest developmental scores during the adolescent period (see Appendix A2.19.2). While no data currently exist regarding the relationship between the developmental rates of African American and Asian American populations, this conclusion does not agree with the overall ancestry pattern seen in the significant differences across the entire age range (see Table 5.13). As was the case during the juvenile period, the Kruskal-Wallis and Dunn's tests likely detect differences in the sample distribution and identify them as differences between ancestry groups. The age distribution of the African American and Asian American samples is relatively similar (see Figure 7.5), and both samples include comparatively more individuals at the higher end of the age range than the other three ancestry groups (see Table 4.2).

The age distribution of the sample likely contributes to the pattern of development in female ancestry groups during the adolescent period. The Hispanic and Native American female samples exhibit the lowest developmental scores during the adolescent

period, followed by the European American and African American female samples, with Asian American females exhibiting the highest Demirjian et al. (1973) scores (see Appendix A2.19.3). The decreased Hispanic female scores and increased Asian American female scores are likely a product of the age distribution again (see Figure 7.5).

In the comparison of male ancestry groups, the Kruskal-Wallis test identifies three teeth that demonstrate significant differences between groups (#15, 17, and 24) (see Appendix A2.19.4). Tooth #24 is the mandibular central incisor, and it is worth addressing why this tooth might exhibit significant differences during this period. In the pair-wise comparisons, the Asian American male sample exhibits significantly lower scores for tooth #24 compared to the African American, Hispanic, and Native American male samples at $\alpha = 0.05$ and compared to the European American sample at the Bonferroni corrected $\alpha = 0.000284$ (see Appendix A2.19.4). Since Liversidge (2009) suggests that the central incisor should have ceased development before the adolescent period begins, the significance of these results is unusual. It is possible an error in assessing or recording scores occurred in the Asian American male sample. Tooth #24 exhibits one of the highest intraobserver error rates (see Appendix 1), and as previously mentioned, the mandibular central incisors can be completely obscured by a ghost image of the cervical vertebrae when the patient is not properly positioned. Since there are only 19 Asian American male individuals in the adolescent subset (see Table 4.2), any aberrant scores may be more heavily weighted in the analysis.

Overall, the Hispanic male sample exhibits the lowest Demirjian et al. (1973) scores during the adolescent period, followed by the European American males, then Asian American and Native American males, with the African American male sample

exhibiting the highest developmental scores (see Appendix A2.19.4). The European American, Asian American, and African American male samples exhibit similar age distributions to one another during the adolescent period (see Figure 7.5). The Hispanic male average developmental scores likely decrease due to the lack of individuals at the top of the age range, while the Native American male sample likely experiences an increase in the average developmental score due to a relative increase in individuals at the top of the age range. Otherwise, the European American, Asian American, and African American male samples are exhibiting the same pattern during the adolescent period as observed in the significant differences through the whole age range (see Table 5.13).

Considering the teeth individually, all differences that are significant at the Bonferroni corrected alpha level during the adolescent period are between females and males. Two of the three teeth that exhibit significant differences at the Bonferroni corrected $\alpha = 0.0015625$ are canines (see Table 5.3). Liversidge (2010) suggests that, of all the teeth, sex differences are most pronounced in the ages of attainment of Demirjian et al. (1973) stage H in the canine. Since the development of the canine should be complete shortly after the adolescent period begins (Liversidge 2009), the Bonferroni significant differences in the canine between females and males during the adolescent period are consistent with previous research.

7.2.4: Overall Sex and Ancestry Differences (Years 5-20)

Most comparisons between females and males in the current study suggest that developmental scores are not significantly different (see Table 5.1). However, while the proportion is small, significant differences do exist. This result lends support to the first hypothesis of this dissertation research: that sex and ancestry groups undergo dental

development at different rates. When differences do exist, nearly all cases indicate female developmental scores are higher than male scores (39 instances across 16 years), and only females exhibit developmental scores that are significantly higher at the Bonferroni corrected $\alpha = 0.0015625$ (see Table 5.1). Male developmental scores are significantly higher than female scores twice, once at age seven (#17) and once at age 20 (#16) (see Appendices A2.3.1 and A2.16.1).

When significant differences are considered across the age range, canines exhibit the greatest proportion of significant differences between females and males (see Table 5.3 and Figures 5.1-5.2). This conclusion supports the sexually dimorphic nature of these teeth (e.g., Anderson et al. 1976; Liversidge 2010, 2016a; Mayhall 2000). Molars exhibit the next highest proportion of significant differences between the sexes, with the third molars demonstrating significance most often (see Table 5.3). The two instances in which male developmental scores were significantly higher than females scores are both third molars: the mandibular third molar at the initiation of development and the maxillary third molar in the later root and apex development stages. These results, in which female dental development is advanced relative to males except in the third molar, are consistent with previous research (e.g., Anderson et al. 1976; Arany et al. 2004; Engström et al. 1983; Garn et al. 1962; Gleiser and Hunt 1955; Gunst et al. 2003; Kasper et al. 2009; Knell et al. 2009; Kullman et al. 1992; McGettigan et al. 2011; Mesotten et al. 2002; Mincer et al. 1993; Moorrees and Kent 1978; Nolla 1960; Prieto et al. 2005; Schour and Massler 1941; Sisman et al. 2007; Solari and Abramovitch 2002).

When significant differences are summarized from the total ancestry and both sex/ancestry comparisons, premolars exhibit the highest proportion of significant

differences between ancestry groups. Incisors exhibit the next highest proportion of significant differences between ancestry groups, though none are significant at the Bonferroni alpha level (see Table 5.14). This result disagrees with previous research on the subject, at least to a degree. Garn and colleagues (1973b) compared dental eruption between American black and white individuals, and the incisors yielded the most significant differences between the two samples, followed by the molars, with premolars and canines demonstrating the fewest differences. The level of significance observed in the premolars in the current study is not in accordance with previous work, though the high proportion of significant differences in the incisors supports the conclusion of Garn and colleagues (1973b).

Many studies have been conducted on population differences in dental development. Among those that analyze all teeth, American black individuals exhibit earlier ages of emergence than American white individuals (e.g., Garn et al. 1972; Garn et al. 1973b). Native American populations exhibit mixed results when compared with other ancestry groups. Some researchers suggest Native American groups exhibit earlier development and eruption compared to European American and African American samples (e.g., Garn and Moorrees 1951; Owsley and Jantz 1983; Steggarda and Hill 1942), while other studies find Native American development and eruption are advanced in the posterior dentition compared to European American groups but delayed in the anterior dentition (e.g., Dahlberg and Menegaz-Bock 1958; Tompkins 1996).

In studies based on samples from the United States, most research is focused on population differences in the third molars. American black individuals reach third molar developmental stages approximately one year earlier than American white individuals

(e.g., Blankenship et al. 2007: 430; Gorgani et al. 1990; Harris 2007: 102; Harris and McKee 1990; Kaiser and Senn 2004), while Hispanic individuals reach developmental stages between 8 and 18 months earlier than American white samples (e.g., Kasper et al. 2009: 653; Solari and Abramovitch 2002). In a literature review on population differences in third molar development, Lewis and Senn (2010: 83) found African American individuals reached developmental stages earliest, followed by Hispanic individuals about 0.5 years later, with European American individuals reaching developmental stages latest approximately 0.5 years after the Hispanic sample and one year after the African American sample. Few data have been collected on Asian American samples. Drvostep and Senn (2017) found Texas Asian individuals reach developmental stages ahead of either Texas Hispanic or American white individuals but no comparison has been made to American black individuals.

Based on the z-scores from significant differences across the whole age range, the Native American sample exhibits the lowest developmental scores, followed by the European American and Asian American samples respectively, with the Hispanic and African American samples exhibiting the highest developmental scores (see Table 5.13). The results of the present study concur with the conclusion that individuals of African American ancestry develop their dentition earlier than individuals of European American ancestry (e.g., Blankenship et al. 2007; Garn et al. 1972; Garn et al. 1973b; Gorgani et al. 1990; Harris 2007; Harris and McKee 1990; Kaiser and Senn 2004), as well as studies that suggest that Hispanic dental development is advanced compared to European American individuals (e.g., Kasper et al. 2009; Solari and Abramovitch 2002). The current study diverges only slightly from the conclusion of Lewis and Senn (2010) that

American blacks reach developmental stages earlier than Hispanics. Significant differences between African American and Hispanic individuals are evenly distributed between positive and negative z-scores (see Table 5.13), suggesting that neither ancestry group is consistently developmentally advanced. However, both the African American and Hispanic sample consistently demonstrate higher developmental scores than the European American sample, a conclusion in accordance with Lewis and Senn (2010).

The current study diverges from the results presented by Drvostep and Senn (2017) regarding Asian dental development. These authors suggest Texas Asian individuals reach developmental stages before both Texas Hispanic and American white individuals. The current results suggest Asian American individuals are advanced relative to the European American sample but delayed relative to the Hispanic sample (see Table 5.13). Finally, based on the significant differences across the entire age range, the Native American sample exhibits the lowest developmental scores, a conclusion that is not in agreement with previous research on Native American dental development (e.g., Dahlberg and Menegaz-Bock 1958; Garn and Moorrees 1951; Owsley and Jantz 1983; Steggarda and Hill 1942; Tompkins 1996).

The areas in which the present study diverges from previous research regarding ancestry differences in rates of dental development could be explained by the sample distribution. Instead of African American dental development being consistently advanced relative to Hispanic development, as suggested by Lewis and Senn (2010), the current study finds the developmental pace of these two ancestry groups is relatively equal. That is, neither African American nor Hispanic individuals consistently exhibit significantly higher developmental scores. Both samples are developmentally advanced

in a nearly equal number of cases (see Table 5.13). The African American sample in this study is represented by fewer individuals than the Hispanic sample (n = 80 and n = 672, respectively) (see Table 4.2). Therefore, it is likely the Hispanic sample is a better representation of the normal variation within this ancestry group than the African American sample. With a larger sample size, it is possible that the African American sample could exhibit higher Demirjian et al. (1973) scores.

The Asian American sample in this study is also underrepresented (n = 73) (see Table 4.2). The small sample size could explain why the results in the present study are not in complete agreement with Drvostep and Senn (2017). It is possible that a larger Asian American sample would better capture the relationship between the Asian American and Hispanic populations. However, the possibility exists that the differences observed in this study are real, as opposed to artifacts of sample size. In most cases in which significant differences were found across the entire age range, the Hispanic sample exhibits higher developmental scores than the Asian American sample (20 of 23 cases) (see Table 5.13). If the Asian American population truly reaches developmental stages earlier than the Hispanic population, the expectation is that more than three significant differences would favor the Asian American sample, even with a small sample size (as was the case with the African American-Hispanic comparison).

Another possibility is that neither Drvostep and Senn (2017) nor the present study is incorrect about the relationship between Asian and Hispanic individuals. Perhaps the physical location of the samples contributes to the contrasting results. The composition of the Hispanic samples does not differ greatly between these two studies. Drvostep and Senn (2017) utilized Hispanic individuals from San Antonio, TX. The current Hispanic

sample is also primarily from UT (n = 446), with fewer individuals from UNM (n = 190) and OHSU (n = 36). Therefore, differences in the location of the Hispanic samples likely do not contribute to this result. However, while Drvostep and Senn (2017) also utilized Asian individuals from San Antonio, TX, the Asian American sample in the current study is comprised of 6 individuals from UT, 25 individuals from UNM, and 42 individuals from OHSU. Most of the current Asian American sample is from Oregon, compared to the Drvostep and Senn (2017) sample that was entirely from Texas. Asian samples from these two areas of the country may have different population histories, contributing to the seemingly disparate rates of dental development.

According to demographic data reported in the 2010 U.S. Census, the ethnic groups with the highest representation in the Asian population in Texas are Asian Indian, Vietnamese, Chinese (except Taiwanese), Korean, and Pakistani (Figure 7.6) (U.S. Census 2010c). In Oregon, the ethnic groups with the highest proportions in the Asian population are Chinese (except Taiwanese), Vietnamese, Asian Indian, Filipino, Korean, and Japanese (Figure 7.7) (U.S. Census 2010b). The Asian population in Texas includes higher proportions of ethnic groups from South Asia (e.g., Asian Indian, Pakistani, Nepalese, Burmese, Bhutanese, and Bangladeshi), while the Asian population in Oregon includes higher proportions of ethnic groups from East Asia (e.g., Chinese, Korean, Japanese, Thai, Laotian, Indonesian, Hmong, and Cambodian). It is possible that individuals from different areas of Asia also exhibit differences in the rates of dental development, and the differing Asian sample compositions of the present study compared to that of Drvostep and Senn (2017) may explain the disparate results.

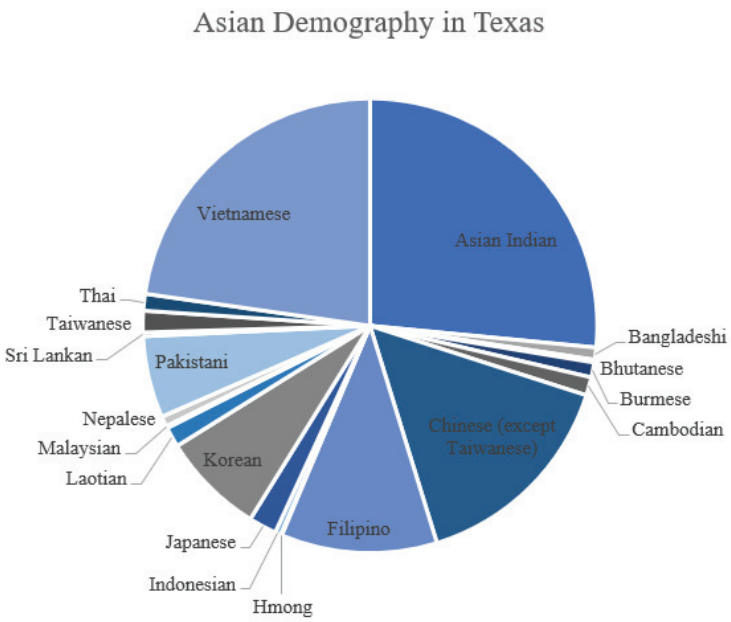


Figure 7.6: Demography of Asian population in Texas, as reported by 2010 U.S. Census (U.S. Census 2010c).

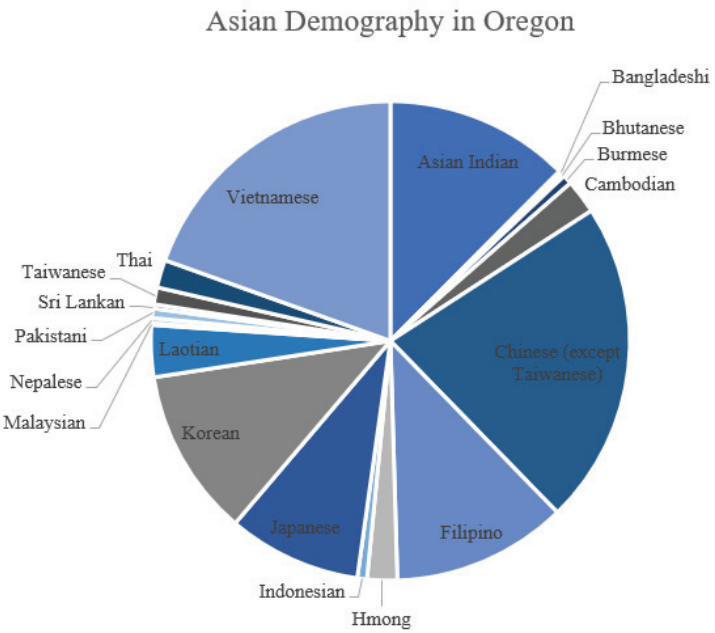


Figure 7.7: Demography of Asian population in Oregon, as reported by 2010 U.S. Census (U.S. Census 2010b).

Of all the pair-wise comparisons, the European American and Hispanic samples exhibit the most significant differences, in the total ancestry comparison and both sex/ancestry comparisons (see Table 5.13 and Figures 5.3-5.8). The differences between these two ancestry groups overwhelmingly indicate that Hispanics exhibit higher developmental scores, and advanced dental development, compared to the European American sample, a conclusion in agreement with previous research (e.g., Kasper et al. 2009; Solari and Abramovitch 2002). These two ancestry groups are the largest in the dataset (n = 865 for European American sample, n = 672 for Hispanic sample) (see Table 4.2). Therefore, the relative developmental delay of the European American sample compared to the Hispanic sample captured by the Kruskal-Wallis and Dunn's tests is likely representative of true population differences.

The Native American sample exhibits the lowest developmental scores through the age range, suggesting a developmental delay relative to the other ancestry groups. This result may be in accord with some of the conclusions of previous research: Native American samples have demonstrated later ages of eruption and development in the anterior dentition compared to European American samples (e.g., Dahlberg and Menegaz-Bock 1958; Tompkins 1996). However, the Native American sample exhibiting the lowest developmental scores is contradictory to many findings in the literature, where Native American eruption and development is advanced relative to European American and African American samples, in either the posterior dentition only (e.g., Dahlberg and Menegaz-Bock 1958; Owsley and Jantz 1983; Tompkins 1996) or all teeth (e.g., Garn and Moorrees 1951; Steggarda and Hill 1942). This disparate result may be a product of sample size.

Apart from the Hawaiian sample (n = 4), Native Americans are the most underrepresented group (n = 63) (see Table 4.2). As was the case with the African American and Asian American samples, a larger sample size may better capture the relationship between Native American individuals and the other ancestry groups under consideration. However, as was argued for the Asian American sample, more significant differences would be expected to favor the Native American sample if this population truly reaches dental developmental stages earlier than other ancestry groups (see Table 5.13).

There may also be a temporal component contributing to the disparate results. Many studies that examine differences in dental development of Native American populations utilize skeletal material from archaeological contexts (e.g., Owsley and Jantz 1983; Tompkins 1996). Even those studies that examine living individuals are no longer considered modern in the forensic sense, i.e., less than 50 years old (e.g., Dahlberg and Menegaz-Bock 1958; Garn and Moorrees 1951; Steggarda and Hill 1942). The effects of secular change on the process of dental development are under debate; individuals may reach developmental stages at earlier ages than in previous generations (e.g., Cardoso et al. 2010; Heuzé and Cardoso 2008; Nadler 1998; O'Neill 2012; Sasso et al. 2012), at later ages (e.g., Rautman and Edgar 2013), or perhaps at similar mean ages across time periods (e.g., Liversidge 1999; Muller-Bolla et al. 2003).

Regardless of direction, most authors agree secular change influences dental development, even within the past 50 years or less (e.g., Cardoso et al. 2010; Heuzé and Cardoso 2008; Nadler 1998; O'Neill 2012; Rautman and Edgar 2013; Sasso et al. 2012). Apart from the study by Heuzé and Cardoso (2008) that compared historic Portuguese

children to individuals from Europe, Africa, and the Middle East, each study on secular change focused on either European or European-derived samples (e.g., Cardoso et al. 2010; Nadler 1998; O'Neill 2012; Rautman and Edgar 2013; Sasso et al. 2012). Research confirms that secular change has affected individuals of European American ancestry in a period of only 50 years, but no such data are available for Native Americans. Therefore, without understanding how secular change has affected Native American populations, it is impossible to know whether the disparate results from the current study are a product of small sample size or are a product of comparing results from modern individuals to those derived from historic or archaeological samples.

Overall, the z-scores from significant differences across the whole age range indicate females develop their dentition earlier than males (see Table 5.1). Across ancestry groups, the Native American sample exhibits the lowest developmental scores and the most delayed dental development, followed by the European American and Asian American samples, with the Hispanic and African American samples exhibiting the highest developmental scores and the most advanced dental development (see Table 5.13).

While some significant differences exist between sex, ancestry, and sex/ancestry groups, there are many more instances in which no significant difference exists. Consider the European American and Hispanic comparison: there are 59 significant differences in the total ancestry test (see Table 5.4). However, 16 teeth are being compared every year across a span of 16 years. Considering teeth that could not be compared, a total of 215 pair-wise comparisons were performed between the European American and Hispanic samples (see Table 5.4). This means that the European American

and Hispanic samples exhibit significant differences in only 27.44% of pair-wise comparisons, and these two groups exhibit the highest number of differences of all the comparisons performed. Therefore, while significant differences exist between the sexes and ancestry groups, supporting the first hypothesis, these differences should be kept in perspective. Differences may be of a low enough magnitude that age estimation methods are not affected, a conclusion that has been proposed by other authors (e.g., Konigsberg et al. 2008; Liversidge 2010).

7.3: Confidence Interval Performance – CIs based on All Individuals vs. CIs based on Subsets

The trend across comparisons is for no significant differences in accuracy rates to exist between the CIs created from the total training sample and the specific CIs created from subsets divided by sex, ancestry, and sex/ancestry (see Table 5.15). Before discussing the significant differences that do occur, the sample sizes within the test set should be addressed. Any results obtained from the African American, Asian American, and Native American individuals in the test set should be evaluated with caution. The sample size for these three groups is very small in the test set (n = 3 African American individuals, n = 4 Asian American individuals, and n = 4 Native American individuals). Differences in accuracy rates between the CIs based on all individuals and those based on subset of the training sample are likely inflated as a product of small sample sizes, especially as the ancestry groups are divided by sex. Conversely, results that do not exhibit significance may also be affected by sample size; it is possible that certain teeth or comparisons would exhibit statistical significance with a larger sample. Therefore,

statistically significant differences in the confidence intervals derived from these ancestry groups will be discussed, but these differences should be interpreted with caution.

If significant differences do occur, the CIs based on subsets perform better than the CIs based on all individuals; however, none of these differences exhibit significance at the Bonferroni corrected $\alpha = 0.000173$ (see Table 5.15). Apart from the single comparison in which the Native-American-specific CI outperforms the CI based on all individuals, all significant differences occur while comparing the CIs based on all individuals to Hispanic-specific CIs. Most of these differences favor the Hispanic CIs (5 of 6 cases) (see Table 5.15). The relationship between the European American and Hispanic samples could explain why the Hispanic-specific CIs exhibit increased accuracy. These two ancestry groups exhibit the highest number of significant differences in Demirjian et al. (1973) scores through the whole age range (see Table 5.13), with Hispanic individuals exhibiting advanced development relative to European American individuals. Additionally, the European American sample ($n = 865$) is better represented in the total dataset than the Hispanic sample ($n = 672$) (see Table 4.2). The overrepresentation of the European American sample, and the relative developmental delay of this group, may be skewing the CIs created from the entire training sample toward older ages, which could explain why the Hispanic sample is experiencing increased accuracy with the CIs based upon the Hispanic subsets.

The African American and Asian American samples exhibit no significant differences when the CIs based on all individuals are compared to those based on subsets. If these populations were better represented, it is possible the observed differences could reach statistical significance (see Appendix 4). However, the Native American sample

exhibits higher accuracy for all teeth combined using the Native American-specific CI range (see Table 5.15). The Native American sample exhibits significantly delayed dental development relative to all other ancestry groups, which could explain why the CI based on the Native American subset is more accurate for all teeth combined (see Table 5.13); the CIs based on all individuals are likely being skewed toward younger ages than the Native American developmental pace. In the one-tailed tests to determine whether the Native-American-specific CIs are more accurate, the p-values for three additional teeth are below 15% (see Appendix A4.7). As with the African American and Asian American samples, the differences observed between the CIs based on all individuals and those based on the Native American subset may or may not have reached statistical significance with the inclusion of more individuals.

When teeth are considered individually, the trend is for no significant differences in accuracy rates between the CIs created from the total training sample and the specific CIs created from subsets divided by sex, ancestry, and sex/ancestry (see Table 5.16). By tooth class, premolars exhibit significant differences between the CIs based on all individuals and those based on subsets slightly more often than molars, and no anterior teeth yield any significant results (see Table 5.16). In the context of sex and ancestry differences in dental development, this result makes sense. Premolars exhibit the highest proportion of significant differences between ancestry groups, while molars yield the second highest proportion of significant differences between sexes (see Tables 5.3 and 5.13). Since the posterior teeth demonstrate high proportions of significant differences between sex and ancestry groups, it is unsurprising that these teeth also exhibit the only

differences between the CIs based on the entire training set and those based on subsets of the training set (see Table 5.16).

Confidence intervals created from the entire training sample are narrower than the CIs based on subsamples in nearly all comparisons (98.48% of cases) (see Table 5.17). However, it should be noted that the differences are not extreme. To reference the age estimation example with Subject A, the greatest difference between CIs based on all individuals and those based on subsets occurs at tooth #16. The CI based on all individuals for a Demirjian et al. (1973) score of A is 0.493 years wide, while the European-American-female-specific CI is 1.189 years wide (see Table 6.2). While the CI based on all individuals is narrower, the widths are within one year of each other. Precision of specific CIs is poorer in samples comprising fewer individuals, but differences are typically minimal. In other words, the precision of the CIs based on all individuals is likely comparable to the specific CIs for the better represented subsamples, e.g., female, male, European American, and Hispanic (see Appendix 3).

Considering accuracy and precision together, the overall trend is that there are no significant differences between the confidence intervals derived from the entire training set and the confidence intervals created from subsets divided by sex, ancestry, and sex/ancestry. These results do not support the second hypothesis being tested by this dissertation research: that sex- and ancestry-specific methods of age estimation will perform better than general methods. When significant differences are found, the CI based on subsets has a higher accuracy rate more often than the CI based on all individuals (see Table 5.16). However, the CIs based on all individuals are more precise than the specific sets of CIs in an overwhelming majority of cases (see Table 5.17).

These results suggest the CIs based on all individuals perform equally well or better than the CIs based upon subsets overall, meaning that confidence intervals derived from the whole training sample should be utilized, particularly when remains are skeletonized. General models for age estimation are more pragmatic in the forensic anthropological context, as estimating sex and ancestry from juvenile skeletal remains is more difficult than from adult remains.

The only ancestry group for whom specific sets of CIs demonstrate notable differences from those based on all individuals is the Hispanic group. When significant differences exist between the CIs based on all individuals and the Hispanic-specific sets of CIs, the Hispanic CIs exhibit higher accuracy values in five of six cases (see Appendices A4.6, A4.13, and A4.14). These results agree with previous research on the performance of anthropological methods on individuals of Hispanic ancestry. While no age estimation studies have yet presented this conclusion, methods for estimating other components of the biological profile perform better on Hispanic individuals when those methods are derived from a Hispanic training sample, as compared to methods derived from other populations. Ancestry estimation methods derived from Hispanic training samples exhibit increased accuracy on Hispanic individuals (e.g., Spradley and Jantz 2011; Spradley et al. 2008), as do sex estimation methods (e.g., Spradley et al. 2008, 2015; Tise et al. 2013) and methods for estimating stature (e.g., Spradley et al. 2008; Wilson et al. 2010).

However, when all pair-wise comparisons are considered, the increase in accuracy rates of the Hispanic-specific CIs is minimal, as opposed to the clear majority of instances in which no significant differences occur between the CIs based on all

individuals and the Hispanic CIs (see Table 5.16). Additionally, the CIs based on all individuals consistently exhibit greater precision (see Table 5.17). Therefore, the recommendation to utilize a general model of age estimation from confidence intervals in the forensic anthropological context remains. Estimating sex and ancestry from juvenile skeletal remains may introduce unnecessary error into the age estimate, particularly when the CIs based on all individuals deliver almost equal accuracy rates and better precision compared to the CIs based on subsets of the training set (see Tables 5.16 and 5.17).

7.4: Linear Model Performance for Age Estimation

Thirteen linear models were devised to incorporate multiple teeth into age estimates, and each model produces a point estimate of the individual's chronological age as well as a 51% and 95% prediction interval (see Table 5.18). The point estimates produced by the linear models based on all individuals consistently demonstrate lower accuracy than the PIs, which is not surprising. However, the point estimates from 12 of the 13 linear models based on all individuals (excluding the maxillary forensic teeth model) perform significantly better than chance (see Table 5.18). Although the accuracy of the point estimates is not high enough for use in the forensic context, this suggests that the models produce relatively good predictions of chronological age.

Overall, 95% prediction intervals produced by the linear models based on all individuals yield high accuracy rates (93-97%). The only exception is the model based on all individuals that uses the three maxillary posterior teeth with the narrowest average CIs (#13, 12, and 16) (see Table 5.18). While this is not the only model to incorporate a third molar, the inclusion of this developmentally variable tooth may be contributing to the decrease in accuracy. Additionally, the maxillary premolars appear to experience

radiograph distortion more frequently than the maxillary molars, which may also contribute to the decreased accuracy of the 95% PIs (see Table 5.18). Models based on mandibular teeth tend to exhibit higher accuracy, while models based on maxillary teeth tend to create more precise PIs (see Tables 5.18-5.19).

In addition to exhibiting higher accuracy rates, models incorporating mandibular teeth could consistently be applied to a higher number of individuals in the test sample, indicating that these models may be more applicable in the forensic context. The teeth in the mandible typically exhibit higher intraobserver Kappa values than the maxillary teeth using the Demirjian et al. (1973) scoring system (see Appendix 1). Additionally, the anterior teeth are more subject to positioning errors during the process of orthopantomogram production (e.g., Peretz et al. 2012). Mandibular models can be applied to more individuals in the test sample than the maxillary models (see Table 5.18), because maxillary teeth are more likely to be missing a score due to an inability to make the assessment.

Since sex and ancestry groups demonstrate some significant differences in developmental scores, eight versions of each linear model were created: one general model built on the entire training sample, two sex-specific linear models, and five ancestry-specific linear models (see Appendix 5). Three variables were considered when evaluating the performance of the linear models: accuracy of prediction intervals, precision of prediction intervals as measured by the width of the PI, and applicability of the model to the test sample.

To investigate the difference between linear models based on all individuals and the linear models based on subsets of the training set, the four models based on all

individuals that exhibit the highest measures of performance were selected for evaluation. In order of performance, the four best linear models include those based on: 1) the three posterior mandibular teeth with the narrowest average CIs (#21, 19, and 20); 2) the mandibular forensic teeth (#18, 19, 20, and 21); 3) the four maxillary teeth with the narrowest average CIs (#11, 9, 13, and 10); and 4) the three maxillary molars (#14, 15, and 16) (see Tables 5.18-5.19).

The models based on all individuals that incorporate the mandibular forensic teeth and the narrowest three posterior mandibular teeth generate the best performance measures overall. Both models yield comparably high accuracy rates, and these models can be applied to the greatest number of individuals in the test sample (see Tables 5.18-5.19). The introduction of a fourth tooth into the mandibular forensic model contributes to greater precision of PIs, but this increase in precision is associated with a decrease in accuracy (see Tables 5.18-5.19).

Overall, these two models based on all individuals yield the best results for age estimation and are similar in their performance. This result is unsurprising for several reasons. First, these two models share three teeth in common (#19, 20, and 21), which explains why the performance measures are similar. Second, both models are based on posterior mandibular teeth; these teeth all exhibit "almost perfect" agreement in the intraobserver error test and are least subject to panoramic imaging errors (see Appendix 1) (Landis and Koch 1977; Peretz et al. 2012). When all three measures of performance are considered simultaneously, the model based on all individuals that uses the three posterior mandibular teeth with the narrowest average CIs performs best for age estimation in this sample (see Appendix A5.13.1).

The other two linear models based on all individuals that exhibit the best performance measures are based on maxillary teeth, and maxillary teeth tend to exhibit higher intraobserver error with the Demirjian et al. (1973) scoring system. Additionally, maxillary teeth are more subject to positioning errors in panoramic radiography (e.g., Peretz et al. 2012; Rondon et al. 2014). As a result, these models can be applied to far fewer individuals in the test sample (see Table 5.18).

Of all seven population-specific versions of the four best linear models, the male- and European-American-specific versions exhibit the highest performance measures (see Table 5.20). These results are likely related to the significant differences observed between the sexes and between the European American and Hispanic samples. Both the male and the European American samples tend to experience delayed dental development compared to their counterpart (see Tables 5.1 and 5.13). Linear models based on the entire training set must account for the variation present in all sex and ancestry groups, which likely contributes to a slight decrease in accuracy and precision. The inclusion of females and Hispanic individuals pulls the PIs toward younger ages. However, when age is estimated for males and individuals of European American ancestry using linear models based on these subsets, accuracy and precision are slightly higher.

As noted in the Results chapter, linear models based on the African American, Asian American, and Native American samples are not as precise as the linear models based on all individuals. This is likely a product of small sample size; with fewer individuals informing the model, the prediction intervals must be wider to accurately estimate age. However, the sex-specific and European-American- and Hispanic-specific linear models exhibit comparable measures of performance compared to the linear

models based on all individuals, if not slightly better accuracy and precision (see Table 5.20 and Appendix 5).

As was the case with the confidence intervals for age estimation, the linear models based on all individuals are recommended for use in forensic cases in which remains are skeletonized. The linear models based on the entire training set perform better than those produced for ancestry groups with small sample sizes and comparably to those produced from subsets with higher representation in the dataset. Linear models based on all individuals accurately estimate chronological age without introducing error with the estimation of sex and ancestry from juvenile skeletal remains. However, for the purposes of age estimation in the living, the female-, male-, European-American-, and Hispanic-specific linear models produce slightly higher accuracy and precision compared to the linear models based on all individuals and can be recommended for use.

Unlike the confidence intervals, results from the comparison of linear models based on all individuals and those based on subsets may support the second hypothesis proposed during this research. Though this is not the case for all ancestry groups, the sex- and ancestry-specific linear models do produce slightly better age estimates than the linear models based on all individuals (see Table 5.20 and Appendix 5). However, despite the accuracy and precision values being slightly lower, linear models based on all individuals produce comparable measures of performance compared to linear models based on subsets. Therefore, this difference may not be of practical significance.

7.4.1: Sex and Ancestry Differences in Linear Model Performance

Since the linear models based on the entire training sample are recommended for age estimation from skeletal remains, their performance was evaluated on subsets of the

data divided by sex, ancestry, and sex/ancestry (see Appendix 5). The four linear models based on all individuals that exhibit the highest performance measures are discussed in detail. Females exhibit decreased accuracy in all four models based on all individuals at the 95% PI, while males only exhibit decreased accuracy in the model based on all individuals incorporating the mandibular forensic teeth (see Appendix 5). European American and Hispanic samples also exhibit decreased accuracy, though no other ancestry groups are affected (see Appendix 5). The relationship between the sexes and these two ancestry groups are likely contributing to the patterns observed in the performance of the linear models.

The results when the linear models based on all individuals are applied to the European American and Hispanic female samples could be explained by the relationship between the developmental pace of these two ancestry groups (see Appendix 5). The Hispanic sample exhibits significantly higher developmental scores than the European American sample, which indicates that the Hispanic sample is advanced in its development (see Table 5.13). Hispanic females in the test sample are over-aged, which means the estimated age is higher than the chronological age. Conversely, the European American females in the test sample are under-aged, which means the estimated age is lower than the chronological age. The European American and Hispanic samples are the largest in the dataset (see Table 4.2), which means these ancestry groups have the greatest influence on the linear models based on the entire training set. The purpose of the linear models is to find the best fit for the data in the training sample, and the best fit lines appear to be between the European American and Hispanic developmental pace. The presence of the developmentally advanced Hispanic individuals in the training sample

causes the linear models based on all individuals to underestimate the age of the European American females, while the developmentally delayed European American sample causes the linear models based on all individuals to overestimate the age of the Hispanic females (see Appendix 4).

The male sample only yields significant results using one of the four best linear models based on all individuals, with European American males exhibiting over-aging using the 95% PIs (see Appendix A5.4). This result is not initially intuitive, as the greater number of females in the sample should decrease the ages that the linear model predicts. Additionally, all ancestry groups but the Native American sample exhibit advanced development relative to European American individuals (see Table 5.13), which should also decrease the predicted ages. On further investigation, the over-aging in this linear model occurs in reference to a single individual. While the demographic information reports that this individual is seven years old, the developmental stages recorded are inconsistent with other individuals at seven years. Rather, the overall pattern of dental development suggests this individual may be older than the record states. Therefore, the under-aging of the European American male sample could be explained by the presence of this individual in the test sample.

7.4.2: Differences in Linear Model Performance across Age Groups

Individuals in the childhood age range (years 5-6) exhibit the highest accuracy rates and the lowest precision, i.e., the widest PI ranges (see Appendix 5). The high accuracy rates and low precision of the childhood sample relative to the other age groups must be viewed with caution. The childhood sample already contains the fewest individuals in the dataset (n = 83) (see Table 4.2), and of this subset, only three

individuals were randomly assigned to the test sample. Therefore, the performance of the linear models based on all individuals could be tested on at most three individuals, sometimes fewer if scores could not be assigned for all the teeth informing the model. All 95% PIs exhibit 100% accuracy; however, when the 51% PIs are not correct, the childhood sample experiences over-aging (see Appendix 5).

The juvenile and adolescent samples exhibit comparable accuracy and precision using the four best linear models based on all individuals (see Appendices A5.4, A5.7, A5.11, and A5.13). When the 95% PI does not exhibit 100% accuracy, the tendency is for over-aging to occur in the juvenile sample, i.e., the estimated age is higher than the chronological age (see Appendices A5.4.2, A5.11.2, and A5.13.2), and under-aging to occur in the adolescent sample, i.e., the estimated age is lower than the chronological age (see Appendices A5.4.2, A5.7.2, and A5.13.2). The pattern of over-aging in young individuals and under-aging in older individuals can be observed in the plot of predicted age by chronological age produced from the mandibular forensic linear model based on all individuals (Figure 7.8).

This pattern is consistent with previous research. Many authors suggest that age estimation methods frequently overestimate age in young individuals and underestimate age in older individuals; this trend has been documented in juvenile age estimation methods (e.g., Cardoso 2005; Kasper et al. 2009; Liversidge et al. 2010; Stull 2013; Stull et al. 2014; Yan et al. 2013), as well as adult age estimation methods (e.g., Aykroyd et al. 1999; Boldsen et al. 2002; Buckberry and Chamberlain 2002; Konigsberg and Frankenberg 1992; Osborne et al. 2004; Prince and Konigsberg 2008). This phenomenon is referred to as “attraction of the middle” (Masset 1989: 82) and is related to the concept

of age mimicry previously discussed in Chapter 3. When data are normally distributed, more individuals exist in the center of the age range than at either end. Age estimation methods are calibrated to the sample from which they were derived. Therefore, age estimates are inherently "attracted" to the mean, contributing to overestimates in younger individuals and underestimates in older individuals.

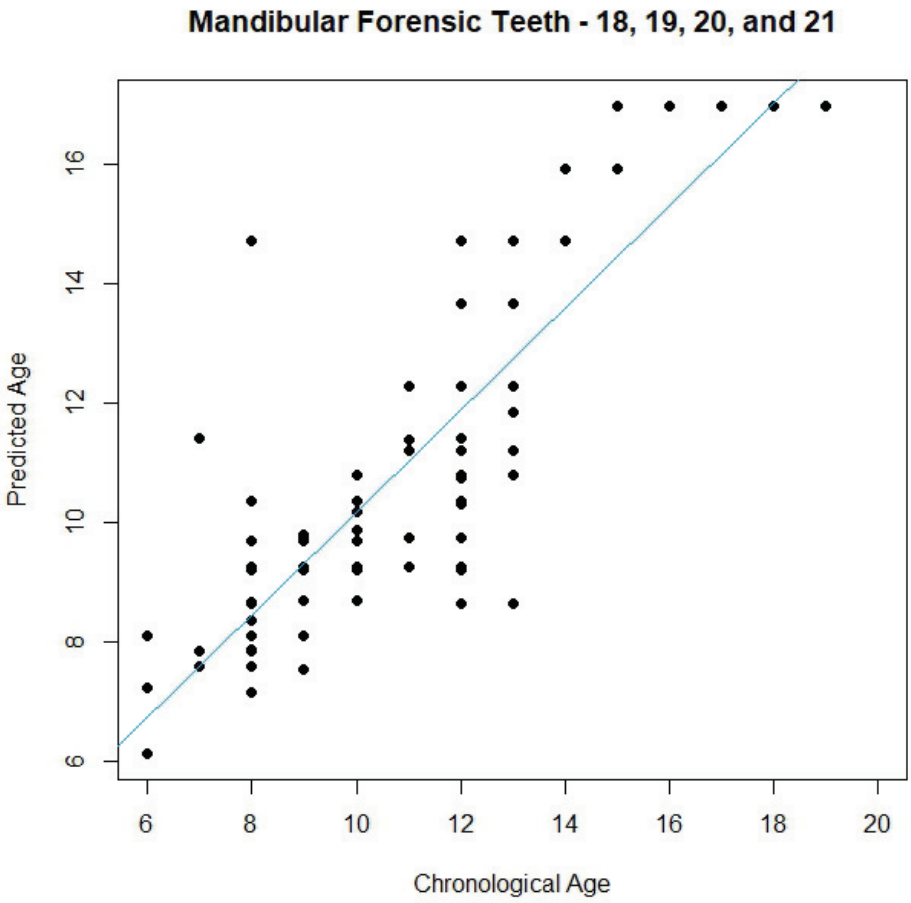


Figure 7.8: Plot of linear model based on all individuals incorporating mandibular forensic teeth. Predicted ages for young individuals tend to fall below the regression line, while predicted ages for older individuals tend to lie above the line.

Overall, the prediction intervals derived from the linear models, based on the entire training set and based on subsets of the training set, produce high accuracy rates,

both at 51% and 95% confidence levels (see Table 5.18). However, while the accuracy values are higher with the 95% PI, so are the widths of the intervals. Reppien and colleagues (2006: S87) suggest that, with the amount of information to be obtained from the developing dentition, age ranges for juveniles presented in the forensic context should be between 2-4 years wide. The 51% PIs are all within this suggested range. However, this is not the case for the 95% PIs, where most ranges are between five and seven years wide (see Table 5.19). In a forensic context, especially when estimating age for subadults, a 5-7 year age range may not be particularly informative. With a different method of analysis, the width of the 95% prediction intervals could potentially be reduced, increasing the utility of this age estimation method in the forensic context.

Chapter 8: Conclusions

The results presented here support the first hypothesis regarding sex and ancestry differences in dental development: using Kruskal-Wallis and Dunn's tests (Dunn 1964; Kruskal and Wallis 1952), some significant differences were observed between sex and ancestry groups in the current sample. When significant differences exist, females tend to exhibit advanced dental development compared to males; the only instances in which male development is significantly advanced over females are in the third molars (see Table 5.1 and Appendix 2). Both of these conclusions are supported by previous research (e.g., Anderson et al. 1976; Arany et al. 2004; Engström et al. 1983; Garn et al. 1962; Gleiser and Hunt 1955; Gunst et al. 2003; Kasper et al. 2009; Knell et al. 2009; Kullman et al. 1992; McGettigan et al. 2011; Mesotten et al. 2002; Mincer et al. 1993; Moorrees and Kent 1978; Nolla 1960; Prieto et al. 2005; Schour and Massler 1941; Sisman et al. 2007; Solari and Abramovitch 2002).

Between ancestry groups, fewer significant differences were observed between the African American, Asian American, and Native American samples, compared to one another and to the European American and Hispanic samples (see Table 5.13). However, this lack of statistical significance may be a matter of small sample size (see Table 4.2). The comparisons between the European American and Hispanic samples yield the greatest number of significant results, the majority of which indicate that Hispanic dental development is more advanced relative to European American dental development (see Table 5.13). This result agrees with conclusions presented by other authors (e.g., Kasper et al. 2009; Lewis and Senn 2010; Solari and Abramovitch 2002).

The developmental pace of the Native American sample relative to other ancestry groups should be interpreted with caution, as this group exhibits the smallest sample size apart from the Hawaiian sample (see Table 4.2). However, it is interesting that the delayed development observed here does not agree with previous research on Native American populations (see Table 5.13) (e.g., Dahlberg and Menegaz-Bock 1958; Garn and Moorrees 1951; Owsley and Jantz 1983; Steggarda and Hill 1942; Tompkins 1996). This difference may be a product of comparing results derived from modern individuals to those derived from historic or archaeological samples. If the Native American results are inconsistent due to this temporal difference, this suggests secular change has influenced the rate of dental development in the Native American population, a conclusion that has been proposed for other ancestry groups (e.g., Cardoso et al. 2010; Heuzé and Cardoso 2008; Nadler 1998; O'Neill 2012; Rautman and Edgar 2013; Sasso et al. 2012).

Methods in biological anthropology, particularly those that estimate components of the biological profile, are most effective on populations whose composition is like the sample from which the method was derived (Garvin et al. 2012; Milner and Boldsen 2012; SWGAnth 2013; Ubelaker 2006). This conclusion applies to not only age estimation methods (e.g., Davis and Hägg 1993; Willems et al. 2001), but other aspects of the biological profile as well, including sex estimation (e.g., Garvin 2012; Ramsthaler et al. 2007; Spradley et al. 2008, 2015; Tise et al. 2013), ancestry estimation (e.g., Hefner and Ousley 2014; Jantz and Ousley 2013; Snow et al. 1979; Spradley and Jantz 2011; Spradley et al. 2008), and stature estimation (e.g., Ousley 2012; Spradley et al. 2008; Trotter and Gleser 1958; Wilson et al. 2010). For these reasons, it is problematic that

subadult dental age estimation methods currently in use in the forensic context in the United States are either based on foreign samples (e.g., AlQahtani et al. 2010; Demirjian et al. 1973) or are outdated (e.g., Moorrees et al. 1963; Schour and Massler 1941). The use of a modern sample from the United States should make the age estimation methods presented here more applicable in a forensic context, potentially increasing the accuracy and precision with which age can be estimated.

While significant differences have been observed between sex and ancestry groups, there are more comparisons that do not yield significant differences. When confidence intervals derived from the entire training sample are compared to those derived from subsets divided by sex, ancestry, and sex/ancestry, the overall trend is for no significant differences to exist among accuracy rates. Additionally, the confidence intervals based on all individuals exhibit more precision than the confidence intervals divided by sex and ancestry. Linear models based on the entire training sample also produce comparable measures of performance when compared to African-American-, Asian-American-, and Native-American-specific versions of linear models. However, the specific linear models based on the sexes and the European American and Hispanic samples exhibit slightly higher accuracy and precision than the linear models based on all individuals.

Therefore, while the first hypothesis regarding sex and ancestry differences is supported by this research, the second hypothesis, that sex- and/or ancestry-specific models will outperform general models for age estimation, can be tentatively supported at best. The only significant differences in accuracy rates favor the Hispanic-specific CIs over the CIs based on all individuals, while the female-, male-, European-American-, and

Hispanic-specific linear models are slightly more accurate and precise. But, often, the general method of age estimation is comparable to the specific methods.

These results indicate that sex and ancestry differences in dental development may be minimal enough that age estimation methods are not affected (e.g., Konigsberg et al. 2008; Liversidge 2010). The confidence intervals based on all individuals produce comparable accuracy and greater precision compared to the sex-, ancestry-, or sex-and-ancestry-specific confidence intervals; therefore, the recommendation is to utilize confidence intervals based on all individuals for age estimation in a forensic context. As for the linear models, linear models based on all individuals exhibit comparable accuracy and precision to those based on sex and ancestry, and these models are more practical when dealing with skeletonized juvenile remains where estimating sex and ancestry can be difficult if not impossible. However, linear models derived from the female, male, European American, and Hispanic subsets can be recommended for use when age estimates must be produced for living individuals.

When the linear models based on the entire training set were applied to the test sample, the point estimates of age perform significantly better than chance in 12 of the 13 models. The accuracy rates of the 95% prediction intervals are all between 93-97% with one exception, suggesting that chronological age can be predicted with high confidence from these linear models (see Table 5.18). However, the high accuracy of the 95% prediction interval is likely related to the low degree of precision; all 95% prediction intervals produce estimated ranges between 5-7 years wide (see Table 5.19). Reppien and colleagues (2006: S87) suggest that the ranges for subadult age estimation should be between 2-4 years wide. Only the 51% prediction intervals typically yield ranges in line

with this suggestion (see Table 5.19). With a different method of analysis, the precision of these linear models might be improved.

8.1: Project Significance and Future Directions

The confidence intervals and linear models produced from this dataset exhibit high accuracy values, but the linear models may not yet be precise enough for use in the forensic context. Future research will incorporate more robust statistical analyses to increase the precision of age estimates from dental development. Additionally, while the goal of this dissertation was to create subadult dental age estimation methods using a more appropriate sample, these methods are of no use if the forensic community cannot utilize them. As illustrated by the example using Subject A, although point estimates of chronological age can be calculated manually, these calculations are tedious and require multiple orthogonal polynomial contrast tables to appropriately transform the data. Additionally, the calculation of prediction intervals requires matrix algebra. Therefore, if the math is not done manually, age estimation from the methods currently requires multiple software programs, in addition to statistical code produced during this research (R Core Team 2017). Therefore, future goals include devising a user-friendly means of applying these methods of age estimation, such as a web-based application in the statistical software R (R Core Team 2017).

There are currently no age estimation methods using dental development that are derived from a modern American population. The methods presented here fill that void. These methods could be used in age estimations to aid in the identification of skeletal remains of unknown individuals. Additionally, since the analysis of dental development is a non-invasive and non-destructive technique, the methods can also be used as an age

estimation technique for living individuals. Accuracy in age estimation in critical in the forensic sciences, for both the living and the deceased, and the current project could increase the accuracy of age estimations in the forensic context in the United States.

Appendix 1: Intraobserver Error Results

Table A1.1: Results of Cohen's weighted Kappa (Cohen 1968) intraobserver error tests, using both linear and quadratic weights. Tooth indicates the tooth number, as defined by the Universal Numbering System (ADA 1999), and n is the number of individuals that were assigned scores during both the first and second round of scoring.

Tooth	n	Moorrees et al. (1963)		Demirjian et al. (1973)	
		Linear Weights	Quadratic Weights	Linear Weights	Quadratic Weights
9: UI1	n=15	Kappa=1 z=6.03; p-value<0.0000	Kappa=1 z=3.87, p-value=0.0001	Kappa=0.932 z=4.97, p-value<0.0000	Kappa=0.962 z=3.74, p-value=0.0002
10: UI2	n=16	Kappa=0.681 z=4.22; p-value<0.0000	Kappa=0.635 z=2.56; p-value=0.0104	Kappa=0.943 z=5.37; p-value<0.0000	Kappa=0.969 z=3.89; p-value=0.0001
11: UC	n=22	Kappa=0.818 z=4.97; p-value<0.0000	Kappa=0.842 z=3.95; p-value<0.0000	Kappa=0.908 z=6.62; p-value<0.0000	Kappa=0.947 z=4.49; p-value<0.0000
12: UP1	n=11	Kappa=0.522 z=2.45; p-value=0.0144	Kappa=0.421 z=1.56; p-value=0.1190	Kappa=0.703 z=3.48; p-value=0.0005	Kappa=0.824 z=2.75; p-value=0.0060
13: UP2	n=14	Kappa=0.708 z=3.7; p-value=0.0002	Kappa=0.743 z=2.89; p-value=0.0039	Kappa=0.767 z=4.57; p-value<0.0000	Kappa=0.885 z=3.33; p-value=0.0009
14: UM1	n=11	Kappa=0.841 z=3.38; p-value=0.0007	Kappa=0.932 z=3.17; p-value=0.0015	Kappa=0.836 z=3.32; p-value=0.0009	Kappa=0.864 z=3.04; p-value=0.0024
15: UM2	n=23	Kappa=0.877 z=6.33; p-value<0.0000	Kappa=0.977 z=4.7; p-value<0.0000	Kappa=0.854 z=6.24; p-value<0.0000	Kappa=0.948 z=4.61; p-value<0.0000
16: UM3	n=17	Kappa=0.763 z=5.46; p-value<0.0000	Kappa=0.816 z=3.49; p-value=0.0005	Kappa=0.58 z=4.25; p-value<0.0000	Kappa=0.723 z=3.35; p-value=0.0008
17: LM3	n=17	Kappa=0.871 z=5.8; p-value<0.0000	Kappa=0.913 z=3.79; p-value=0.0002	Kappa=0.807 z=5.55; p-value<0.0000	Kappa=0.923 z=3.93; p-value<0.0000
18: LM2	n=30	Kappa=0.848 z=6.72; p-value<0.0000	Kappa=0.857 z=4.7; p-value<0.0000	Kappa=0.855 z=7.5; p-value<0.0000	Kappa=0.950 z=5.28; p-value<0.0000
19: LM1	n=29	Kappa=0.702 z=5.06; p-value<0.0000	Kappa=0.786 z=4.32; p-value<0.0000	Kappa=0.813 z=5.18; p-value<0.0000	Kappa=0.849 z=4.6; p-value<0.0000

Tooth	n	Moorrees et al. (1963)		Demirjian et al. (1973)	
		Linear Weights	Quadratic Weights	Linear Weights	Quadratic Weights
20: LP2	n=30	Kappa=0.658 z=5.3; p-value<0.0000	Kappa=0.607 z=3.42; p-value=0.0006	Kappa=0.842 z=7.24; p-value<0.0000	Kappa=0.935 z=5.13; p-value<0.0000
21: LP1	n=27	Kappa=0.71 z=5.28; p-value<0.0000	Kappa=0.686 z=3.62; p-value=0.0003	Kappa=0.835 z=6.77; p-value<0.0000	Kappa=0.923 z=4.81; p-value<0.0000
22: LC	n=27	Kappa=0.69 z=5.21; p-value<0.0000	Kappa=0.63 z=3.3; p-value=0.0010	Kappa=0.893 z=6.63; p-value<0.0000	Kappa=0.942 z=4.91; p-value<0.0000
23: LI2	n=19	Kappa=0.731 z=4.7; p-value<0.0000	Kappa=0.787 z=3.7; p-value=0.0002	Kappa=0.905 z=4.63; p-value<0.0000	Kappa=0.924 z=4.04; p-value<0.0000
24: LI1	n=18	Kappa=0.66 z=3.53; p-value=0.0004	Kappa=0.724 z=3.24; p-value=0.0012	Kappa=0.581 z=3.32; p-value=0.0009	Kappa=0.679 z=3.12; p-value=0.0018

Appendix 2: Results of Kruskal-Wallis and Dunn's Tests

A2.x.1: Sex comparisons of dental development using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964). P-values presented apply to both tests, as Dunn's post-hoc test is performing a single pair-wise comparison. P-values in *italics** are significant at $\alpha = 0.05$, while p-values in ***bold italics**** are significant at Bonferroni adjusted $\alpha = 0.0015625$. Positive z-scores indicate females have higher developmental scores; negative z-scores indicate males have higher developmental scores.

A2.x.2, A2.x.3, A2.x.4: Ancestry and ancestry/sex comparisons using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964). Kruskal-Wallis results are left of the bolded line, and Dunn's post-hoc results are right of the bolded line. Values presented in Dunn's post-hoc comparisons are z-scores followed by p-values. P-values in *italics** are significant at $\alpha = 0.05$, while p-values in ***bold italics**** are significant at Bonferroni adjusted $\alpha = 0.000284$. Positive z-scores indicate the first group has higher developmental scores; negative z-scores indicate the second group has higher developmental scores. For example, a positive value in the African American-Asian American comparison indicates that African American developmental scores are higher, while a negative value means that Asian American developmental scores are higher.

N/A means a comparison could not be performed. In some cases, this may mean that there is information missing at one or more teeth for one of the groups under comparison. For example, comparisons are not performed between females and males at age 5 for teeth #16 and #17 (Appendix A2.1.1) because the third molars have not yet begun development. Alternatively, an N/A may occur if developmental scores are invariable. For example, development of the first molar should be complete after age 13, which means there should be only Demirjian et al. (1973) scores of H. With no variety in scores, the Kruskal-Wallis and Dunn's statistics cannot be calculated.

Abbreviations for Appendix 2: K-W = Kruskal-Wallis; df = degrees of freedom; AfA = African American; AsA = Asian American; EA = European American; H = Hispanic; N = Native American.

Appendix A2.1: Age 5

Table A2.1.1: Sex comparisons for age 5 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	0.0990	1	0.7530	-0.3147
10: UI2	0.6044	1	0.4369	0.7774
11: UC	0.2231	1	0.6367	0.4724
12: UP1	0.0103	1	0.9193	0.1013
13: UP2	0.0000	1	1.0000	0.0000
14: UM1	0.2564	1	0.6124	-0.5066
15: UM2	0.0013	1	0.9709	0.0365
16: UM3	N/A	N/A	N/A	N/A
17: LM3	N/A	N/A	N/A	N/A
18: LM2	0.4565	1	0.4993	0.6756
19: LM1	0.1288	1	0.7197	-0.3588
20: LP2	0.2629	1	0.6081	0.5127
21: LP1	2.8872	1	0.0892	1.6992
22: LC	0.1594	1	0.6897	0.3992
23: LI2	0.3758	1	0.5399	0.6130
24: LI1	0.0972	1	0.7552	-0.3118

Table A2.1.2: Ancestry comparisons for age 5 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=1.0932 p=0.5789	2	N/A	N/A	N/A	N/A	0.5737 0.5662	0.0350 0.9721	N/A	-1.0094 0.3128	N/A	N/A
10: UI2	χ^2=0.1442 p=0.9304	2	N/A	N/A	N/A	N/A	-0.3798 0.7041	-0.2924 0.7700	N/A	0.1961 0.8445	N/A	N/A
11: UC	χ^2=0.0424 p=0.9790	2	N/A	N/A	N/A	N/A	-0.1662 0.8680	-0.2019 0.8400	N/A	-0.0792 0.9369	N/A	N/A
12: UP1	χ^2=2.6269 p=0.1051	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-1.6208 0.1051	N/A	N/A
13: UP2	χ^2=1.1053 p=0.2931	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-1.0513 0.2931	N/A	N/A
14: UM1	χ^2=4.4235 p=0.1095	2	N/A	N/A	N/A	N/A	-1.4845 0.1377	-1.9941 *0.0461**	N/A	-1.1323 0.2575	N/A	N/A
15: UM2	χ^2=3.6212 p=0.1636	2	N/A	N/A	N/A	N/A	-1.4527 0.1463	-1.8279 0.0676	N/A	-0.8825 0.3775	N/A	N/A
16: UM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17: LM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18: LM2	χ^2=1.9858 p=0.3705	2	N/A	N/A	N/A	N/A	1.0174 0.3090	0.5307 0.5956	N/A	-1.1735 0.2406	N/A	N/A
19: LM1	χ^2=2.8555 p=0.2398	2	N/A	N/A	N/A	N/A	-1.0652 0.2868	-1.5080 0.1316	N/A	-1.0477 0.2948	N/A	N/A
20: LP2	χ^2=0.4498 p=0.7986	2	N/A	N/A	N/A	N/A	0.1573 0.8750	-0.1299 0.8967	N/A	-0.6707 0.5024	N/A	N/A
21: LP1	χ^2=1.3277 p=0.5149	2	N/A	N/A	N/A	N/A	0.9637 0.3352	0.6219 0.5340	N/A	-0.8267 0.4084	N/A	N/A
22: LC	χ^2=1.5681 p=0.4566	2	N/A	N/A	N/A	N/A	0.2733 0.7847	-0.2494 0.8030	N/A	-1.2522 0.2105	N/A	N/A
23: LI2	χ^2=1.2858 p=0.5258	2	N/A	N/A	N/A	N/A	-0.0433 0.9655	-0.5723 0.5671	N/A	-1.0835 0.2786	N/A	N/A
24: LI1	χ^2=3.1835 p=0.2036	2	N/A	N/A	N/A	N/A	-0.5672 0.5706	-1.2792 0.2008	N/A	-1.5103 0.1310	N/A	N/A

Table A2.1.3: Ancestry comparisons for females at age 5 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=1.2819 p=0.5268	2	N/A	N/A	N/A	N/A	0.6498 0.5158	-0.0541 0.9569	N/A	-1.0602 0.2891	N/A	N/A
10: UI2	χ^2=0.7941 p=0.6723	2	N/A	N/A	N/A	N/A	-0.4951 0.6205	-0.8677 0.3855	N/A	-0.4201 0.6744	N/A	N/A
11: UC	χ^2=0.2344 p=0.8894	2	N/A	N/A	N/A	N/A	-0.1885 0.8505	-0.3893 0.6971	N/A	-0.3974 0.6911	N/A	N/A
12: UP1	χ^2=2.4000 p=0.1213	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-1.5492 0.1213	N/A	N/A
13: UP2	χ^2=1.4205 p=0.2333	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-1.1918 0.2333	N/A	N/A
14: UM1	χ^2=4.7236 p=0.0943	2	N/A	N/A	N/A	N/A	-1.4640 0.1432	-2.1047 *0.0353**	N/A	-1.2573 0.2086	N/A	N/A
15: UM2	χ^2=2.7196 p=0.2567	2	N/A	N/A	N/A	N/A	-1.4193 0.1558	-1.6491 0.0991	N/A	-0.5281 0.5974	N/A	N/A
16: UM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17: LM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18: LM2	χ^2=1.8626 p=0.3940	2	N/A	N/A	N/A	N/A	0.7726 0.4398	0.0921 0.9266	N/A	-1.2605 0.2075	N/A	N/A
19: LM1	χ^2=2.2719 p=0.3211	2	N/A	N/A	N/A	N/A	-0.9383 0.3481	-1.4082 0.1591	N/A	-0.9602 0.3370	N/A	N/A
20: LP2	χ^2=1.5619 p=0.458	2	N/A	N/A	N/A	N/A	0.1455 0.8843	-0.5217 0.6018	N/A	-1.2417 0.2143	N/A	N/A
21: LP1	χ^2=2.3084 p=0.3153	2	N/A	N/A	N/A	N/A	0.6919 0.4890	-0.0932 0.9257	N/A	-1.4665 0.1425	N/A	N/A
22: LC	χ^2=1.4052 p=0.4953	2	N/A	N/A	N/A	N/A	0.1173 0.9066	-0.4997 0.6173	N/A	-1.1784 0.2386	N/A	N/A
23: LI2	χ^2=3.9304 p=0.1401	2	N/A	N/A	N/A	N/A	-0.1042 0.9170	-1.2667 0.2053	N/A	-1.9093 0.0562	N/A	N/A
24: LI1	χ^2=4.1868 p=0.1233	2	N/A	N/A	N/A	N/A	-0.4361 0.6627	-1.5254 0.1272	N/A	-1.8768 0.0605	N/A	N/A

Table A2.1.4: Ancestry comparisons for males at age 5 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=0.0000 p=1.0000	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0000 1.0000	N/A	N/A
12: UP1	χ^2=0.3333 p=0.5637	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-0.5774 0.5637	N/A	N/A
13: UP2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14: UM1	χ^2=0.0000 p=1.0000	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0000 1.0000	N/A	N/A
15: UM2	χ^2=1.3333 p=0.2482	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-1.1547 0.2482	N/A	N/A
16: UM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17: LM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18: LM2	χ^2=0.7619 p=0.3827	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-0.8729 0.3827	N/A	N/A
19: LM1	χ^2=0.1458 p=0.7025	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-0.3819 0.7025	N/A	N/A
20: LP2	χ^2=0.1482 p=0.7003	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.3849 0.7003	N/A	N/A
21: LP1	χ^2=0.3333 p=0.5637	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-0.5774 0.5637	N/A	N/A
22: LC	χ^2=0.9259 p=0.3359	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-0.9623 0.3359	N/A	N/A
23: LI2	χ^2=0.0000 p=1.0000	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0000 1.0000	N/A	N/A
24: LI1	χ^2=0.0000 p=1.0000	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0000 1.0000	N/A	N/A

Appendix A2.2: Age 6

Table A2.2.1: Sex comparisons for age 6 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	0.0000	1	1.0000	0.0000
10: UI2	0.2713	1	0.6025	0.5208
11: UC	1.2613	1	0.2614	1.1231
12: UP1	0.2315	1	0.6304	-0.4811
13: UP2	1.2397	1	0.2655	1.1134
14: UM1	0.0122	1	0.9120	0.1105
15: UM2	0.3009	1	0.5833	-0.5486
16: UM3	N/A	N/A	N/A	N/A
17: LM3	N/A	N/A	N/A	N/A
18: LM2	0.3067	1	0.5797	-0.5538
19: LM1	1.0128	1	0.3142	1.0064
20: LP2	0.4806	1	0.4882	-0.6932
21: LP1	0.0300	1	0.8628	0.1731
22: LC	0.9537	1	0.3288	0.9766
23: LI2	0.0015	1	0.9687	0.0392
24: LI1	0.0371	1	0.8472	0.1927

Table A2.2.2: Ancestry comparisons for age 6 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=6.3975 p=0.0938	3	-0.0661 0.9473	-0.0357 0.9715	-1.2945 0.1955	N/A	0.0530 0.9577	-1.3651 0.1722	N/A	-1.0094 0.3128	-2.4209 *0.0155**	N/A
10: UI2	χ^2=7.8959 *p=0.0482**	3	0.0000 1.0000	-0.0229 0.9817	-1.6461 0.0997	N/A	-0.0229 0.9817	-1.6461 0.0997	N/A	0.1961 0.8445	-2.5790 *0.0099**	N/A
11: UC	χ^2=6.6426 p=0.0842	3	1.1397 0.5226	0.7448 0.4564	-0.4001 0.6891	N/A	-0.7547 0.4504	-1.9821 *0.0475**	N/A	-0.0792 0.9369	-2.1607 *0.0307**	N/A
12: UP1	χ^2=11.864 *p=0.0079**	3	0.6393 0.5226	1.4273 0.1535	-0.9830 0.3256	N/A	0.6343 0.5259	-1.7540 0.0794	N/A	-1.6208 0.1051	-3.3837 *0.0007**	N/A
13: UP2	χ^2=9.063 *p=0.0285**	3	0.6657 0.5056	0.9434 0.3455	-0.8486 0.3961	N/A	0.1014 0.9193	-1.6971 0.0897	N/A	-1.0513 0.2931	-2.8788 *0.0040**	N/A
14: UM1	χ^2=4.5044 p=0.2119	3	0.6405 0.5218	0.8571 0.3914	-0.2809 0.7788	N/A	0.1205 0.9041	-1.2308 0.2184	N/A	-1.1323 0.2575	-2.0222 *0.0432**	N/A
15: UM2	χ^2=4.4363 p=0.2180	3	-1.3190 0.1872	-0.2803 0.7792	-1.1213 0.2622	N/A	1.5090 0.1313	0.5557 0.5784	N/A	-0.8825 0.3775	-1.5992 0.1098	N/A
16: UM3	χ^2=0.6667 p=0.4142	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.8165 0.4142	N/A
17: LM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18: LM2	χ^2=1.1990 p=0.7532	3	0.3913 0.6956	0.3661 0.7143	-0.1559 0.8761	N/A	-0.1389 0.8896	-0.7031 0.4820	N/A	-1.1735 0.2406	-1.0018 0.3165	N/A
19: LM1	χ^2=9.4217 *p=0.0242**	3	0.9648 0.3347	1.3250 0.1852	-0.1972 0.8437	N/A	0.1229 0.9022	-1.5281 0.1265	N/A	-1.0477 0.2948	-2.9137 *0.0036**	N/A
20: LP2	χ^2=7.9301 *p=0.0475**	3	1.1330 0.2572	1.8857 0.0593	0.5800 0.5619	N/A	0.5105 0.6097	-0.9036 0.3662	N/A	-0.6707 0.5024	-2.4651 *0.0137**	N/A
21: LP1	χ^2=4.8114 p=0.1861	3	0.9967 0.3189	0.7357 0.4619	-0.2373 0.8124	N/A	-0.5704 0.5684	-1.6156 0.1062	N/A	-0.8267 0.4084	-1.8658 0.0621	N/A
22: LC	χ^2=6.5643 p=0.0872	3	-0.0279 0.9777	0.6897 0.4904	-0.4951 0.6206	N/A	0.8233 0.4104	-0.5216 0.6020	N/A	-1.2522 0.2105	-2.5502 *0.0108**	N/A
23: LI2	χ^2=6.3027 p=0.0978	3	1.8041 0.0712	1.4945 0.1350	0.6030 0.5465	N/A	-0.7501 0.4532	-1.8760 0.0607	N/A	-1.0835 0.2786	-1.6813 0.0927	N/A
24: LI1	χ^2=4.0105 p=0.2603	3	0.0000 1.0000	0.0526 0.9580	-1.1045 0.2694	N/A	0.0526 0.9580	-1.1045 0.2694	N/A	-1.5103 0.1310	-1.8311 0.0671	N/A

Table A2.2.3: Ancestry comparisons for females at age 6 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=4.9003 p=0.0863	2	N/A	0.1373 0.8908	-1.2910 0.1967	N/A	N/A	N/A	N/A	-2.1528 *0.0313**	N/A	N/A
10: UI2	χ^2=8.2219 *p=0.0164**	2	N/A	0.6360 0.5248	-1.3355 0.1817	N/A	N/A	N/A	N/A	-2.8362 *0.0046**	N/A	N/A
11: UC	χ^2=6.8738 *p=0.0322**	2	N/A	1.0891 0.2761	-0.4590 0.6462	N/A	N/A	N/A	N/A	-2.5937 *0.0095**	N/A	N/A
12: UP1	χ^2=6.9894 *p=0.0304**	2	N/A	1.3997 0.1616	-0.6573 0.5110	N/A	N/A	N/A	N/A	-2.5944 *0.0095**	N/A	N/A
13: UP2	χ^2=7.9033 *p=0.0192**	2	N/A	0.8001 0.4237	-1.2678 0.2049	N/A	N/A	N/A	N/A	-2.8000 *0.0051**	N/A	N/A
14: UM1	χ^2=3.9252 p=0.1405	2	N/A	0.9004 0.3679	-0.4649 0.6420	N/A	N/A	N/A	N/A	-1.9305 0.0535	N/A	N/A
15: UM2	χ^2=5.5832 p=0.0613	2	N/A	-0.0646 0.9485	-1.4115 0.1581	N/A	N/A	N/A	N/A	-2.2406 *0.0251**	N/A	N/A
16: UM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17: LM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18: LM2	χ^2=4.2482 p=0.1195	2	N/A	0.8132 0.4161	-0.3871 0.6987	N/A	N/A	N/A	N/A	-2.0468 *0.0407**	N/A	N/A
19: LM1	χ^2=8.4499 *p=0.0146**	2	N/A	1.9668 *0.0492**	0.4305 0.6669	N/A	N/A	N/A	N/A	-2.6104 *0.0090**	N/A	N/A
20: LP2	χ^2=10.768 *p=0.0046**	2	N/A	2.1850 *0.0289**	0.4389 0.6608	N/A	N/A	N/A	N/A	-2.9674 *0.0030**	N/A	N/A
21: LP1	χ^2=6.1222 *p=0.0468**	2	N/A	1.2852 0.1987	-0.1196 0.9048	N/A	N/A	N/A	N/A	-2.3920 *0.0168**	N/A	N/A
22: LC	χ^2=7.8613 *p=0.0196**	2	N/A	1.8290 0.0674	0.5716 0.5676	N/A	N/A	N/A	N/A	-2.5149 *0.0119**	N/A	N/A
23: LI2	χ^2=4.4932 p=0.1058	2	N/A	1.6125 0.1069	0.4158 0.6776	N/A	N/A	N/A	N/A	-1.8279 0.0676	N/A	N/A
24: LI1	χ^2=0.9975 p=0.6073	2	N/A	0.3472 0.7284	-0.3190 0.7497	N/A	N/A	N/A	N/A	-0.9987 0.3179	N/A	N/A

Table A2.2.4: Ancestry comparisons for males at age 6 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=1.6147 p=0.4460	2	N/A	N/A	N/A	N/A	-0.1594 0.8734	-1.0419 0.2975	N/A	-1.1610 0.2456	N/A	N/A
10: UI2	χ^2=1.9601 p=0.5807	3	-0.6559 0.5119	-0.9219 0.3566	-1.2497 0.2114	N/A	-0.3992 0.6898	-0.9477 0.3434	N/A	-0.6861 0.4927	N/A	N/A
11: UC	χ^2=1.3967 p=0.7063	3	0.2722 0.7855	-0.1557 0.8763	-0.3357 0.7371	N/A	-0.8737 0.3823	-1.1690 0.2424	N/A	-0.4434 0.6575	N/A	N/A
12: UP1	χ^2=4.8725 p=0.1814	3	0.4682 0.6396	0.5922 0.5537	-0.6594 0.5097	N/A	0.1481 0.8823	-1.6731 0.0943	N/A	-2.0661 *0.0388**	N/A	N/A
13: UP2	χ^2=1.4846 p=0.4760	2	N/A	N/A	N/A	N/A	0.1898 0.8495	-0.8516 0.3944	N/A	-1.1432 0.2530	N/A	N/A
14: UM1	χ^2=0.8114 p=0.6665	2	N/A	N/A	N/A	N/A	0.1190 0.9053	-0.7987 0.4256	N/A	-0.7676 0.4427	N/A	N/A
15: UM2	χ^2=1.0960 p=0.7780	3	-0.5054 0.6133	-0.0586 0.9533	-0.0139 0.9889	N/A	0.9364 0.3491	0.9663 0.3339	N/A	0.1065 0.9152	N/A	N/A
16: UM3	χ^2=0.6667 p=0.4142	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.8165 0.4142	N/A	N/A
17: LM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18: LM2	χ^2=0.7596 p=0.8591	3	0.2835 0.7768	-0.0900 0.9283	0.1637 0.8700	N/A	-0.7748 0.4385	-0.2474 0.8046	N/A	0.6218 0.5341	N/A	N/A
19: LM1	χ^2=2.8303 p=0.4185	3	-0.6508 0.5152	-0.6742 0.5002	-1.2177 0.2243	N/A	0.0290 0.9769	-1.0230 0.3063	N/A	-1.3709 0.1704	N/A	N/A
20: LP2	χ^2=0.7805 p=0.8541	3	0.6611 0.5086	0.5807 0.5614	0.3470 0.7286	N/A	-0.2310 0.8174	-0.6426 0.5205	N/A	-0.5463 0.5849	N/A	N/A
21: LP1	χ^2=1.2370 p=0.7442	3	0.2562 0.7978	-0.1453 0.8845	-0.3160 0.752	N/A	-0.8273 0.4081	-1.1004 0.2712	N/A	-0.4277 0.6688	N/A	N/A
22: LC	χ^2=3.7783 p=0.2864	3	-1.6440 0.1002	-1.4070 0.1594	-1.7895 0.0735	N/A	0.6609 0.5087	-0.0803 0.9360	N/A	-0.9828 0.3257	N/A	N/A
23: LI2	χ^2=3.8012 p=0.1495	2	N/A	N/A	N/A	N/A	-1.6651 0.0959	-1.7914 0.0732	N/A	-0.0241 0.9808	N/A	N/A
24: LI1	χ^2=4.5743 p=0.2058	3	-0.8000 0.4237	-0.6532	-1.5837 0.1133	N/A	0.2667 0.7897	-1.2741 0.2026	N/A	-1.6694 0.0950	N/A	N/A

Appendix A2.3: Age 7

Table A2.3.1: Sex comparisons for age 7 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	0.4782	1	0.4892	0.6915
10: UI2	0.5040	1	0.4778	0.7099
11: UC	4.4960	1	*0.0340**	2.1204
12: UP1	1.6380	1	0.2006	-1.2798
13: UP2	0.6270	1	0.4285	-0.7918
14: UM1	0.2432	1	0.6219	0.4932
15: UM2	0.0200	1	0.8876	0.1413
16: UM3	1.3370	1	0.2476	-1.1563
17: LM3	4.8913	1	*0.0270**	-2.2116
18: LM2	0.3696	1	0.5432	-0.6079
19: LM1	0.9993	1	0.3175	0.9996
20: LP2	1.2371	1	0.2660	1.1123
21: LP1	1.3010	1	0.2540	1.1406
22: LC	5.4031	1	*0.0201**	2.3245
23: LI2	0.3700	1	0.5430	0.6083
24: LI1	0.0350	1	0.8516	-0.1871

Table A2.3.2: Ancestry comparisons for age 7 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=2.0458 p=0.5630	3	0.1720 0.8634	-0.0620 0.9506	-0.2799 0.7796	N/A	-0.6040 0.5458	-1.1597 0.2462	N/A	-1.0638 0.2874	N/A	N/A
10: UI2	χ^2=1.7106 p=0.6346	3	1.0078 0.3135	0.5702 0.5685	0.4619 0.6442	N/A	-0.9661 0.3340	-1.1770 0.2392	N/A	-0.3791 0.7046	N/A	N/A
11: UC	χ^2=2.2914 p=0.5142	3	0.6019 0.5473	0.2153 0.8296	-0.0407 0.9676	N/A	-0.8224 0.4109	-1.2883 0.1976	N/A	-1.0432 0.2969	N/A	N/A
12: UP1	χ^2=0.4902 p=0.9210	3	0.5746 0.5656	0.3084 0.7578	0.3334 0.7388	N/A	-0.5960 0.5512	-0.5653 0.5718	N/A	0.0798 0.9364	N/A	N/A
13: UP2	χ^2=3.5305 p=0.3168	3	0.2972 0.7663	1.1361 0.2559	0.7073 0.4794	N/A	1.3189 0.1872	0.6163 0.5377	N/A	-1.3470 0.1780	N/A	N/A
14: UM1	χ^2=4.1637 p=0.1247	2	N/A	N/A	N/A	N/A	-0.6096 0.5421	-1.2981 0.1942	N/A	-1.7674 0.0772	N/A	N/A
15: UM2	χ^2=0.3800 p=0.9443	3	0.1495 0.8812	0.2931 0.7694	0.1536 0.8780	N/A	0.2275 0.8200	-0.0243 0.9806	N/A	-0.5677 0.5702	N/A	N/A
16: UM3	χ^2=1.3519 p=0.7169	3	0 1	-1.0014 0.3166	-0.6239 0.5327	N/A	-0.7570 0.4491	-0.4627 0.6436	N/A	0.6260 0.5313	N/A	N/A
17: LM3	χ^2=2.0076 p=0.3665	2	N/A	-0.9708 0.3317	-0.2559 0.7980	N/A	N/A	N/A	N/A	1.3130 0.1892	N/A	N/A
18: LM2	χ^2=1.8060 p=0.6136	3	1.0504 0.2935	1.3212 0.1864	1.3068 0.1913	N/A	0.2680 0.7887	0.2401 0.8102	N/A	-0.0655 0.9478	N/A	N/A
19: LM1	χ^2=4.9087 p=0.1786	3	1.7206 0.0853	1.9590 0.0501	1.6580 0.0973	N/A	0.0690 0.9450	-0.4779 0.6327	N/A	-1.2382 0.2157	N/A	N/A
20: LP2	χ^2=12.0260 *p=0.0073**	3	1.0147 0.3103	1.3742 0.1694	0.5623 0.5739	N/A	0.4356 0.6631	-1.0324 0.3019	N/A	-3.3127 *0.0009**	N/A	N/A
21: LP1	χ^2=7.9945 *p=0.0461**	3	1.1329 0.2573	1.9369 0.0528	1.4074 0.1593	N/A	1.2118 0.2256	0.2554 0.7985	N/A	-2.1745 *0.0297**	N/A	N/A
22: LC	χ^2=2.7613 p=0.4299	3	0.8773 0.3803	1.1718 0.2413	0.9529 0.3407	N/A	0.5465 0.5847	0.0290 0.9768	N/A	-1.2514 0.2108	N/A	N/A
23: LI2	χ^2=3.7833 p=0.2858	3	0.8399 0.4010	0.8042 0.4213	0.3154 0.7525	N/A	-0.2250 0.8220	-1.1067 0.2684	N/A	-1.7116 0.0870	N/A	N/A
24: LI1	χ^2=2.0672 p=0.5586	3	0.5853 0.5584	0.5333 0.5938	0.2645 0.7914	N/A	-0.2028 0.8393	-0.8897 0.3736	N/A	-1.2275 0.2196	N/A	N/A

Table A2.3.3: Ancestry comparisons for females at age 7 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=4.0203 p=0.1340	2	N/A	N/A	N/A	N/A	-1.9621 *0.0498**	-1.9238 0.0544	N/A	0.1640 0.8697	N/A	N/A
10: UI2	χ^2=5.9451 p=0.1143	3	2.2781 *0.0227**	1.6073 0.1080	1.7432 0.0813	N/A	-1.6988 0.0894	-1.4796 0.1390	N/A	0.5120 0.6086	N/A	N/A
11: UC	χ^2=3.5895 p=0.3093	3	1.7283 0.0839	1.2739 0.2027	1.1866 0.2354	N/A	-1.2103 0.2262	-1.4022 0.1609	N/A	-0.4051 0.6854	N/A	N/A
12: UP1	χ^2=0.4323 p=0.8056	2	N/A	N/A	N/A	N/A	-0.5567 0.5777	-0.6557 0.5120	N/A	-0.1143 0.9090	N/A	N/A
13: UP2	χ^2=6.1475 p=0.1046	3	1.3465 0.1781	1.8356 0.0664	1.2921 0.1963	N/A	0.5268 0.5984	-0.3967 0.6916	N/A	-1.9499 0.0512	N/A	N/A
14: UM1	χ^2=1.7765 p=0.4114	2	N/A	N/A	N/A	N/A	0.4920 0.6227	0.1093 0.9130	N/A	-1.3095 0.1904	N/A	N/A
15: UM2	χ^2=2.0101 p=0.5703	3	1.2276 0.2196	0.9573 0.3384	1.1231 0.2614	N/A	-0.7548 0.4503	-0.4542 0.6497	N/A	0.7062 0.4800	N/A	N/A
16: UM3	χ^2=0.5000 p=0.7788	2	N/A	0.0000 1.0000	-0.4629 0.6434	N/A	N/A	N/A	N/A	-0.6124 0.5403	N/A	N/A
17: LM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18: LM2	χ^2=1.9952 p=0.5734	3	1.0347 0.3008	0.8761 0.3810	1.0912 0.2752	N/A	-0.5069 0.6123	-0.1026 0.9183	N/A	0.9435 0.3454	N/A	N/A
19: LM1	χ^2=9.1252 *p=0.0266**	3	2.7986 *0.0051**	2.7551 *0.0059**	2.5102 *0.0121**	N/A	-0.6311 0.5280	-1.1328 *0.0121**	N/A	-1.1329 0.2573	N/A	N/A
20: LP2	χ^2=5.7565 p=0.1241	3	1.4779 0.1394	1.4806 0.1387	1.0569 0.2905	N/A	-0.2824 0.7776	-1.1173 0.2639	N/A	-1.8845 0.0595	N/A	N/A
21: LP1	χ^2=4.0133 p=0.2600	3	1.5956 0.1106	1.7393 0.0820	1.4875 0.1369	N/A	-0.0349 0.9722	-0.5367 0.5915	N/A	-1.1412 0.2538	N/A	N/A
22: LC	χ^2=0.8455 p=0.8386	3	0.8577 0.3911	0.9027 0.3667	0.8765 0.3807	N/A	-0.1229 0.9022	-0.1746 0.8614	N/A	-0.1309 0.8958	N/A	N/A
23: LI2	χ^2=4.3709 p=0.2241	3	1.6172 0.1058	1.3831 0.1666	1.0676 0.2857	N/A	-0.7342 0.4628	-1.3714 0.1702	N/A	-1.2318 0.2180	N/A	N/A
24: LI1	χ^2=2.6537 p=0.2653	2	N/A	N/A	N/A	N/A	0.0961 0.9234	-0.7412 0.4586	N/A	-1.5705 0.1163	N/A	N/A

Table A2.3.4: Ancestry comparisons for males at age 7 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=4.1661 p=0.2441	3	-0.4939 0.6214	0.2934 0.7692	-0.3117 0.7552	N/A	1.3928 0.1637	0.3984 0.6903	N/A	-1.8155 0.0694	N/A	N/A
10: UI2	χ^2=2.9182 p=0.4044	3	-0.9298 0.3525	-0.6174 0.5370	-1.1360 0.2560	N/A	0.6830 0.4946	-0.1607 0.8723	N/A	-1.4202 0.1555	N/A	N/A
11: UC	χ^2=1.9620 p=0.5803	3	-0.8581 0.3908	-0.8571 0.3914	-1.1272 0.2596	N/A	0.1953 0.8452	-0.2616 0.7936	N/A	-0.9922 0.3211	N/A	N/A
12: UP1	χ^2=0.1033 p=0.9914	3	0.0000 1.0000	0.0147 0.9883	0.1405 0.8883	N/A	0.0147 0.9883	0.1405 0.8883	N/A	0.3006 0.7637	N/A	N/A
13: UP2	χ^2=1.3789 p=0.7105	3	-0.7585 0.4481	-0.2115 0.8325	-0.1361 0.8917	N/A	1.0325 0.3018	1.1264 0.2600	N/A	0.1906 0.8489	N/A	N/A
14: UM1	χ^2=2.8991 p=0.2347	2	N/A	N/A	N/A	N/A	-0.9321 0.3513	-1.5009 0.1334	N/A	-1.1809 0.2376	N/A	N/A
15: UM2	χ^2=2.9843 p=0.3941	3	-0.8421 0.3997	-0.3784 0.7052	-0.7841 0.4330	N/A	0.9688 0.3326	0.2772 0.7816	N/A	-1.4747 0.1403	N/A	N/A
16: UM3	χ^2=1.4563 p=0.6924	3	0.0000 1.0000	-0.9271 0.3539	-0.5040 0.6143	N/A	-0.9271 0.3539	-0.5040 0.6143	N/A	0.5952 0.5517	N/A	N/A
17: LM3	χ^2=2.9375 p=0.2302	2	N/A	-1.2374 0.2159	-0.2835 0.7768	N/A	N/A	N/A	N/A	1.5877 0.1124	N/A	N/A
18: LM2	χ^2=2.5683 p=0.4631	3	0.3938 0.6937	0.9691 0.3325	0.6288 0.5295	N/A	0.8753 0.3814	0.3051 0.7599	N/A	-1.2294 0.2189	N/A	N/A
19: LM1	χ^2=0.7326 p=0.8655	3	0.0000 1.0000	0.4230 0.6723	0.2927 0.7697	N/A	0.7094 0.4781	0.4863 0.6267	N/A	-0.4630 0.6433	N/A	N/A
20: LP2	χ^2=7.4693 p=0.0584	3	0.0000 1.0000	0.6113 0.5410	-0.1224 0.9026	N/A	1.0252 0.3053	-0.2037 0.8386	N/A	-2.6747 *0.0075**	N/A	N/A
21: LP1	χ^2=6.1723 p=0.1035	3	0.0000 1.0000	1.1106 0.2667	0.6264 0.5310	N/A	1.8626 0.0625	1.0424 0.2972	N/A	-1.7539 0.0795	N/A	N/A
22: LC	χ^2=2.9881 p=0.2245	2	N/A	N/A	N/A	N/A	1.0489 0.2942	0.3128 0.7545	N/A	-1.5609 0.1185	N/A	N/A
23: LI2	χ^2=1.5222 p=0.6772	3	-0.5843 0.5590	-0.3115 0.7554	-0.6630 0.5073	N/A	0.5716 0.5676	-0.0120 0.9904	N/A	-1.0862 0.2774	N/A	N/A
24: LI1	χ^2=0.3956 p=0.9411	3	0.5689 0.5695	0.3287 0.7424	0.3530 0.7241	N/A	-0.4930 0.6220	-0.4718 0.6371	N/A	0.0593 0.9527	N/A	N/A

Appendix A2.4: Age 8

Table A2.4.1: Sex comparisons for age 8 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	7.4726	1	*0.0063**	2.7336
10: UI2	0.8482	1	0.3571	0.9210
11: UC	15.154	1	***<0.0000****	3.8928
12: UP1	2.8917	1	0.0890	1.7005
13: UP2	1.8046	1	0.1792	1.3434
14: UM1	1.4557	1	0.2276	1.2065
15: UM2	14.972	1	***0.0001****	3.8693
16: UM3	0.4148	1	0.5195	0.6440
17: LM3	3.9346	1	*0.0473**	1.9836
18: LM2	12.518	1	***0.0004****	3.5381
19: LM1	3.9007	1	*0.0483**	1.9750
20: LP2	2.9831	1	0.0841	1.7272
21: LP1	7.0148	1	*0.0081**	2.6485
22: LC	10.043	1	***0.0015****	3.1691
23: LI2	3.2674	1	0.0707	1.8076
24: LI1	1.0985	1	0.2946	1.0481

Table A2.4.2: Ancestry comparisons for age 8 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=15.129 *p=0.0044**	4	0.4375 0.6618	2.1278 *0.0334**	0.5878 0.5567	1.5472 0.1218	1.1728 0.2409	-0.0641 0.9489	1.1639 0.2445	-3.4218 *0.0006**	0.6034 0.5462	1.3987 0.1619
10: UI2	χ^2=14.078 *p=0.0071**	4	0.7001 0.4834	2.3791 *0.0174**	1.0638 0.2874	0.8754 0.3814	1.2947 0.1954	0.0708 0.9435	0.5054 0.6133	-3.2362 *0.0012**	-0.0023 0.9981	0.5126 0.6082
11: UC	χ^2=25.874 ***p<0.0000*** **	4	0.5814 0.5610	1.5307 0.1258	-0.4444 0.6567	1.1831 0.2368	0.5373 0.5911	-1.0976 0.2724	0.7574 0.4488	-4.9383 ***0.0000*** **	0.5502 0.5822	1.5118 0.1306
12: UP1	χ^2=28.172 ***p<0.0000*** **	4	-0.3733 0.7089	0.6951 0.4870	-1.7290 0.0838	1.0465 0.2953	1.1171 0.2639	-1.1048 0.2693	1.2382 0.2156	-5.0438 ***0.0000*** **	0.8143 0.4155	1.8552 0.0636
13: UP2	χ^2=31.811 ***p<0.0000*** **	4	-0.8262 0.4087	1.2306 0.2185	-1.1048 0.2693	0.0405 0.9677	2.2246 *0.0261**	0.0572 0.9544	0.6027 0.5467	-5.5392 ***0.0000*** **	-0.6367 0.5243	0.6536 0.5134
14: UM1	χ^2=6.7626 p=0.1490	4	0.3096 0.7568	1.3171 0.1878	0.1205 0.9041	0.3096 0.7568	0.1943 0.8459	-0.2796 0.7798	0.0000 1.0000	-2.4789 *0.0132**	-0.1943 0.8459	0.2796 0.7798
15: UM2	χ^2=23.701 ***p<0.0000*** **	4	-0.0399 0.9682	1.2107 0.2260	-0.6560 0.5118	-0.0273 0.9783	1.1096 0.2672	-0.5221 0.6016	0.0000 1.0000	-4.8500 ***0.0000*** **	-0.6532 0.5136	0.3072 0.7587
16: UM3	χ^2=1.3052 p=0.7279	3	0.9499 0.3422	-0.1524 0.8789	-0.0303 0.9758	N/A	-1.1393 0.2546	1.0887 0.2763	N/A	0.2086 0.8348	N/A	N/A
17: LM3	χ^2=0.9325 p=0.8176	3	0.9529 0.3407	0.3119 0.7551	0.3273 0.7434	N/A	-0.8537 0.3933	-0.8731 0.3826	N/A	-0.0014 0.9989	N/A	N/A
18: LM2	χ^2=24.439 ***p<0.0000*** **	4	-0.3228 0.7469	1.2892 0.1973	-0.7082 0.4788	0.9403 0.3471	1.4134 0.1575	-0.1611 0.8720	1.0962 0.2730	-4.1804 ***0.0000*** **	0.4230 0.6723	1.3487 0.1774
19: LM1	χ^2=10.087 *p=0.0390**	4	-1.1346 0.2565	0.8580 0.3909	-0.2583 0.7962	0.3242 0.7458	2.0726 *0.0382**	1.1927 0.2330	1.0252 0.3053	-2.6882 *0.0072**	-0.0458 0.9634	0.4715 0.6373
20: LP2	χ^2=39.039 ***p<0.0000*** **	4	-0.9431 0.3456	1.2115 0.2257	-1.3424 0.1795	-0.0254 0.9797	2.0045 *0.0450**	0.1584 0.8742	0.5939 0.5526	-6.1508 ***0.0000*** **	-0.5891 0.5558	0.5946 0.5521
21: LP1	χ^2=41.491 ***p<0.0000*** **	4	-0.8112 0.4173	1.3465 0.1782	-1.2665 0.2053	0.9085 0.3636	2.0595 *0.0394**	-0.0002 0.9999	1.3749 0.1692	-6.2792 ***0.0000*** **	0.3616 0.7177	1.5729 0.1157
22: LC	χ^2=25.155 ***p<0.0000*** **	4	-0.5611 0.5747	1.7071 0.0878	-0.2678 0.7889	1.1133 0.2656	2.0363 *0.0417**	0.4792 0.6318	1.4111 0.1582	-4.7160 ***0.0000*** **	0.4159 0.6775	1.3322 0.1828
23: LI2	χ^2=23.537 ***p<0.0000*** **	4	0.5643 0.5725	3.4882 *0.0005**	2.0963 *0.0361**	2.6678 *0.0076**	1.9989 *0.0456**	0.9264 0.3542	2.0615 *0.0393**	-3.3271 *0.0009**	1.0588 0.2897	1.8272 0.0677
24: LI1	χ^2=11.332 *p=0.0231**	4	1.3845 0.1662	2.6726 *0.0075**	1.5280 0.1265	1.6651 0.0959	0.4103 0.6816	-0.5088 0.6109	0.5396 0.5895	-2.5283 *0.0115**	0.3516 0.7251	1.0162 0.3095

Table A2.4.3: Ancestry comparisons for females at age 8 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=5.9226 p=0.0518	2	N/A	1.0658 0.2865	-0.0825 0.9343	N/A	N/A	N/A	N/A	-2.3722 *0.0174**	N/A	N/A
10: UI2	χ^2=9.0247 *p=0.0290**	3	1.2062 0.2277	2.5936 0.0095	1.6814 0.0927	N/A	-0.9328 0.9257	-0.5240 0.6003	N/A	-2.0393 *0.0414**	N/A	N/A
11: UC	χ^2=7.0009 p=0.0719	3	-0.6079 0.5433	0.3601 0.7188	-0.7768 0.4373	N/A	0.8041 0.4213	0.3213 0.7480	N/A	-2.5750 *0.0100**	N/A	N/A
12: UP1	χ^2=17.184 *p=0.0006**	3	0.0742 0.9408	0.0155 0.9876	-1.9537 0.0507	N/A	-0.0730 0.9418	-1.0966 0.2728	N/A	-3.9043 ***0.0001****	N/A	N/A
13: UP2	χ^2=19.736 *p=0.0002**	3	0.7229 0.4698	1.1101 0.2670	-0.7580 0.4485	N/A	-0.2192 0.8265	-1.1904 0.2339	N/A	-4.3738 ***0.0000****	N/A	N/A
14: UM1	χ^2=4.7675 p=0.0922	2	N/A	1.1972 0.2312	-0.0304 0.9758	N/A	N/A	N/A	N/A	-2.0965 *0.0360**	N/A	N/A
15: UM2	χ^2=14.119 *p=0.0027**	3	0.0119 0.9905	0.3445 0.7304	-1.1905 0.2338	N/A	0.1469 0.8833	-0.5637 0.5729	N/A	-3.7231 ***0.0002****	N/A	N/A
16: UM3	χ^2=2.1633 p=0.3390	2	N/A	-0.5966 0.5508	0.5111 0.6093	N/A	N/A	N/A	N/A	1.4537 0.1460	N/A	N/A
17: LM3	χ^2=1.8561 p=0.3953	2	N/A	-0.2877 0.7736	0.6893 0.4906	N/A	N/A	N/A	N/A	1.2920 0.1964	N/A	N/A
18: LM2	χ^2=11.079 *p=0.0113**	3	0.5088 0.6109	1.0559 0.2910	-0.4758 0.6342	N/A	0.1191 0.9052	-0.7280 0.4666	N/A	-3.2879 *0.0010**	N/A	N/A
19: LM1	χ^2=9.7879 *p=0.0205**	3	-1.8511 0.0642	0.7593 0.4477	-0.3418 0.7325	N/A	2.2631 *0.0236**	1.8272 0.0677	N/A	-2.3636 *0.0181**	N/A	N/A
20: LP2	χ^2=17.245 *p=0.0006**	3	-0.5767 0.5641	0.2546 0.7990	-1.6462 0.0997	N/A	0.7123 0.4763	-0.0406 0.9676	N/A	-4.0694 ***0.0000****	N/A	N/A
21: LP1	χ^2=18.305 *p=0.0004**	3	-0.9543 0.3399	0.4902 0.6240	-1.4540 0.1459	N/A	1.2060 0.2278	0.4359 0.6629	N/A	-4.1648 ***0.0000****	N/A	N/A
22: LC	χ^2=8.0798 *p=0.0444**	3	-0.0950 0.9243	1.2052 0.2281	-0.1019 0.9189	N/A	0.5808 0.5614	0.0603 0.9519	N/A	-2.7762 *0.0055**	N/A	N/A
23: LI2	χ^2=12.125 p=0.0070	3	0.8405 0.4006	2.9292 *0.0034**	1.8632 0.0624	N/A	0.5923 0.5536	0.0381 0.9696	N/A	-2.4635 *0.0138**	N/A	N/A
24: LI1	χ^2=6.1303 p=0.1054	3	1.2627 0.2067	2.0132 *0.0441**	1.1444 0.2524	N/A	-0.3104 0.7562	-0.7996 0.4239	N/A	-1.8392 0.0659	N/A	N/A

Table A2.4.4: Ancestry comparisons for males at age 8 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=9.4138 p=0.0516	4	0.4334 0.6647	1.8760 0.0607	0.9039 0.3660	1.3655 0.1721	1.6992 0.0893	0.4772 0.6332	1.1115 0.2663	-2.3805 *0.0173**	0.1658 0.8683	0.9594 0.3373
10: UI2	χ^2=7.4235 p=0.1151	4	-0.7748 0.4384	0.1602 0.8727	-0.6720 0.5016	0.0000 1.0000	1.6047 0.1086	0.3279 0.7430	0.5918 0.5540	-2.4912 *0.0127**	-0.1148 0.9086	0.4825 0.6294
11: UC	χ^2=21.425 ***p=0.0003****	4	0.8574 0.3912	1.7461 0.0808	0.1954 0.8451	1.0850 0.2779	0.8774 0.3803	-1.0797 0.2803	0.4355 0.6632	-4.4750 ***0.0000****	-0.0650 0.9482	1.2087 0.2268
12: UP1	χ^2=12.463 *p=0.0142**	4	0.0000 1.0000	1.2515 0.2107	-0.1283 0.8979	1.4444 0.1486	1.6742 0.0941	-0.1746 0.8614	1.5822 0.1136	-3.1237 *0.0018**	0.8006 0.4233	1.8243 0.0681
13: UP2	χ^2=14.513 *p=0.0058**	4	-1.2901 0.1970	0.5921 0.5538	-0.7850 0.4325	-0.2512 0.8017	2.6297 *0.0071**	0.9799 0.3271	0.8520 0.3942	-3.3188 *0.0009**	-0.8049 0.4209	0.3347 0.7379
14: UM1	χ^2=1.5214 p=0.8245	4	0.0000 1.0000	0.2431 0.8079	-0.0994 0.9208	0.0000 1.0000	0.2431 0.8079	-0.0994 0.9208	0.0000 1.0000	-1.2181 0.2232	-0.2431 0.8079	0.0994 0.9208
15: UM2	χ^2=12.562 *p=0.0136**	4	0.0000 1.0000	1.4301 0.1527	0.3196 0.7492	0.0000 1.0000	1.8104 0.0702	0.4043 0.6860	0.0000 1.0000	-3.1693 *0.0015**	-1.1795 0.2382	-0.2637 0.7920
16: UM3	χ^2=2.8526 p=0.4149	3	0.0000 1.0000	-0.5170 0.6052	-0.9403 0.3471	N/A	-0.7024 0.4824	-1.2900 0.1970	N/A	-1.0861 0.2775	N/A	N/A
17: LM3	χ^2=2.0074 p=0.5709	3	0.0000 1.0000	-0.2572 0.7970	-0.8003 0.4235	N/A	-0.3067 0.7591	-0.9541 0.3401	N/A	-1.1520 0.2493	N/A	N/A
18: LM2	χ^2=14.284 *p=0.0064**	4	-1.0853 0.2778	0.3653 0.7149	-0.8077 0.4193	0.2245 0.8223	2.1545 *0.0312**	0.6612 0.5085	1.1923 0.2331	-3.4342 *0.0006**	-0.0167 0.9867	0.9501 0.3421
19: LM1	χ^2=2.9117 p=0.5727	4	-0.7859 0.4319	0.1857 0.8527	-0.2115 0.8325	0.0000 1.0000	1.4601 0.1443	0.9513 0.3415	0.6860 0.4927	-1.1622 0.2452	-0.1530 0.8784	0.1744 0.8615
20: LP2	χ^2=24.764 ***p<0.0000****	4	-0.0619 0.9506	1.8795 0.0602	0.2893 0.7723	0.5277 0.5977	2.2415 *0.0250**	0.4215 0.6734	0.6109 0.5413	-4.6433 ***0.0000****	-0.8807 0.3785	0.4282 0.6685
21: LP1	χ^2=25.536 ***p<0.0000****	4	-0.1019 0.9188	1.6680 0.0953	0.0355 0.9717	1.1038 0.2697	2.2726 *0.0231**	0.2030 0.8391	1.2933 0.1959	-4.7496 ***0.0000****	0.0224 0.9821	1.3657 0.1720
22: LC	χ^2=17.456 *p=0.0016**	4	-0.7270 0.4672	1.0174 0.3090	-0.2714 0.7861	0.7417 0.4583	2.4213 *0.0155**	0.7841 0.4330	1.4438 0.1488	-3.7517 ***0.0002****	0.1003 0.9201	1.1612 0.2455
23: LI2	χ^2=12.332 *p=0.0151**	4	0.0000 1.0000	2.0786 *0.0377**	1.1546 0.2482	2.0231 *0.0431**	2.0786 *0.0377**	1.1546 0.2482	2.0231 *0.0431**	-2.3049 *0.0212**	0.8203 0.4120	1.5825 0.1135
24: LI1	χ^2=4.9544 p=0.2920	4	0.7542 0.4507	1.6995 0.0892	1.0021 0.3163	1.3492 0.1773	0.6895 0.4905	-0.0162 0.9869	0.6746 0.4999	-1.6183 0.1056	0.2663 0.7900	0.8577 0.3910

Appendix A2.5: Age 9

Table A2.5.1: Sex comparisons for age 9 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	0.1975	1	0.6568	0.4444
10: UI2	0.7711	1	0.3799	0.8781
11: UC	13.746	1	***0.0002****	3.7076
12: UP1	1.3545	1	0.2445	-1.1638
13: UP2	0.5186	1	0.4715	0.7201
14: UM1	11.732	1	***0.0006****	3.4252
15: UM2	5.1505	1	*0.0232**	2.2695
16: UM3	6.8504	1	*0.0089**	2.6173
17: LM3	6.4917	1	*0.0108**	2.5479
18: LM2	6.0664	1	*0.0138**	2.4630
19: LM1	11.649	1	***0.0006****	3.4131
20: LP2	2.1017	1	0.1471	1.4497
21: LP1	4.3544	1	*0.0369**	2.0867
22: LC	12.549	1	***0.0004****	3.5425
23: LI2	1.3290	1	0.2490	1.1528
24: LI1	0.2325	1	0.6297	0.4282

Table A2.5.2: Ancestry comparisons for age 9 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=9.6100 *p=0.0475**	4	0.0000 1.0000	0.5342 0.5932	-0.3828 0.7019	0.0000 1.0000	0.8252 0.4092	-0.5809 0.5613	0.0000 1.0000	-3.0665 *0.0022**	-0.6491 0.5162	0.4623 0.6439
10: UI2	χ^2=4.4425 p=0.3494	4	-0.5713 0.5678	-0.3510 0.7256	-0.9190 0.3581	-1.0580 0.2901	0.4694 0.6388	-0.3771 0.7061	-0.6463 0.5181	-1.7870 0.0739	-1.2174 0.2235	-0.4816 0.6301
11: UC	χ^2=6.3828 p=0.1723	4	0.4578 0.6471	-0.0348 0.9722	-0.7554 0.4500	-0.7630 0.4455	0.7588 0.4480	-0.3467 0.7288	-0.4292 0.6678	-2.3749 *0.0176**	-1.1254 0.2604	-0.2479 0.8042
12: UP1	χ^2=8.3259 p=0.0803	4	0.0000 1.0000	0.5309 0.5955	-0.2615 0.7937	-0.3169 0.7513	0.5309 0.5955	-0.2615 0.7937	-0.3169 0.7513	-2.7691 *0.0056**	-1.4765 0.1398	-0.1624 0.8710
13: UP2	χ^2=10.882 *p=0.0279**	4	1.1585 0.2467	1.3336 0.1823	0.3880 0.6980	0.9139 0.3608	-0.0690 0.9450	-1.3795 0.1677	-0.2995 0.7645	-3.0667 *0.0022**	-0.3343 0.7382	0.9750 0.3296
14: UM1	χ^2=1.6793 p=0.7945	4	-0.7273 0.4671	-0.7243 0.4689	-0.9626 0.3357	-0.9958 0.3193	0.2372 0.8125	-0.0598 0.9523	-0.3636 0.7161	-0.7970 0.4255	-0.6556 0.5121	-0.4071 0.6839
15: UM2	χ^2=9.8877 *p=0.0424**	4	-0.2574 0.7969	-0.6261 0.5312	-1.5308 0.1258	-1.1609 0.2457	-0.4402 0.6598	-1.6837 0.0922	-1.0831 0.2788	-2.7048 *0.0068**	-0.9709 0.3316	-0.0618 0.9507
16: UM3	χ^2=3.9958 p=0.4066	4	1.3611 0.1735	0.5145 0.6069	0.2185 0.8270	1.0168 0.3092	-1.2899 0.1971	-1.5364 0.1244	-0.5380 0.5906	-0.8029 0.4220	0.8936 0.3715	1.2346 0.2170
17: LM3	χ^2=2.5740 p=0.6314	4	1.0534 0.2922	0.0705 0.9438	-0.2738 0.7842	0.0000 1.0000	-1.2420 0.2142	-1.5380 0.1241	-0.8903 0.3733	-0.7218 0.4704	-0.0514 0.9590	0.1988 0.8424
18: LM2	χ^2=11.793 *p=0.0190**	4	0.5481 0.5836	0.1879 0.8510	-0.9312 0.3517	0.1823 0.8554	-0.6124 0.5403	-2.0208 *0.0433**	-0.3443 0.7306	-3.1144 *0.0018**	0.0619 0.9506	1.1801 0.2380
19: LM1	χ^2=4.3706 p=0.3582	4	-1.2463 0.2127	-1.1920 0.2333	-1.6868 0.0916	-0.6193 0.5357	0.4245 0.6712	-0.2085 0.8348	0.5539 0.5797	-1.3904 0.1644	0.3434 0.7313	0.8414 0.4001
20: LP2	χ^2=15.258 *p=0.0042**	4	1.9474 0.0515	1.4984 0.1340	0.3520 0.7249	0.1436 0.8858	-1.1228 0.2615	-2.5579 *0.0105**	-1.7868 0.0740	-3.1703 *0.0015**	-1.3017 0.1930	-0.1559 0.8761
21: LP1	χ^2=17.326 p=0.0017	4	1.6420 0.1006	1.1037 0.2697	-0.1994 0.8420	0.0917 0.9269	-1.1488 0.2506	-2.7814 *0.0054**	-1.4467 0.1480	-3.5975 *0.0003**	-0.8919 0.3725	0.3035 0.7615
22: LC	χ^2=4.6659 p=0.3233	4	0.3737 0.7087	0.2734 0.7846	-0.3001 0.7641	0.5218 0.6018	-0.2429 0.8081	-1.0754 0.2822	0.2130 0.8313	-1.9083 0.0563	0.4677 0.6400	1.1585 0.2466
23: LI2	χ^2=5.3604 p=0.2523	4	-0.4933 0.6218	0.1164 0.9073	-0.6904 0.4900	0.2235 0.8231	0.9198 0.3577	-0.1223 0.9027	0.8151 0.4150	-2.1449 *0.0320**	0.1951 0.8453	1.1649 0.2441
24: LI1	χ^2=2.1310 p=0.7117	4	-0.4175 0.6763	-0.2625 0.7929	-0.6677 0.5043	0.0000 1.0000	0.3450 0.7301	-0.3267 0.7439	0.4175 0.6763	-1.3072 0.1912	0.2625 0.7929	0.6677 0.5043

Table A2.5.3: Ancestry comparisons for females at age 9 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=5.4935 p=0.2403	4	0.0000 1.0000	0.3086 0.7576	-0.4206 0.6741	0.0000 1.0000	0.5191 0.6037	-0.6843 0.4938	0.0000 1.0000	-2.3368 *0.0195**	-0.3086 0.7576	0.4206 0.6741
10: UI2	χ^2=8.0318 p=0.0904	4	-0.4653 0.6417	-0.7410 0.4587	-1.3911 0.1642	1.3960 0.1627	-0.3564 0.7215	-1.4302 0.1527	-1.3162 0.1881	-2.2967 *0.0216**	-1.4234 0.1546	-0.2931 0.7695
11: UC	χ^2=3.8431 p=0.4277	4	0.3722 0.7098	0.1689 0.8658	-0.3790 0.7047	0.0000 1.0000	-0.4189 0.6753	-1.3113 0.1898	-0.4297 0.6674	-1.7724 0.0763	-0.2048 0.8377	0.4580 0.6469
12: UP1	χ^2=9.8077 *p=0.0203**	3	N/A	N/A	N/A	N/A	0.5593 0.5759	-0.2842 0.7763	0.0000 1.0000	-3.1124 *0.0019**	-0.9380 0.3482	0.4736 0.6358
13: UP2	χ^2=13.691 *p=0.0083**	4	1.4975 0.1343	1.2152 0.2243	0.3753 0.7075	1.0899 0.2758	-0.8180 0.4134	-2.2087 *0.0272**	-0.5765 0.5643	-3.2045 *0.0014**	0.0395 0.9685	1.4367 0.1508
14: UM1	χ^2=2.5833 p=0.4604	3	N/A	N/A	N/A	N/A	0.2239 0.8229	-0.3295 0.7418	0.8072 0.4196	-1.2762 0.2019	0.8072 0.4196	1.1988 0.2306
15: UM2	χ^2=10.525 *p=0.0325**	4	-0.5310 0.5954	-0.9091 0.3633	-1.7448 0.0810	-0.9498 0.3422	-0.5142 0.6071	-1.8946 0.0581	-0.6131 0.5398	-2.7317 *0.0063**	-0.3507 0.7258	0.6650 0.5061
16: UM3	χ^2=2.8893 p=0.4090	3	N/A	-1.0630 0.2878	-1.3797 0.1677	-0.7519 0.4521	N/A	N/A	N/A	-1.0328 0.3017	0.2298 0.8183	0.6603 0.5091
17: LM3	χ^2=2.6003 p=0.6268	4	0.9487 0.3428	0.0687 0.9452	0.0870 0.9307	-0.7746 0.4386	-1.2105 0.2261	-1.2133 0.2250	-1.5492 0.1213	0.0437 0.9652	-0.9755 0.3293	-0.9962 0.3191
18: LM2	χ^2=10.170 *p=0.0377**	4	0.1156 0.9079	-0.4183 0.6757	-1.2065 0.2276	-0.2172 0.8280	-0.9136 0.3609	-2.2100 *0.0271**	-0.4139 0.6789	-2.6305 *0.0085**	0.1743 0.8616	1.1290 0.2589
19: LM1	χ^2=6.0380 p=0.1963	4	-0.4172 0.6765	-1.0458 0.2957	1.3735 0.1696	0.0000 1.0000	-0.9554 0.3394	-1.4939 0.1352	0.4818 0.6300	-1.1044 0.2694	1.2677 0.2049	1.6620 0.0965
20: LP2	χ^2=10.364 *p=0.0347**	4	2.0000 *0.0455**	1.5342 0.1250	0.8247 0.4095	0.9858 0.3377	-1.2063 0.2277	-2.3603 *0.0183**	-1.0715 0.2839	-2.3346 *0.0196**	-0.3914 0.6955	0.4269 0.6434
21: LP1	χ^2=16.513 *p=0.0024**	4	1.8489 0.0645	0.7197 0.4717	-0.0864 0.9311	0.0000 1.0000	-2.2769 *0.0228**	-3.5853 *0.0003**	-2.1349 *0.0328**	-2.6635 *0.0077**	-0.8722 0.3831	0.1046 0.9167
22: LC	χ^2=0.9932 p=0.9108	4	0.0000 1.0000	-0.3624 0.7171	-0.4876 0.6258	0.0000 1.0000	-0.5559 0.5783	-0.7430 0.4575	0.0000 1.0000	-0.4177 0.6762	0.4393 0.6604	0.5897 0.5554
23: LI2	χ^2=5.9160 p=0.2055	4	-1.0971 0.2726	-0.8060 0.4202	-1.4494 0.1472	0.0000 1.0000	0.6709 0.5023	-0.2213 0.8248	1.2440 0.2135	-1.6703 0.0949	0.9706 0.3318	1.7392 0.0820
24: LI1	χ^2=3.3304 p=0.5041	4	0.0000 1.0000	-0.6365 0.5245	-0.6910 0.4896	0.8463 0.3974	-0.8539 0.3932	-0.9271 0.3539	0.9271 0.3539	-0.1153 0.9079	1.4687 0.1419	1.5084 0.1315

Table A2.5.4: Ancestry comparisons for males at age 9 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=4.5340 p=0.3385	4	0.0000 1.0000	0.4524 0.6510	-0.1494 0.8812	0.0000 1.0000	0.6294 0.5291	-0.2062 0.8366	0.0000 1.0000	-2.0785 *0.0377**	-0.6294 0.5291	0.2062 0.8366
10: UI2	χ^2=1.0057 p=0.9089	4	-0.4850 0.6276	0.1098 0.9126	-0.0808 0.9356	0.0000 1.0000	0.9430 0.3457	0.6797 0.4967	0.4850 0.6276	-0.5514 0.5814	-0.1098 0.9126	0.0808 0.9356
11: UC	χ^2=6.8389 p=0.1446	4	-1.1931 0.2328	-0.2591 0.7956	-0.8460 0.3976	-1.1318 0.2577	1.6180 0.1057	0.8044 0.4211	0.0000 1.0000	-1.9583 0.0502	1.4164 0.1567	-0.7044 0.4812
12: UP1	χ^2=0.8253 p=0.9350	4	0.0000 1.0000	-0.0231 0.9816	-0.1094 0.9129	-0.6352 0.5253	-0.0168 0.9866	-0.0788 0.9372	-0.5022 0.6155	-0.1940 0.8462	-0.8894 0.3738	-0.8193 0.4126
13: UP2	χ^2=2.1903 p=0.7008	4	0.1466 0.8835	0.7741 0.4389	0.3208 0.7484	0.2600 0.7948	0.7123 0.4763	0.1652 0.8688	0.1269 0.8991	-1.3128 0.1892	-0.5421 0.5877	0.0072 0.9943
14: UM1	χ^2=3.9390 p=0.4143	4	0.0000 1.0000	-0.2739 0.7842	-0.3250 0.7452	-1.7735 0.0761	-0.1975 0.8434	-0.2355 0.8138	-1.5359 0.1246	-0.1304 0.8962	-1.9307 0.0535	-1.8816 0.0599
15: UM2	χ^2=2.0715 p=0.7226	4	0.1659 0.8682	0.0298 0.9762	-0.3744 0.7081	-0.6941 0.4876	-0.2088 0.8346	-0.6697 0.5030	-0.8779 0.3800	-1.1256 0.2603	-0.9013 0.3674	-0.5663 0.5712
16: UM3	χ^2=6.0374 p=0.1964	4	2.0060 *0.0454**	1.5556 0.1198	1.8904 0.0587	2.0006 *0.0454**	-1.1532 0.2488	-0.7562 0.4496	0.0000 1.0000	0.8193 0.4126	1.1532 0.2488	0.7562 0.4496
17: LM3	χ^2=1.7898 p=0.7743	4	0.6849 0.4934	0.2922 0.7702	-0.1553 0.8766	0.6849 0.4934	-0.5899 0.5552	-0.9161 0.3596	0.0000 1.0000	-0.8052 0.4207	0.5899 0.5552	0.9161 0.3596
18: LM2	χ^2=3.5636 p=0.4683	4	0.5158 0.6060	0.7376 0.4607	0.0070 0.9945	0.4652 0.6418	0.0379 0.9697	-0.6908 0.4897	-0.0124 0.9901	-1.7956 0.0726	-0.0491 0.9609	0.5888 0.5560
19: LM1	χ^2=4.9753 p=0.2898	4	-1.6698 0.0950	0.4244 0.6713	-0.8567 0.3916	-1.0306 0.3027	1.8407 0.0657	1.4021 0.1609	0.5153 0.6063	-1.0683 0.2854	-0.9498 0.3422	-0.5682 0.5699
20: LP2	χ^2=7.2977 p=0.1210	4	0.9652 0.3345	0.8825 0.3775	-0.0179 0.9857	-0.5859 0.5580	-0.4267 0.6696	-1.3235 0.1857	-1.4794 0.1390	-2.2128 *0.0269**	-1.5229 0.1278	-0.7337 0.4632
21: LP1	χ^2=6.7630 p=0.1490	4	0.0000 1.0000	1.0174 0.3090	0.0032 0.9974	0.4974 0.6189	1.0174 0.3090	0.0032 0.9974	0.4974 0.6189	-2.4770 *0.0132**	-0.1379 0.8903	0.5928 0.5533
22: LC	χ^2=6.7816 p=0.1479	4	0.6261 0.5312	0.7559 0.4497	0.0381 0.9696	0.7920 0.4284	0.0077 0.9939	-0.9837 0.3253	0.2367 0.8129	-2.4178 *0.0156**	0.2964 0.7669	1.1637 0.2445
23: LI2	χ^2=2.9114 p=0.5728	4	0.2888 0.7728	0.8541 0.3930	0.2777 0.7813	0.2888 0.7728	0.5953 0.5516	-0.0999 0.9204	0.0000 1.0000	-1.5814 0.1138	-0.5953 0.5516	0.0999 0.9204
24: LI1	χ^2=2.9114 p=4.5340	3	N/A	N/A	N/A	N/A	1.3535 0.1759	0.7424 0.4578	0.0000 1.0000	-1.5266 0.1269	-0.9753 0.3294	-0.5363 0.5918

Appendix A2.6: Age 10

Table A2.6.1: Sex comparisons for age 10 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	0.1002	1	0.7516	0.3165
10: UI2	1.2870	1	0.2566	1.1345
11: UC	29.645	1	***<0.0000*****	5.4447
12: UP1	1.7811	1	0.1820	1.3346
13: UP2	0.6347	1	0.4256	0.7967
14: UM1	1.1433	1	0.2850	1.0693
15: UM2	0.8361	1	0.3605	0.9144
16: UM3	8.2597	1	*0.0041**	2.8740
17: LM3	2.6250	1	0.1052	1.6202
18: LM2	0.9628	1	0.3265	0.9812
19: LM1	1.9007	1	0.1680	1.3786
20: LP2	3.9818	1	*0.0460**	1.9954
21: LP1	10.226	1	***0.0014****	3.1978
22: LC	22.29	1	***<0.0000****	4.7213
23: LI2	4.3427	1	*0.0372**	2.0839
24: LI1	3.8194	1	0.0507	1.9543

Table A2.6.2: Ancestry comparisons for age 10 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=11.416 *p=0.0223**	4	-0.2018 0.8401	-0.4576 0.6473	-1.4411 0.1496	0.9590 0.3376	-0.1807 0.8566	-1.1658 0.2437	1.1017 0.2706	-2.7574 *0.0058**	1.3655 0.1721	1.9458 0.0517
10: UI2	χ^2=12.987 *p=0.0113**	4	0.0000 1.0000	-0.9156 0.3599	-2.0432 *0.0410**	-0.6713 0.5020	-0.6575 0.5109	-1.4723 0.1409	-0.5382 0.5904	-3.1005 *0.0019**	0.0474 0.9622	1.3034 0.1924
11: UC	χ^2=3.2701 p=0.5137	4	0.1447 0.8849	-0.7782 0.4365	-1.0759 0.2820	-0.2468 0.8051	-0.8898 0.3736	-1.1575 0.2471	-0.3883 0.6978	-0.9488 0.3427	0.5876 0.5568	0.9584 0.3379
12: UP1	χ^2=16.712 *p=0.0022**	4	-0.4691 0.6390	0.4328 0.6651	-1.0107 0.3122	0.1211 0.9036	0.8762 0.3809	-0.1624 0.8710	0.5826 0.5601	-4.0335 ***0.0001****	-0.3056 0.7599	1.2948 0.1954
13: UP2	χ^2=24.971 ***p<0.0000****	4	-0.8111 0.4173	-0.8012 0.4230	-2.4762 *0.0133**	-0.8051 0.4207	0.3785 0.7051	-0.9409 0.3468	0.1752 0.8609	-4.6879 ***0.0000****	-0.2580 0.7964	1.7029 0.0886
14: UM1	χ^2=7.9858 p=0.0921	4	0.3785 0.7051	0.7569 0.4491	-0.3456 0.7296	0.3785 0.7051	0.1571 0.8751	-0.7636 0.4451	0.0000 1.0000	-2.7599 *0.0058**	-0.1571 0.8751	0.7636 0.4451
15: UM2	χ^2=19.364 *p=0.0007**	4	0.3672 0.7135	0.0813 0.9352	-1.2925 0.1962	-0.1786 0.8582	-0.4095 0.6822	-1.6439 0.1002	-0.5598 0.5756	-4.2333 ***0.0000****	-0.3622 0.7172	1.2466 0.2126
16: UM3	χ^2=7.5766 p=0.1084	4	0.3229 0.7468	0.0397 0.9683	-0.9340 0.3503	0.3954 0.6925	-0.3589 0.7197	-1.0613 0.2886	0.0000 1.0000	-2.4522 *0.0142**	0.4979 0.6186	1.4697 0.1416
17: LM3	χ^2=2.1062 p=0.7162	4	0.4061 0.6847	0.2068 0.8362	-0.1667 0.8676	-0.3989 0.6900	-0.3528 0.7242	-0.7251 0.4684	-0.8571 0.3914	-1.1501 0.2501	-0.9012 0.3675	-0.4142 0.6787
18: LM2	χ^2=23.393 ***p=0.0001****	4	-0.7072 0.4794	-0.6261 0.5313	-2.1614 *0.0307**	-0.5327 0.5943	0.3807 0.7034	-0.8885 0.3743	0.2757 0.7828	-4.5800 ***0.0000****	-0.0682 0.9456	1.6901 0.0910
19: LM1	χ^2=11.128 *p=0.0252**	4	0.7746 0.4385	0.2896 0.7721	-0.7580 0.4485	0.0000 1.0000	-0.7433 0.4573	-1.6046 0.1086	-0.8165 0.4142	-3.1173 *0.0018**	-0.3315 0.7403	0.8666 0.3861
20: LP2	χ^2=18.974 *p=0.0008**	4	-0.7287 0.4662	-0.2632 0.7924	-1.6989 0.0893	-0.8710 0.3838	0.7063 0.4800	-0.4802 0.6311	0.0000 1.0000	-4.2399 ***0.0000****	-0.9809 0.3266	0.6655 0.5057
21: LP1	χ^2=26.758 ***p<0.0000****	4	0.5962 0.5510	0.3591 0.7195	-1.3317 0.1830	-0.3341 0.7383	-0.4599 0.6456	-1.8522 0.0640	-0.9106 0.3625	-5.0324 ***0.0000****	-0.8627 0.3883	0.9568 0.3387
22: LC	χ^2=11.560 *p=0.0209**	4	-0.3621 0.7173	-1.6523 0.0985	-2.4782 *0.0132**	-1.4367 0.1508	-0.9033 0.3663	-1.5874 0.1124	-0.9023 0.3669	-2.4188 *0.0156**	-0.2688 0.7881	0.6258 0.5314
23: LI2	χ^2=12.013 *p=0.0173**	4	0.2507 0.8021	0.1363 0.8915	-1.3161 0.1882	-0.2447 0.8067	-0.1995 0.8419	-1.2517 0.2107	-0.4505 0.6524	-3.3049 *0.0010**	-0.4640 0.6426	0.9856 0.3243
24: LI1	χ^2=10.723 *p=0.0299**	4	0.0000 1.0000	-1.0175 0.3089	-2.3168 *0.0205**	-0.5706 0.5683	-0.6184 0.5363	-1.3911 0.1642	-0.4420 0.6585	-2.4849 *0.0130**	0.0766 0.9389	1.0091 0.3129

Table A2.6.3: Ancestry comparisons for females at age 10 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=5.8274 p=0.1203	3	-0.1877 0.8511	-0.2548 0.7989	-1.1826 0.2370	N/A	-0.0290 0.9768	-1.1411 0.2538	N/A	-2.2012 *0.0277**	N/A	N/A
10: UI2	χ^2=7.7699 p=0.1004	4	1.0761 0.2819	0.2404 0.8100	-0.3710 0.7106	0.0000 1.0000	-1.2507 0.2111	-1.8681 0.0617	-1.3179 0.1875	-2.2731 *0.0230**	-0.4007 0.6887	0.6228 0.5334
11: UC	χ^2=7.3885 p=0.1167	4	0.0000 1.0000	-1.5113 0.1307	-1.1309 0.2581	-0.4732 0.6360	-1.8327 0.0668	-1.3722 0.1700	-0.5422 0.5877	1.3700 0.1707	1.4784 0.1393	0.8946 0.3710
12: UP1	χ^2=6.4623 p=0.1672	4	-0.8660 0.3865	-0.6161 0.5378	-1.4281 0.1533	-0.5000 0.6171	0.5684 0.5698	-0.2449 0.8065	0.5000 0.6171	-2.2450 *0.0248**	0.0327 0.9739	1.1454 0.2520
13: UP2	χ^2=14.318 *p=0.0063**	4	-0.9071 0.3643	-0.8856 0.3758	-1.9784 *0.0479**	-1.0757 0.2821	0.3095 0.7569	-1.0118 0.3116	-0.1355 0.8922	-3.4739 *0.0005**	-0.5500 0.5823	0.9576 0.3383
14: UM1	χ^2=3.3188 p=0.5060	4	-0.8797 0.3790	-1.3628 0.1730	-1.5673 0.1170	-1.5236 0.1276	-0.4594 0.6460	-0.7078 0.4790	-0.8797 0.3790	-0.4147 0.6784	-0.6814 0.4956	-0.5486 0.5833
15: UM2	χ^2=6.2707 p=0.1798	4	-0.5497 0.5825	-0.8937 0.3715	-1.4583 0.1448	-0.5460 0.5851	-0.2419 0.8089	-0.9251 0.3549	0.0616 0.9509	-1.9541 0.0507	0.4011 0.6883	1.2677 0.2049
16: UM3	χ^2=5.2894 p=0.2589	4	-0.2589 0.7957	-1.1440 0.2526	-1.4523 0.1464	-0.2589 0.7957	-0.9895 0.3224	-1.3630 0.1729	0.0000 1.0000	-0.9211 0.3570	0.9895 0.3224	1.3630 0.1729
17: LM3	χ^2=1.0444 p=0.9030	4	0.5223 0.6015	0.4480 0.6542	0.4491 0.6534	0.8091 0.4185	-0.2472 0.8047	-0.2479 0.8042	0.3948 0.6930	0.0015 0.9988	0.8531 0.3936	0.8580 0.3909
18: LM2	χ^2=12.425 *p=0.0145**	4	-1.1740 0.2404	-1.0727 0.2834	-1.9273 0.0539	-0.9871 0.3236	0.5009 0.6164	-0.5324 0.5944	0.3367 0.7364	-3.1234 *0.0018**	-0.1108 0.9117	1.2022 0.2293
19: LM1	χ^2=4.6419 p=0.3261	4	0.3682 0.7128	0.0285 0.9772	-0.4329 0.6651	-0.7231 0.4696	-0.5305 0.5958	-1.0925 0.2746	-1.2886 0.1975	-1.6912 0.0908	-1.3324 0.1827	-0.6279 0.5300
20: LP2	χ^2=10.535 *p=0.0323**	4	-0.2890 0.7726	-0.2501 0.8025	-1.0941 0.2739	-0.1892 0.8499	0.1401 0.8886	-0.8835 0.3770	0.1445 0.8851	-3.0620 *0.0022**	0.0472 0.9624	1.3468 0.1780
21: LP1	χ^2=20.463 *p=0.0004**	4	0.4662 0.6410	-0.1289 0.8975	-1.2630 0.2066	-0.4290 0.6680	-0.8719 0.3833	-2.2513 *0.0244**	-1.0742 0.2827	-4.1549 ***0.0000****	-0.5664 0.5711	1.1780 0.2388
22: LC	χ^2=7.3015 p=0.1208	4	0.0000 1.0000	-1.1011 0.2709	-1.5262 0.1269	-0.5602 0.5754	-1.3344 0.1821	-1.8522 0.0640	-0.6352 0.5253	-1.4936 0.1353	0.5952 0.5517	1.1846 0.2362
23: LI2	χ^2=4.7597 p=0.3128	4	0.0000 1.0000	0.0000 1.0000	-0.8082 0.4190	-0.3824 0.7022	0.0000 1.0000	-0.8082 0.4190	-0.3824 0.7022	-2.0667 *0.0388**	-0.5638 0.5729	0.3975 0.6910
24: LI1	χ^2=9.1608 p=0.0572	4	0.0000 1.0000	-1.3384 0.1808	-1.8553 0.0635	0.0000 1.0000	-1.3384 0.1808	-1.8553 0.0635	0.0000 1.0000	-1.0162 0.3095	1.3384 0.1808	1.8553 0.0635

Table A2.6.4: Ancestry comparisons for males at age 10 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=5.7480 p=0.1245	3	N/A	-0.3288 0.7423	-0.8113 0.4172	0.8363 0.4030	N/A	N/A	N/A	-1.6383 0.1014	1.4916 0.1358	1.9607 *0.0499**
10: UI2	χ^2=6.5941 p=0.1590	4	-0.8519 0.3943	-1.1327 0.2573	-1.9654 *0.0494**	-0.2694 0.7876	0.3005 0.7638	-0.2275 0.8200	0.6024 0.5469	-1.9460 0.0517	0.5973 0.5503	1.3092 0.1905
11: UC	χ^2=3.6083 p=0.4616	4	0.0130 0.9896	0.2545 0.7991	-0.4317 0.6660	0.0184 0.9853	0.1346 0.8929	-0.2709 0.7865	0.0000 1.0000	-1.8989 0.0576	-0.2291 0.8188	0.4567 0.6479
12: UP1	χ^2=11.851 *p=0.0079**	3	N/A	1.1188 0.2632	-0.0796 0.9366	0.6174 0.5370	N/A	N/A	N/A	-3.3764 *0.0007**	-0.0584 0.9534	0.8003 0.4236
13: UP2	χ^2=10.906 *p=0.0122**	3	N/A	-0.2816 0.7783	-1.5240 0.1275	0.0000 1.0000	N/A	N/A	N/A	-3.0986 *0.0019**	0.2816 0.7783	1.5240 0.1275
14: UM1	χ^2=11.059 *p=0.0114**	3	N/A	1.7932 0.0729	0.5407 0.5887	1.6370 0.1016	N/A	N/A	N/A	-2.8798 *0.0040**	0.6505 0.5154	1.5653 0.1175
15: UM2	χ^2=17.098 *p=0.0019**	4	1.1281 0.2593	0.8541 0.3930	-0.5809 0.5613	-0.1993 0.8420	-0.7875 0.4310	-1.6292 0.1033	-1.2121 0.2255	-3.9346 ***0.0001****	-0.9564 0.3389	0.2300 0.8181
16: UM3	χ^2=4.1370 p=0.2470	3	N/A	0.9984 0.3181	0.0890 0.9291	0.5618 0.5743	N/A	N/A	N/A	-1.9178 0.0551	-0.1570 0.8752	0.6267 0.5309
17: LM3	χ^2=6.0584 p=0.1948	4	0.7743 0.4387	0.1305 0.8962	-0.3958 0.6923	-1.3919 0.1640	-0.8060 0.4203	-1.1151 0.2648	-1.7585 0.0787	-1.3045 0.1921	-2.0290 *0.0425**	-1.4781 0.1394
18: LM2	χ^2=11.055 *p=0.0260**	4	0.1701 0.8649	0.0023 0.9982	-1.2635 0.2064	0.0830 0.9338	-0.1874 0.8513	-0.8428 0.3993	-0.1098 0.9125	-3.2091 *0.0013**	0.1051 0.9163	1.2130 0.2251
19: LM1	χ^2=10.637 *p=0.0310**	4	0.8905 0.3732	0.3985 0.6903	-0.6321 0.5273	1.3036 0.1924	-0.7829 0.4337	-1.3108 0.1899	0.0000 1.0000	-2.5974 *0.0094**	1.3336 0.1823	2.2157 *0.0267**
20: LP2	χ^2=9.1009 p=0.0586	4	-0.7746 0.4386	-0.0651 0.9481	-1.1446 0.2524	-1.1338 0.2569	0.8249 0.4094	0.2617 0.7935	0.0000 1.0000	-2.7197 *0.0065**	-1.4044 0.1602	-0.4424 0.6582
21: LP1	χ^2=6.8213 p=0.1456	4	0.0083 0.9934	0.5919 0.5539	-0.4438 0.6572	0.0107 0.9914	0.2942 0.7686	-0.2392 0.8109	0.0000 1.0000	-2.6026 *0.0093**	-0.4125 0.6800	0.3342 0.7383
22: LC	χ^2=4.2641 p=0.3714	4	-0.4354 0.6633	-1.2844 0.1990	-1.7163 0.0861	-1.5984 0.1100	-0.1764 0.8600	-0.4100 0.6818	-0.6357 0.5250	-1.1296 0.2586	-0.9383 0.3481	-0.5313 0.5952
23: LI2	χ^2=6.0922 p=0.1924	4	0.5849 0.5586	0.1298 0.8967	-0.9441 0.3451	0.0751 0.9401	-0.5762 0.5645	-1.1377 0.2552	-0.5167 0.6054	-2.2483 *0.0246**	-0.0190 0.9848	0.9246 0.3551
24: LI1	χ^2=4.5000 p=0.2123	3	N/A	-0.3618 0.7175	-1.3823 0.1669	-0.9674 0.3333	N/A	N/A	N/A	-1.8141 0.0697	-0.8655 0.3868s	-0.3167 0.7515

Appendix A2.7: Age 11

Table A2.7.1: Sex comparisons for age 11 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	2.0340	1	0.1538	1.4262
10: UI2	5.5660	1	*0.0183**	2.3592
11: UC	5.9241	1	*0.0149**	2.4340
12: UP1	1.7166	1	0.1901	1.3102
13: UP2	0.0602	1	0.8061	0.2454
14: UM1	1.3849	1	0.2393	1.1768
15: UM2	2.9701	1	0.0848	1.7234
16: UM3	1.1271	1	0.2884	1.0617
17: LM3	0.8253	1	0.3636	0.9085
18: LM2	2.0684	1	0.1504	1.4382
19: LM1	2.4884	1	0.1147	1.5775
20: LP2	0.7565	1	0.3844	0.8698
21: LP1	3.1012	1	0.0782	1.7610
22: LC	10.868	1	***0.0010****	3.2967
23: LI2	3.1298	1	0.0769	1.7691
24: LI1	0.4178	1	0.5180	0.6464

Table A2.7.2: Ancestry comparisons for age 11 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=4.3181 p=0.3647	4	0.0000 1.0000	0.7860 0.4319	0.3957 0.6924	0.8763 0.3809	0.7860 0.4319	0.3957 0.6924	0.8763 0.3809	-1.7743 0.0760	0.3841 0.7009	0.9276 0.3536
10: UI2	χ^2=7.6770 p=0.1042	4	-2.0571 *0.0397**	-1.1252 0.2605	-1.5050 0.1323	-0.4489 0.6535	1.7857 0.0741	1.3236 0.1856	2.0571 *0.0397**	-1.2971 0.1946	0.9281 0.3533	1.5098 0.1311
11: UC	χ^2=4.1528 p=0.3857	4	-1.3844 0.1662	0.1995 0.8419	0.3135 0.7539	-0.0890 0.9290	1.9257 0.0541	2.0083 *0.0446**	1.1992 0.2304	0.2665 0.7898	-0.2836 0.7767	-0.3810 0.7032
12: UP1	χ^2=16.546 *p=0.0024**	4	-1.4778 0.1395	-0.2003 0.8412	-1.5739 0.1155	-0.6609 0.5087	1.8260 0.0679	0.4382 0.6613	0.9914 0.3215	-3.7798 ***0.0002****	-0.7725 0.4398	0.9695 0.3323
13: UP2	χ^2=11.727 *p=0.0195**	4	-2.0437 *0.0410**	-0.6795 0.4968	-1.7746 0.0760	-0.9516 0.3413	2.0478 *0.0406**	1.0365 0.3000	1.1465 0.2516	-2.7382 *0.0062**	-0.6166 0.5375	0.4915 0.6231
14: UM1	χ^2=1.1728 p=0.8826	4	0.0000 1.0000	0.4518 0.6514	0.3467 0.7288	0.0000 1.0000	0.6323 0.5272	0.4847 0.6279	0.0000 1.0000	-0.4961 0.6198	-0.7664 0.4434	-0.5870 0.5572
15: UM2	χ^2=21.000 *p=0.0003**	4	-2.1367 *0.0326**	-0.0453 0.9638	-1.5921 0.1114	-0.3709 0.7107	2.6126 *0.0090**	1.3726 0.1699	1.8892 0.0589	-3.9809 ***0.0001****	-0.4791 0.6318	1.2081 0.2270
16: UM3	χ^2=3.6160 p=0.4605	4	1.5471 0.1218	1.6857 0.0918	1.3048 0.1920	0.8436 0.3989	-0.4485 0.6538	-0.7948 0.4267	-0.6057 0.5447	-0.8414 0.4001	-0.3788 0.7048	-0.0574 0.9542
17: LM3	χ^2=7.6588 p=0.1049	4	0.1951 0.8453	2.0979 *0.0359**	1.8518 0.0641	1.9699 *0.0488**	1.7012 0.0889	1.4739 0.1405	1.7256 0.0844	-0.5286 0.5971	0.6889 0.4909	0.8891 0.3740
18: LM2	χ^2=14.730 *p=0.0053**	4	-0.3747 0.7079	0.8939 0.3714	-0.5623 0.5739	1.1587 0.2466	1.3253 0.1851	-0.0346 0.9724	1.4777 0.1395	-3.5071 *0.0005**	0.6920 0.4890	2.0378 *0.0416**
19: LM1	χ^2=4.3105 p=0.3656	4	-1.2506 0.2111	-0.1832 0.8547	-0.7604 0.4470	0.2084 0.8349	1.4746 0.1403	0.9250 0.3550	1.4059 0.1597	-1.4006 0.1613	0.4447 0.6565	0.9810 0.3266
20: LP2	χ^2=10.123 *p=0.0384**	4	-0.2329 0.8158	1.7044 0.0883	0.8080 0.4191	1.7804 0.0750	1.8933 0.0583	1.0573 0.2904	1.9400 0.0524	-2.1366 *0.0326**	0.7551 0.4502	1.5727 0.1158
21: LP1	χ^2=13.329 *p=0.0098**	4	-1.9254 0.0542	-1.2832 0.1994	-2.4466 *0.0144**	-1.5942 0.1109	1.3466 0.1781	0.2659 0.7903	0.4053 0.6852	-2.9742 *0.0029**	-0.8873 0.3749	0.2867 0.7744
22: LC	χ^2=2.2454 p=0.6907	4	-1.4847 0.1376	-0.9234 0.3558	-0.9274 0.3537	-0.5742 0.5659	1.1112 0.2665	1.0938 0.2740	1.0043 0.3152	-0.0308 0.9754	0.1851 0.8532	0.1957 0.8448
23: LI2	χ^2=9.1312 p=0.0579	4	-1.0935 0.2742	-0.1702 0.8648	-1.0603 0.2890	0.0000 1.0000	1.4206 0.1554	0.3933 0.6941	1.0935 0.2742	-2.7306 *0.0063**	0.1702 0.8648	1.0603 0.2890
24: LI1	χ^2=6.4113 p=0.1705	4	0.0000 1.0000	0.5318 0.5949	0.2172 0.8281	1.8422 0.0654	0.5318 0.5949	0.2172 0.8281	1.8422 0.0654	-1.1063 0.2686	2.0209 *0.0433**	2.3344 *0.0196**

Table A2.7.3: Ancestry comparisons for females at age 11 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=1.3273 p=0.7227	3	N/A	N/A	N/A	N/A	0.5080 0.6114	0.4097 0.6820	0.9753 0.3294	-0.3058 0.7597	0.9184 0.3584	1.0339 0.3012
10: UI2	χ^2=6.7532 p=0.0802	3	N/A	N/A	N/A	N/A	1.1310 0.2580	0.5324 0.5945	1.9160 0.0554	-1.3178 0.1876	1.5756 0.1151	2.3282 *0.0199**
11: UC	χ^2=2.8460 p=0.4160	3	N/A	N/A	N/A	N/A	1.6580 0.0973	1.5827 0.1135	1.5411 0.1233	-0.1139 0.9093	0.1838 0.8541	0.2374 0.8123
12: UP1	χ^2=10.042 *p=0.0182**	3	N/A	N/A	N/A	N/A	1.3099 0.1902	-0.0758 0.9396	0.8952 0.3707	-3.0371 *0.0024**	-0.4375 0.6617	1.5476 0.1217
13: UP2	χ^2=2.4643 p=0.4818	3	N/A	N/A	N/A	N/A	0.8125 0.4165	0.2567 0.7974	0.4661 0.6411	-1.4454 0.1483	-0.4200 0.6745	0.4019 0.6878
14: UM1	χ^2=0.7495 p=0.8615	3	N/A	N/A	N/A	N/A	0.3975 0.6910	0.2128 0.8315	0.0000 1.0000	-0.5842 0.5591	-0.6642 0.5065	-0.3487 0.7273
15: UM2	χ^2=6.9388 p=0.0739	3	N/A	N/A	N/A	N/A	1.8283 0.0675	1.0590 0.2896	1.6630 0.0963	-2.0180 *0.0436**	0.1322 0.8948	1.2296 0.2188
16: UM3	χ^2=2.2475 p=0.5227	3	N/A	N/A	N/A	N/A	-1.0929 0.2744	-0.6689 0.5036	-0.9060 0.3649	1.1479 0.2510	0.0212 0.9831	-0.5443 0.5862
17: LM3	χ^2=2.9212 p=0.4039	3	N/A	N/A	N/A	N/A	0.5076 0.6117	0.8811 0.3782	1.2537 0.2099	1.0311 0.3025	1.3466 0.1781	0.8138 0.4158
18: LM2	χ^2=10.470 *p=0.0150**	3	N/A	N/A	N/A	N/A	1.7526 0.0797	0.9411 0.3467	2.1447 *0.0320**	-2.3464 *0.0190**	1.1117 0.2663	2.2690 *0.0233**
19: LM1	χ^2=5.3679 p=0.1468	3	N/A	N/A	N/A	N/A	0.8962 0.3701	0.1377 0.8905	0.6512 0.5149	-2.2206 *0.0264**	-0.2194 0.8264	0.9119 0.3618
20: LP2	χ^2=9.0135 *p=0.0291**	3	N/A	N/A	N/A	N/A	2.0005 *0.0454**	1.6459 0.0998	2.7442 *0.0061**	-0.9799 0.3271	1.7928 0.0730	2.2385 *0.0252**
21: LP1	χ^2=5.3781 p=0.1461	3	N/A	N/A	N/A	N/A	1.1424 0.2533	0.3962 0.6919	0.8690 0.3849	-2.1393 *0.0324**	-0.2140 0.8306	0.8969 0.3698
22: LC	χ^2=1.2014 p=0.7527	3	N/A	N/A	N/A	N/A	0.2087 0.8346	0.2389 0.8112	0.7795 0.4357	0.0936 0.9254	1.0526 0.2925	0.9690 0.3325
23: LI2	χ^2=6.0443 p=0.1095	3	N/A	N/A	N/A	N/A	0.8414 0.4001	0.0000 1.0000	1.0856 0.2776	-2.1468 *0.0318**	0.6198 0.5354	1.6057 0.1083
24: LI1	χ^2=6.9130 p=0.0747	3	N/A	N/A	N/A	N/A	0.2337 0.8152	0.2657 0.7905	2.0642 *0.0390**	0.0822 0.9345	2.5710 *0.0101**	2.5237 *0.0116**

Table A2.7.4: Ancestry comparisons for males at age 11 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=5.9244 p=0.0517	2	N/A	1.0980 0.2722	0.3798 0.7041	N/A	N/A	N/A	N/A	-2.3274 *0.0199**	N/A	N/A
10: UI2	χ^2=4.2502 p=0.2357	3	-1.4964 0.1345	-0.5850 0.5585	-1.1555 0.2479	N/A	1.3651 0.1722	0.9713 0.3314	N/A	-1.4137 0.1574	N/A	N/A
11: UC	χ^2=2.2436 p=0.5234	3	-0.6697 0.5030	0.7907 0.4291	0.7172 0.4733	N/A	1.3126 0.1893	1.2623 0.2068	N/A	-0.1326 0.8945	N/A	N/A
12: UP1	χ^2=8.3151 *p=0.0399**	3	-1.0190 0.3082	0.0754 0.9399	-1.2086 0.2268	N/A	1.1972 0.2312	0.4277 0.6688	N/A	-2.6950 *0.0070**	N/A	N/A
13: UP2	χ^2=10.219 *p=0.0168**	3	-2.0808 *0.0375**	-0.4525 0.6509	-1.7558 0.0791	N/A	2.0846 *0.0371**	1.2184 0.2231	N/A	-2.4255 *0.0153**	N/A	N/A
14: UM1	χ^2=0.6347 p=0.8884	3	0.0000 1.0000	0.5281 0.5974	0.3918 0.6952	N/A	0.5281 0.5974	0.3918 0.6952	N/A	-0.4770 0.6334	N/A	N/A
15: UM2	χ^2=15.269 *p=0.0042**	4	-1.3901 0.1645	0.4624 0.6438	-1.4103 0.1584	-0.2241 0.8227	1.7197 0.0855	0.8279 0.4078	0.9032 0.3664	-3.6485 *0.0003**	-0.4598 0.6457	0.4287 0.6681
16: UM3	χ^2=8.8274 p=0.0656	4	1.1594 0.2463	2.4033 *0.0162**	1.0751 0.2823	1.0458 0.2956	0.5123 0.6084	-0.5362 0.5918	0.3500 0.7263	-2.3141 *0.0207**	0.1188 0.9055	0.6647 0.5062
17: LM3	χ^2=11.072 *p=0.0258**	4	0.1729 0.8628	2.7984 *0.0051**	1.7484 0.0804	0.8108 0.4175	1.9900 *0.0466**	1.1663 0.2435	0.6784 0.4975	-1.8187 0.0690	-0.2878 0.7735	0.1409 0.8880
18: LM2	χ^2=8.6195 p=0.0714	4	0.3412 0.7330	1.3038 0.1923	-0.2627 0.7928	0.2000 0.8415	0.6108 0.5413	-0.6133 0.5397	0.0000 1.0000	-2.8870 *0.0039**	-0.3164 0.7517	0.3174 0.7509
19: LM1	χ^2=4.3498 p=0.3607	4	-1.0361 0.3001	-0.0594 0.9526	-0.2324 0.8162	1.5187 0.1288	1.1920 0.2333	1.0584 0.2899	2.0331 *0.0420**	-0.3181 0.7504	1.6277 0.1036	1.6980 0.0895
20: LP2	χ^2=11.032 *p=0.0262**	4	0.5361 0.5919	2.2345 *0.0255**	1.0003 0.3172	-1.0059 0.3145	1.1050 0.2692	0.1394 0.8891	-1.2623 0.2068	-2.2787 *0.0227**	-1.9664 *0.0493**	-1.4666 0.1425
21: LP1	χ^2=8.9793 p=0.0616	4	-1.3143 0.1887	-0.9080 0.3639	-2.1115 *0.0347**	-1.4341 0.1516	0.8846 0.3764	0.0083 0.9934	-0.5366 0.5916	-2.3198 *0.0203**	-1.1352 0.2563	-0.6169 0.5373
22: LC	χ^2=3.3235 p=0.5052	4	-1.2938 0.1957	-0.1363 0.8916	-0.5321 0.5946	-0.9882 0.3231	1.4037 0.1604	1.1418 0.2535	0.0000 1.0000	-0.8226 0.4107	-1.0049 0.3149	-0.8179 0.4134
23: LI2	χ^2=4.8721 p=0.1814	3	-0.8277 0.4078	0.1718 0.8636	-0.7108 0.4772	N/A	1.1761 0.2395	0.4424 0.6582	N/A	-2.0231 *0.0431**	N/A	N/A
24: LI1	χ^2=2.5319 p=0.2820	2	N/A	0.7607 0.4468	0.1761 0.8602	N/A	N/A	N/A	N/A	-1.5215 0.1281	N/A	N/A

Appendix A2.8: Age 12

Table A2.8.1: Sex comparisons for age 12 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	1.9993	1	0.1574	1.4140
10: UI2	1.0213	1	0.3122	1.0106
11: UC	12.221	1	***0.0005***	3.4959
12: UP1	3.0351	1	0.0815	1.7422
13: UP2	5.3839	1	*0.0203**	2.3203
14: UM1	0.1238	1	0.7250	0.3518
15: UM2	1.3118	1	0.2521	1.1453
16: UM3	0.0040	1	0.9493	-0.0635
17: LM3	0.0537	1	0.8167	-0.2318
18: LM2	0.9062	1	0.3411	0.9519
19: LM1	0.1629	1	0.6865	0.4037
20: LP2	11.826	1	***0.0006***	3.4389
21: LP1	9.335	1	*0.0022**	3.0554
22: LC	15.225	1	***<0.0000***	3.9020
23: LI2	0.8929	1	0.3447	0.9449
24: LI1	0.6458	1	0.4216	-0.8036

Table A2.8.2: Ancestry comparisons for age 12 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=2.6377 p=0.6202	4	0.0000 1.0000	-0.9267 0.3541	-0.5162 0.6057	-1.0755 0.2822	-0.9267 0.3541	-0.5162 0.6057	-1.0755 0.2822	0.9543 0.3400	-0.5295 0.5964	-0.9292 0.3528
10: UI2	χ^2=1.9750 p=0.7404	4	1.1215 0.2621	1.0768 0.2816	0.8663 0.3863	1.1769 0.2392	-0.4528 0.6507	-0.6481 0.5169	-0.0770 0.9386	-0.5049 0.6136	0.4530 0.6506	0.6965 0.4861
11: UC	χ^2=4.2637 p=0.3715	4	1.8050 0.0711	1.7661 0.0774	1.8606 0.0628	1.4316 0.1523	-0.8334 0.4046	-0.7419 0.4582	-0.6383 0.5233	0.2605 0.7945	0.0991 0.9210	-0.0213 0.9830
12: UP1	χ^2=1.9849 p=0.7385	4	0.3348 0.7378	1.0450 0.2960	0.8114 0.4171	0.4305 0.6668	0.7554 0.4500	0.4724 0.6367	0.0880 0.9299	-0.7089 0.4784	-0.7333 0.4634	-0.4110 0.6811
13: UP2	χ^2=0.5510 p=0.9684	4	0.0891 0.9290	0.5132 0.6078	0.3541 0.7233	0.4646 0.6422	0.3905 0.6961	0.2319 0.8166	0.3649 0.7152	-0.4677 0.6400	0.0742 0.9408	0.2731 0.7848
14: UM1	χ^2=7.6330 p=0.1060	4	1.2677 0.2049	-1.4348 0.1514	-1.0289 0.3035	-1.1946 0.2322	-2.4020 *0.0163**	-2.1359 *0.0327**	-2.1501 *0.0315**	0.8195 0.4125	-0.2132 0.8312	-0.5888 0.5560
15: UM2	χ^2=1.7695 p=0.7781	4	0.1511 0.8799	0.5525 0.5806	0.1208 0.9039	-0.4303 0.6670	0.1972 0.8436	-0.0924 0.9264	-0.4845 0.6281	-0.8599 0.3898	-1.1274 0.2596	-0.6860 0.4927
16: UM3	χ^2=2.4991 p=0.6448	4	1.2190 0.2228	1.4875 0.1369	1.3288 0.1839	0.9624 0.3358	-0.3296 0.7417	-0.4491 0.6533	-0.5301 0.5960	-0.3662 0.7142	-0.4394 0.6603	-0.2388 0.8113
17: LM3	χ^2=1.1309 p=0.8893	4	0.7533 0.4513	0.9706 0.3318	0.8767 0.3806	0.7101 0.4776	-0.3924 0.6948	-0.4301 0.6671	-0.4056 0.6851	-0.1949 0.8455	-0.0902 0.9281	0.0112 0.9910
18: LM2	χ^2=6.0995 p=0.1918	4	1.1066 0.2685	1.0537 0.2920	0.3093 0.7571	-0.4374 0.6618	-0.5873 0.5570	-1.0793 0.2804	-1.4761 0.1399	-1.6419 0.1006	-1.8028 0.0714	-0.9591 0.3375
19: LM1	χ^2=1.2312 p=0.8729	4	0.0000 1.0000	0.9336 0.3505	0.8772 0.3804	0.7237 0.4693	0.6275 0.5304	0.5934 0.5529	0.5471 0.5843	-0.1016 0.9191	-0.0145 0.9884	0.0363 0.9711
20: LP2	χ^2=3.0587 p=0.5481	4	0.6161 0.5378	1.2371 0.2160	0.7492 0.4537	0.0334 0.9734	0.1134 0.9097	-0.2094 0.8341	-0.5903 0.5550	-1.0381 0.2992	-1.1922 0.2332	-0.7048 0.4809
21: LP1	χ^2=1.7061 p=0.7896	4	-0.1313 0.8955	0.5012 0.6163	0.5656 0.5717	-0.3982 0.6905	0.5190 0.6038	0.5668 0.5708	-0.1938 0.8463	0.1679 0.8666	-1.0419 0.2975	-1.0998 0.2714
22: LC	χ^2=2.6627 p=0.6157	4	0.7125 0.4762	0.9083 0.3637	0.9074 0.3642	-0.2439 0.8073	-0.1638 0.8699	-0.1533 0.8781	-0.9447 0.3448	0.0269 0.9785	-1.3315 0.1830	-1.3226 0.1860
23: LI2	χ^2=0.7325 p=0.9473	4	0.0000 1.0000	0.5474 0.5841	0.4938 0.6214	0.0000 1.0000	0.4516 0.6516	0.4082 0.6831	0.0000 1.0000	-0.1370 0.8910	-0.5474 0.5841	-0.4938 0.6214
24: LI1	χ^2=1.0789 p=0.8976	4	0.0000 1.0000	0.4450 0.6563	0.0000 1.0000	0.0000 1.0000	0.3224 0.7471	0.0000 1.0000	0.0000 1.0000	-0.9749 0.3296	-0.3900 0.6965	0.0000 1.0000

Table A2.8.3: Ancestry comparisons for females at age 12 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=4.2330 p=0.3754	4	-1.2455 0.2129	-1.8512 0.0641	-1.3644 0.1724	-1.2455 0.2129	0.1489 0.8817	0.4949 0.6207	0.0000 1.0000	1.0956 0.2733	-0.1489 0.8817	-0.4949 0.6207
10: UI2	χ^2=1.8081 p=0.7710	4	0.0000 1.0000	0.6410 0.5215	0.8348 0.4038	1.1322 0.2576	0.4622 0.6439	0.6042 0.5457	0.9244 0.3553	0.4867 0.6265	0.8974 0.3695	0.6919 0.4890
11: UC	χ^2=1.7340 p=0.7845	4	0.5523 0.5808	0.7643 0.4447	1.1358 0.2560	0.7810 0.4348	-0.1748 0.8612	0.0538 0.9571	0.0000 1.0000	0.8915 0.3727	0.2945 0.7684	-0.0900 0.9283
12: UP1	χ^2=3.0322 p=0.5523	4	-1.1946 0.2323	-0.5452 0.5856	-0.2237 0.8230	0.0000 1.0000	1.0905 0.2755	1.4301 0.1527	1.1946 0.2323	1.0082 0.3133	0.5452 0.5856	0.2237 0.8230
13: UP2	χ^2=4.1777 p=0.3825	4	-1.9430 0.0520	-0.9401 0.3472	-0.7448 0.4564	-0.6413 0.5213	1.6686 0.0952	1.8059 0.0709	1.5538 0.1202	0.5560 0.5782	0.1652 0.8688	-0.0686 0.9453
14: UM1	χ^2=4.1462 p=0.2461	3	-1.2060 0.2278	-1.9735 0.0484*	-1.9330 0.0532	N/A	0.1741 0.8618	0.1911 0.8484	N/A	0.0576 0.9540	N/A	N/A
15: UM2	χ^2=1.9443 p=0.7460	4	-0.9037 0.3661	-0.5248 0.5997	-0.5031 0.6149	-1.1833 0.2367	0.7288 0.4661	0.7304 0.4651	0.0000 1.0000	0.0202 0.9839	-1.0166 0.3093	-1.0143 0.3104
16: UM3	χ^2=2.3957 p=0.6634	4	0.2096 0.8340	1.3867 0.1655	1.4367 0.1508	0.8152 0.4150	0.4924 0.6224	0.5218 0.6018	0.3059 0.7597	0.1211 0.9036	-0.2980 0.7657	-0.3538 0.7235
17: LM3	χ^2=2.1378 p=0.7104	4	0.8514 0.3945	1.1070 0.2683	1.2113 0.2258	1.2772 0.2015	-0.3943 0.6934	-0.3419 0.7324	0.0000 1.0000	0.2077 0.8355	0.6631 0.5073	0.5740 0.5660
18: LM2	χ^2=2.5585 p=0.6342	4	0.7552 0.4502	0.1732 0.8625	-0.3721 0.7098	-0.6064 0.5443	-0.7363 0.4616	-0.9910 0.3217	-1.1037 0.2697	-1.1221 0.2618	-0.9331 0.3507	-0.4323 0.6655
19: LM1	χ^2=2.1693 p=0.7046	4	0.0000 1.0000	0.5259 0.5990	0.8362 0.4030	1.2688 0.2045	0.2461 0.8056	0.3948 0.6930	0.7613 0.4465	0.6528 0.5139	1.1493 0.2504	0.8525 0.3940
20: LP2	χ^2=3.5325 p=0.4730	4	-0.6156 0.5382	-0.0779 0.9379	-0.1127 0.9103	-1.4271 0.1535	0.6288 0.5295	0.6107 0.5414	-0.2531 0.8002	-0.0708 0.9436	-1.7484 0.0804	-1.7030 0.0886
21: LP1	χ^2=2.2668 p=0.6868	4	-1.0608 0.2888	-0.0119 0.9905	0.3303 0.7412	-0.1725 0.8630	1.1657 0.2437	1.3404 0.1801	0.9130 0.3612	0.7690 0.4419	-0.2099 0.8337	-0.5083 0.6112
22: LC	χ^2=1.9180 p=0.7508	4	-0.4951 0.6205	0.7574 0.4488	0.8951 0.3708	0.7001 0.4838	1.0133 0.3109	1.0979 0.2723	0.9901 0.3221	0.3378 0.7355	0.1894 0.8498	0.0338 0.9731
23: LI2	χ^2=0.8756 p=0.9280	4	0.0000 1.0000	0.2129 0.8314	0.5147 0.6068	0.0000 1.0000	0.1531 0.8783	0.3714 0.7103	0.0000 1.0000	0.7945 0.4269	-0.1531 0.8783	-0.3714 0.7103
24: LI1	χ^2=1.0000 p=0.9098	4	0.0000 1.0000	0.4714 0.6374	0.0000 1.0000	0.0000 1.0000	0.2828 0.7773	0.0000 1.0000	0.0000 1.0000	-0.9401 0.3472	-0.2828 0.7773	0.0000 1.0000

Table A2.8.4: Ancestry comparisons for males at age 12 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=1.7604 p=0.7797	4	0.9258 0.3545	0.5043 0.6141	0.6487 0.5165	0.0000 1.0000	-0.8038 0.4215	-0.5855 0.5582	-1.1339 0.2568	0.3733 0.7090	-0.6890 0.4908	-0.8783 0.3798
10: UI2	χ^2=3.0877 p=0.5433	4	1.1037 0.2697	0.8539 0.3932	0.3502 0.7262	0.5808 0.5614	-0.6287 0.5295	-1.2826 0.1996	-0.7461 0.4556	-1.3133 0.1891	-0.3331 0.7391	0.4680 0.6398
11: UC	χ^2=3.9178 p=0.4172	4	1.7668 0.0773	1.7564 0.0790	1.4915 0.1358	1.1711 0.2416	-0.6359 0.5249	-0.8908 0.3730	-0.7643 0.4447	-0.6182 0.5365	-0.3707 0.7109	-0.0600 0.9522
12: UP1	χ^2=6.0849 p=0.1929	4	1.2650 0.2059	1.7336 0.0830	1.1296 0.2586	0.7332 0.4634	0.3138 0.7537	-0.4964 0.6196	-0.7698 0.4414	-1.6601 0.0969	-1.4967 0.1345	-0.5084 0.6112
13: UP2	χ^2=5.6071 p=0.2305	4	1.7320 0.0833	1.8941 0.0582	1.4160 0.1568	1.6270 0.1037	-0.2468 0.8051	-0.8886 0.3742	-0.1286 0.8977	-1.4761 0.1399	0.0731 0.9417	0.7166 0.4736
14: UM1	χ^2=11.887 *p=0.0182**	4	2.8360 *0.0046**	0.0000 1.0000	0.5789 0.5627	0.0000 1.0000	-3.3255 *0.0009**	-2.9485 *0.0032**	-3.1067 *0.0019**	1.1085 0.2676	0.0000 1.0000	-0.7767 0.4373
15: UM2	χ^2=4.2651 p=0.3713	4	1.1666 0.2434	1.5735 0.1156	0.9733 0.3304	0.7376 0.4607	-0.0089 0.9929	-0.5918 0.5540	-0.6567 0.5114	-1.3809 0.1673	-1.1002 0.2713	-0.2142 0.8304
16: UM3	χ^2=1.4406 p=0.8371	4	0.8198 0.4123	0.4869 0.6263	0.2690 0.7879	0.2933 0.7693	-0.6854 0.4931	-0.9822 0.3260	-0.8161 0.4145	-0.7193 0.4720	-0.3564 0.7215	0.0913 0.9273
17: LM3	χ^2=0.8771 p=0.8309	3	N/A	-0.3795 0.7043	-0.5574 0.5773	-0.6637 0.5069	N/A	N/A	N/A	-0.5869 0.5573	-0.6843 0.4938	-0.3088 0.7575
18: LM2	χ^2=5.2132 p=0.2661	4	1.1938 0.2326	1.5159 0.1296	1.0493 0.2940	0.3585 0.7199	-0.1188 0.9055	-0.5670 0.5707	-1.0683 0.2854	-1.1830 0.2368	-1.6708 0.0948	-0.9587 0.3377
19: LM1	χ^2=2.0515 p=0.7263	4	0.0000 1.0000	0.7101 0.4776	0.3830 0.7017	0.0000 1.0000	0.7101 0.4776	0.3830 0.7017	0.0000 1.0000	-0.8398 0.4010	-1.0736 0.2830	-0.5710 0.5680
20: LP2	χ^2=5.3721 p=0.2512	4	1.5040 0.1326	1.9049 0.0568	1.3494 0.1772	1.6842 0.0921	-0.1500 0.8807	-0.6871 0.4920	0.0366 0.9708	-1.3956 0.1628	0.2358 0.8136	0.8788 0.3795
21: LP1	χ^2=2.3273 p=0.6758	4	0.5319 0.5948	0.6512 0.5149	0.4891 0.6248	-0.4113 0.6809	-0.0771 0.9385	-0.2311 0.8173	-0.9939 0.3203	-0.4073 0.6838	-1.4053 0.1599	-1.1969 0.2314
22: LC	χ^2=5.0580 p=0.2814	4	0.7832 0.4335	0.6077 0.5435	0.4032 0.6868	-0.9152 0.3601	-0.4598 0.6457	-0.6552 0.5123	-1.7731 0.0762	-0.5026 0.6152	-2.1013 *0.0365**	-1.8370 0.0662
23: LI2	χ^2=1.3545 p=0.8521	4	0.0000 1.0000	0.5153 0.6063	0.2050 0.8375	0.0000 1.0000	0.5153 0.6063	0.2050 0.8375	0.0000 1.0000	-0.9086 0.3635	-0.7103 0.4775	-0.2813 0.7785
24: LI1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix A9.1: Age 13

Table A2.9.1: Sex comparisons for age 13 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	3.3722	1	0.0663	1.8364
10: UI2	2.1632	1	0.1414	1.4708
11: UC	6.3540	1	*0.0117**	2.5207
12: UP1	0.6431	1	0.4226	0.8019
13: UP2	1.9830	1	0.1591	1.4082
14: UM1	1.3103	1	0.2523	1.1447
15: UM2	1.0416	1	0.3074	1.0206
16: UM3	0.2866	1	0.5924	0.5353
17: LM3	0.1009	1	0.7507	0.3177
18: LM2	6.2517	1	*0.0124**	2.5003
19: LM1	0.2045	1	0.6511	-0.4522
20: LP2	1.5841	1	0.2082	1.2586
21: LP1	4.7795	1	*0.0288**	2.1862
22: LC	4.3830	1	*0.0363**	2.0936
23: LI2	1.2692	1	0.2599	1.1266
24: LI1	N/A	1	N/A	N/A

Table A2.9.2: Ancestry comparisons for age 13 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=3.1224 p=0.3731	3	0.0000 1.0000	0.8038 0.4215	0.0000 1.0000	N/A	0.6679 0.5042	0.0000 1.0000	N/A	-1.6704 0.0948	N/A	N/A
10: UI2	χ^2=1.2264 p=0.8737	4	0.0000 1.0000	0.6728 0.5011	0.4879 0.6256	0.7691 0.4260	0.6728 0.5011	0.4879 0.6256	0.7691 0.4260	-0.4717 0.6371	0.3685 0.7125	0.6086 0.5428
11: UC	χ^2=3.0441 p=0.5505	4	0.6316 0.5276	0.3611 0.7180	0.0076 0.9939	1.3609 0.1735	-0.4948 0.6208	-0.6917 0.4891	0.4002 0.6890	-0.6208 0.5347	1.3445 0.1788	1.6077 0.1079
12: UP1	χ^2=12.112 *p=0.0165**	4	0.5175 0.6048	0.5236 0.6005	-1.1644 0.2443	0.5175 0.6048	-0.2681 0.7886	-1.2875 0.1979	0.0000 1.0000	-3.3054 *0.0009**	0.2681 0.7886	1.2875 0.1979
13: UP2	χ^2=4.1138 p=0.3908	4	-0.6996 0.4842	0.4069 0.6841	-0.5652 0.5720	-0.0593 0.9527	1.1702 0.2419	0.3946 0.6932	0.5727 0.5668	-1.8572 0.0633	-0.3958 0.6923	0.3789 0.7048
14: UM1	χ^2=1.1613 p=0.8844	4	0.0000 1.0000	0.5920 0.5583	0.0000 1.0000	0.0000 1.0000	0.3619 0.7174	0.0000 1.0000	0.0000 1.0000	-1.0031 0.3158	-0.2599 0.7950	0.0000 1.0000
15: UM2	χ^2=5.9193 p=0.2053	4	0.9982 0.3182	-0.4458 0.6558	-1.2246 0.2207	-0.8041 0.4214	-1.5059 0.1321	-2.0680 *0.0386**	-1.6037 0.1088	-1.4438 0.1488	-0.6189 0.5360	0.0629 0.9499
16: UM3	χ^2=5.2218 p=0.2653	4	-0.3237 0.7462	-0.2145 0.8302	-1.2483 0.2119	0.6075 0.5435	0.2295 0.8185	-0.4473 0.6547	0.7740 0.4389	-1.8140 0.0697	0.8707 0.3839	1.6316 0.1028
17: LM3	χ^2=4.0530 p=0.3989	4	1.2204 0.2223	0.1237 0.9016	-0.5514 0.5814	0.5542 0.5794	-1.2876 0.1979	-1.6958 0.0899	-0.6908 0.4897	-1.1153 0.2645	0.5591 0.5761	1.0783 0.2809
18: LM2	χ^2=2.9555 p=0.5653	4	-0.1221 0.9028	0.8076 0.4193	-0.1144 0.9089	0.5710 0.5680	0.6285 0.5297	0.0652 0.9480	0.5475 0.5840	-1.5715 0.1161	0.0565 0.9550	0.7595 0.4476
19: LM1	χ^2=3.2981 p=0.5092	4	0.0000 1.0000	0.9765 0.3288	0.0000 1.0000	0.0000 1.0000	0.5942 0.5523	0.0000 1.0000	0.0000 1.0000	-1.6596 0.0970	-0.6799 0.4966	0.0000 1.0000
20: LP2	χ^2=3.2800 p=0.5121	4	1.1567 0.2474	0.8473 0.3969	0.1936 0.8465	1.0643 0.2872	-0.7811 0.4347	-1.1675 0.2430	-0.2430 0.8080	-1.1008 0.2710	0.6115 0.5409	1.0989 0.2718
21: LP1	χ^2=7.7489 p=0.1012	4	-0.3179 0.7505	-0.3419 0.7324	-1.0672 0.2859	1.3931 0.1636	0.1612 0.8719	-0.2548 0.7989	1.2796 0.2007	-1.3711 0.1703	2.0285 *0.0425**	2.6351 *0.0084**
22: LC	χ^2=5.4516 p=0.2440	4	0.1185 0.9057	-1.6353 0.1020	-1.6932 0.0904	0.1810 0.8563	-0.8296 0.4068	-0.8651 0.3870	0.0000 1.0000	-0.1717 0.8637	1.4066 0.1595	1.4574 0.1450
23: LI2	χ^2=1.0345 p=0.9045	4	0.0000 1.0000	0.3623 0.7171	0.0000 1.0000	0.0000 1.0000	0.2604 0.7945	0.0000 1.0000	0.0000 1.0000	-0.9807 0.3267	-0.2604 0.7945	0.0000 1.0000
24: LI1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.9.3: Ancestry comparisons for females at age 13 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	χ^2=2.3470 p=0.5036	3	N/A	N/A	N/A	N/A	0.2077 0.8355	0.2539 0.7996	0.9888 0.3227	0.1323 0.8947	1.4745 0.1403	1.3713 0.1703
11: UC	χ^2=5.1533 p=0.2719	4	0.5403 0.5890	-0.2578 0.7966	-0.4103 0.6816	1.2016 0.2295	-0.7647 0.4445	-0.8560 0.3920	0.2628 0.7927	-0.2950 0.7680	1.9670 0.0492	2.1138 *0.0345**
12: UP1	χ^2=8.9532 *p=0.0299**	3	N/A	-0.3939 0.6936	-1.5413 0.1232	0.0000 1.0000	N/A	N/A	N/A	-2.6994 *0.0069**	0.3939 0.6936	1.5413 0.1232
13: UP2	χ^2=6.9886 p=0.1365	4	-1.2942 0.1956	0.1618 0.8714	-0.8378 0.4021	-0.0992 0.9210	1.6639 0.0961	0.9281 0.3534	1.2942 0.1956	-2.2312 *0.0257**	-0.3401 0.7338	0.8548 0.3927
14: UM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=5.9192 p=0.2053	4	0.6305 0.5284	-0.6849 0.4934	-1.4472 0.1478	-0.8293 0.4069	-1.2507 0.2100	-1.8038 0.0713	-1.3244 0.1854	-1.7142 0.0865	-0.4153 0.6779	0.5395 0.5895
16: UM3	χ^2=1.8542 p=0.7626	4	0.0000 1.0000	-0.6336 0.5263	-1.0182 0.3086	-0.1312 0.8956	-0.3796 0.7042	-0.6180 0.5366	-0.0928 0.9261	-0.8016 0.4228	0.4583 0.6468	0.8464 0.3973
17: LM3	χ^2=2.6226 p=0.6228	4	0.6265 0.5310	-0.7870 0.4313	-1.0686 0.2853	-0.3302 0.7413	-1.1027 0.2701	-1.2567 0.2089	-0.8353 0.4035	-0.5312 0.5953	0.3547 0.7228	0.6462 0.5182
18: LM2	χ^2=2.6020 p=0.6265	4	0.4726 0.6365	1.2639 0.2063	0.5640 0.5728	0.7185 0.4725	0.1433 0.8860	-0.2142 0.8304	-0.0182 0.9855	-1.2566 0.2089	-0.3114 0.7555	0.3636 0.7162
19: LM1	χ^2=1.9661 p=0.7420	4	0.0000 1.0000	0.6965 0.4861	0.0000 1.0000	0.0000 1.0000	0.3653 0.7149	0.0000 1.0000	0.0000 1.0000	-1.2782 0.2012	-0.6126 0.5402	0.0000 1.0000
20: LP2	χ^2=2.7520 p=0.6001	4	0.3355 0.7373	0.3966 0.6916	-0.2263 0.8210	0.9456 0.3443	-0.1602 0.8727	-0.4870 0.6262	0.2626 0.7929	-1.1475 0.2512	0.8543 0.3929	1.4471 0.1479
21: LP1	χ^2=9.6054 *p=0.0222**	3	N/A	-1.9552 0.0506	-2.2427 *0.0249**	-0.1092 0.9130	N/A	N/A	N/A	-0.6915 0.4893	2.0660 *0.0388**	2.3810 *0.0173**
22: LC	χ^2=4.6552 p=0.1989	3	N/A	-1.5350 0.1248	-1.5132 0.1302	0.0000 1.0000	N/A	N/A	N/A	0.0014 0.9989	1.5350 0.1248	1.5132 0.1302
23: LI2	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.9.4: Ancestry comparisons for males at age 13 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=4.1653 p=0.2442	3	0.0000 1.0000	1.2625 0.2068	0.0000 1.0000	N/A	0.7873 0.4311	0.0000 1.0000	N/A	-1.8820 0.0598	N/A	N/A
10: UI2	χ^2=1.8889 p=0.7562	4	0.0000 1.0000	1.0157 0.3097	0.6009 0.5479	0.0000 1.0000	0.7454 0.4561	0.4438 0.6572	0.0000 1.0000	-0.7247 0.4686	-0.7454 0.4561	-0.4438 0.6572
11: UC	χ^2=0.9124 p=0.8224	3	0.3751 0.7076	0.9013 0.3675	0.5618 0.5742	N/A	0.0725 0.9422	-0.1041 0.9171	N/A	-0.5499 0.5824	N/A	N/A
12: UP1	χ^2=4.7667 p=0.1897	3	0.7071 0.4795	0.9690 0.3326	-0.2236 0.8231	N/A	-0.1101 0.9123	-0.9909 0.3218	N/A	-2.0656 *0.0389**	N/A	N/A
13: UP2	χ^2=0.5443 p=0.9091	3	0.0000 1.0000	0.5295 0.5964	0.1780 0.8587	N/A	0.4475 0.6545	0.1496 0.8811	N/A	-0.5918 0.5540	N/A	N/A
14: UM1	χ^2=1.4167 p=0.7016	3	0.0000 1.0000	0.6952 0.4869	0.0000 1.0000	N/A	0.4312 0.6664	0.0000 1.0000	N/A	-1.1210 0.2623	N/A	N/A
15: UM2	χ^2=1.6618 p=0.7976	4	0.8389 0.4015	0.0920 0.9267	-0.2777 0.7812	-0.4046 0.6858	-0.9002 0.3680	-1.1727 0.2409	-0.9626 0.3358	-0.5779 0.5634	-0.4887 0.6250	-0.2867 0.7743
16: UM3	χ^2=5.4065 p=0.2481	4	-0.3910 0.6958	0.3972 0.6912	-0.7841 0.4330	1.1945 0.2323	0.7089 0.4784	-0.0929 0.9260	1.3355 0.1817	-1.8313 0.0671	1.0832 0.2787	1.6594 0.0970
17: LM3	χ^2=3.5593 p=0.4689	4	1.1852 0.2359	0.9015 0.3673	0.1956 0.8450	1.1736 0.2406	-0.7293 0.4658	-1.1978 0.2310	0.2400 0.8103	-1.0831 0.2788	0.8147 0.4152	1.1551 0.2481
18: LM2	χ^2=3.2498 p=0.5169	4	-0.6581 0.5104	0.1479 0.8824	-0.5440 0.5864	1.0636 0.2875	0.8448 0.3982	0.3729 0.7092	1.4009 0.1612	-1.1070 0.2683	1.0679 0.2856	1.4021 0.1609
19: LM1	χ^2=1.2273 p=0.8736	4	0.0000 1.0000	0.6422 0.5207	0.0000 1.0000	0.0000 1.0000	0.4308 0.6666	0.0000 1.0000	0.0000 1.0000	-1.0159 0.3097	-0.3112 0.7557	0.0000 1.0000
20: LP2	χ^2=1.7838 p=0.7754	4	1.2502 0.2112	0.8876 0.3748	0.6132 0.5397	0.2627 0.7928	-0.8209 0.4117	-0.9925 0.3210	-0.6191 0.5358	-0.4200 0.6745	-0.1487 0.8818	-0.0199 0.9841
21: LP1	χ^2=6.1221 p=0.1902	4	0.1343 0.8932	1.3057 0.1917	0.3209 0.7483	1.7870 0.0739	0.8098 0.4181	0.0819 0.9347	1.5364 0.1245	-1.6445 0.1001	1.2472 0.2123	1.7720 0.0764
22: LC	χ^2=1.4629 p=0.8332	4	0.1182 0.9059	-0.7739 0.4392	-0.9371 0.3487	0.1182 0.9059	-0.5404 0.5889	-0.6345 0.5257	0.0000 1.0000	-0.3107 0.7560	0.5404 0.5889	0.6345 0.5257
23: LI2	χ^2=1.3636 p=0.8505	4	0.0000 1.0000	0.6030 0.5465	0.0000 1.0000	0.0000 1.0000	0.4438 0.6572	0.0000 1.0000	0.0000 1.0000	-1.0871 0.2770	-0.4438 0.6572	0.0000 1.0000
24: LI1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix A2.10: Age 14

Table A2.10.1: Sex comparisons for age 14 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	N/A	1	N/A	N/A
10: UI2	0.7126	1	0.3986	0.8442
11: UC	0.2678	1	0.6048	-0.5174
12: UP1	0.0358	1	0.8499	0.1892
13: UP2	0.0337	1	0.8544	-0.1835
14: UM1	N/A	1	N/A	N/A
15: UM2	0.8303	1	0.3622	-0.9112
16: UM3	2.1102	1	0.1463	-1.4526
17: LM3	0.1366	1	0.7117	-0.3696
18: LM2	0.0338	1	0.8540	0.1840
19: LM1	N/A	1	N/A	N/A
20: LP2	0.0176	1	0.8944	0.1327
21: LP1	0.0557	1	0.8134	0.2361
22: LC	5.4160	1	*0.0200**	2.3272
23: LI2	0.5027	1	0.4783	0.7090
24: LI1	0.9677	1	0.3252	-0.9837

Table A2.10.2: Ancestry comparisons for age 14 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	χ^2=6.6336 p=0.1566	4	1.8371 0.0662	1.1533 0.2488	0.2739 0.7842	1.4142 0.1573	-1.3442 0.1789	-1.8683 0.0617	-0.5477 0.5839	-1.4214 0.1552	0.7960 0.4260	1.4289 0.1530
11: UC	χ^2=0.7047 p=0.9507	4	-0.4271 0.6693	0.1095 0.9128	-0.0597 0.9524	-0.4271 0.6693	0.6069 0.5439	0.4683 0.6396	0.0000 1.0000	-0.3340 0.7383	-0.6069 0.5439	-0.4683 0.6396
12: UP1	χ^2=1.1013 p=0.8941	4	0.0000 1.0000	-0.5832 0.5597	-0.1849 0.8533	-0.3571 0.7210	-0.5832 0.5597	-0.1849 0.8533	-0.3571 0.7210	0.8906 0.3731	0.1743 0.8617	-0.3018 0.7628
13: UP2	χ^2=0.3653 p=0.9852	4	0.4194 0.6749	0.3651 0.7151	0.2173 0.8279	0.0000 1.0000	-0.2159 0.8291	-0.3339 0.7384	-0.4194 0.6749	-0.2971 0.7664	-0.3651 0.7151	-0.2173 0.8279
14: UM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=3.6058 p=0.4620	4	0.4228 0.6724	1.3665 0.1718	0.5338 0.5935	1.0570 0.2905	0.7261 0.4678	-0.0358 0.9714	0.6072 0.5437	-1.4718 0.1411	0.0785 0.9374	0.8308 0.4061
16: UM3	χ^2=6.8656 p=0.1432	4	2.2811 *0.0225**	2.4096 *0.0160**	2.2590 *0.0239**	1.9120 0.0559	-0.7086 0.4786	-0.8270 0.4082	-0.4581 0.6469	-0.2680 0.7887	0.1303 0.8963	0.2624 0.7930
17: LM3	χ^2=10.487 *p=0.0330**	4	2.3725 *0.0177**	3.1597 *0.0016**	2.7460 *0.0060**	2.5944 *0.0095**	-0.0120 0.9904	-0.4173 0.6764	0.1164 0.9073	-0.8703 0.3841	0.1746 0.8614	0.6132 0.5397
18: LM2	χ^2=0.8082 p=0.9373	4	0.4947 0.6208	0.8613 0.3890	0.6596 0.5095	0.6486 0.5166	0.1548 0.8770	-0.0228 0.9818	0.1237 0.9016	-0.3931 0.6943	0.0053 0.9957	0.1957 0.8448
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=3.3480 p=0.5014	4	-0.6487 0.5165	0.6769 0.4984	0.1273 0.8987	0.8298 0.4066	1.3679 0.1714	0.9039 0.3660	1.3733 0.1697	-1.1007 0.2710	0.4455 0.6559	0.9403 0.3471
21: LP1	χ^2=2.5301 p=0.6392	4	-1.0732 0.2832	-0.2661 0.7902	-0.6812 0.4957	0.4647 0.6421	1.0797 0.2803	0.7630 0.4455	1.2470 0.2124	-0.8310 0.4060	0.6852 0.4932	0.9358 0.3494
22: LC	χ^2=3.7428 p=0.4419	4	1.3302 0.1834	1.8268 0.0677	1.7092 0.0874	1.5598 0.1188	-0.0198 0.9842	-0.0895 0.9286	0.3002 0.7640	-0.1434 0.8860	0.4031 0.6868	0.4603 0.6453
23: LI2	χ^2=3.2738 p=0.5131	4	0.0000 1.0000	1.1409 0.2539	0.3077 0.7583	0.0000 1.0000	1.0559 0.2910	0.2851 0.7755	0.0000 1.0000	-1.4208 0.1554	-0.8416 0.4000	-0.2279 0.8197
24: LI1	χ^2=1.2593 p=0.8682	4	0.0000 1.0000	0.6409 0.5216	0.0000 1.0000	0.0000 1.0000	0.5399 0.5892	0.0000 1.0000	0.0000 1.0000	-1.0194 0.3080	-0.2841 0.7764	0.0000 1.0000

Table A2.10.3: Ancestry comparisons for females at age 14 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	χ^2=5.2741 p=0.1528	3	1.7127 0.0868	0.5106 0.6096	0.0000 1.0000	N/A	-1.7872 0.0739	-2.2280 *0.0259**	N/A	-0.9945 0.3200	N/A	N/A
11: UC	χ^2=0.5866 p=0.8995	3	-0.4813 0.6303	-0.5264 0.5986	-0.7235 0.4694	N/A	0.1226 0.9024	-0.0934 0.9256	N/A	-0.4442 0.6569	N/A	N/A
12: UP1	χ^2=4.8373 p=0.3044	4	-0.7670 0.4431	-1.5842 0.1131	-0.8515 0.3945	-1.3284 0.1840	-0.9346 0.3500	0.0534 0.9574	-0.7670 0.4431	1.6384 0.1013	-0.1980 0.8430	-0.9307 0.3520
13: UP2	χ^2=2.0726 p=0.7224	4	0.9208 0.3572	0.1657 0.8684	0.3780 0.7055	-0.3362 0.7367	-1.0853 0.2778	-0.8108 0.4175	-1.3449 0.1787	0.4537 0.6500	-0.7004 0.4837	-0.9110 0.3623
14: UM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=3.2534 p=0.5163	4	0.2972 0.7663	1.2789 0.2009	0.6791 0.4971	0.8139 0.4157	1.0938 0.2740	0.3832 0.7016	0.5944 0.5522	-1.1866 0.2534	-0.1768 0.8597	0.3866 0.6991
16: UM3	χ^2=0.7063 p=0.9506	4	0.8025 0.4223	0.6948 0.4872	0.5897 0.5554	0.4943 0.6211	-0.3613 0.7179	-0.4699 0.6384	-0.3445 0.7305	-0.2302 0.8179	-0.0981 0.9219	0.0188 0.9850
17: LM3	χ^2=1.4342 p=0.8382	4	0.6864 0.4924	1.0296 0.3032	0.8669 0.3860	1.0297 0.3032	0.4231 0.6722	0.1572 0.8751	0.4854 0.6274	-0.5079 0.6115	0.2190 0.8267	0.4783 0.6324
18: LM2	χ^2=3.0050 p=0.5570	4	0.4199 0.6746	1.1389 0.2547	0.7001 0.4839	1.2596 0.2078	0.7409 0.4587	0.2208 0.8252	0.9388 0.3478	-1.0577 0.2902	0.5230 0.6010	1.0131 0.3110
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=1.2665 p=0.8670	4	-0.7966 0.4257	-0.8418 0.3999	-1.0472 0.2950	-0.5818 0.5607	0.2452 0.8063	0.0216 0.9828	0.2909 0.7711	-0.5370 0.5908	0.1410 0.8878	0.4000 0.6892
21: LP1	χ^2=1.4710 p=0.6890	3	-1.1401 0.2543	-0.7490 0.4538	-0.9046 0.3657	N/A	0.8067 0.4199	0.6155 0.5382	N/A	-0.4106 0.6814	N/A	N/A
22: LC	χ^2=3.0270 p=0.5533	4	0.8317 0.4056	0.9919 0.3213	0.3077 0.7583	0.0000 1.0000	-0.0497 0.9604	-0.8122 0.4167	-0.6575 0.5108	-1.4063 0.1596	-0.7147 0.4748	-0.2258 0.8214
23: LI2	χ^2=0.4399 p=0.9791	4	0.0000 1.0000	0.3055 0.7600	0.4281 0.6686	0.0000 1.0000	0.3659 0.7145	0.5087 0.6110	0.0000 1.0000	0.2786 0.7805	-0.2211 0.8250	-0.3126 0.7546
24: LI1	χ^2=0.9375 p=0.9191	4	0.0000 1.0000	0.4640 0.6427	0.0000 1.0000	0.0000 1.0000	0.4640 0.6427	0.0000 1.0000	0.0000 1.0000	-0.8632 0.3880	-0.3376 0.7357	0.0000 1.0000

Table A2.10.4: Ancestry comparisons for males at age 14 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	χ^2=3.0188 p=0.3887	3	N/A	1.2493 0.2115	0.3598 0.7190	1.1673 0.2431	N/A	N/A	N/A	-1.2784 0.2011	0.2489 0.8035	1.0707 0.2843
11: UC	χ^2=1.3431 p=0.8540	4	-0.5551 0.5788	0.5139 0.6073	0.5102 0.6099	0.0000 1.0000	0.9359 0.3493	0.9337 0.3504	0.5551 0.5788	-0.0107 0.9914	-0.5139 0.6073	-0.5102 0.6099
12: UP1	χ^2=0.9295 p=0.8183	3	N/A	0.8473 0.3968	0.6355 0.5251	0.8204 0.4120	N/A	N/A	N/A	-0.4737 0.6357	0.1428 0.8864	0.4284 0.6683
13: UP2	χ^2=2.7700 p=0.5970	4	-0.8128 0.4163	0.3917 0.6953	0.0000 1.0000	0.8128 0.4163	1.2520 0.2106	0.9658 0.3341	1.4079 0.1592	-0.8406 0.4006	0.6829 0.4947	0.9658 0.3341
14: UM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=1.1915 p=0.8795	4	0.6700 0.5028	0.3875 0.6984	0.1166 0.9071	0.7597 0.4474	-0.4770 0.6334	-0.6920 0.4889	0.0000 1.0000	-0.4355 0.6632	0.5668 0.5709	0.8271 0.4082
16: UM3	χ^2=7.5258 p=0.1106	4	2.1387 *0.0325**	2.4832 *0.0130**	2.4711 *0.0135**	1.9334 0.0532	-0.6723 0.5014	-0.6892 0.4907	-0.4114 0.6808	-0.0378 0.9699	0.1976 0.8434	0.2169 0.8283
17: LM3	χ^2=9.5695 *p=0.0483**	4	2.3597 *0.0183**	2.9119 *0.0036**	2.5457 *0.0109**	2.1280 *0.0333**	-0.6155 0.5382	-0.8935 0.3716	-0.4583 0.6468	-0.6700 0.5029	0.0602 0.9520	0.3925 0.6947
18: LM2	χ^2=0.9406 p=0.9187	4	0.6266 0.5309	0.1672 0.8672	0.4263 0.6699	-0.2368 0.8128	-0.6100 0.5419	-0.4190 0.6752	-0.7926 0.4280	0.4580 0.6470	-0.4409 0.6593	-0.6699 0.5029
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=6.4048 p=0.1709	4	-0.5079 0.6115	1.6244 0.1043	0.9766 0.3288	1.5238 0.1275	1.7920 0.0731	1.3144 0.1887	1.7596 0.0785	-1.1451 0.2522	0.5858 0.5580	1.0634 0.2876
21: LP1	χ^2=1.5946 p=0.8098	4	-0.5037 0.6145	0.2694 0.7876	-0.2056 0.8371	0.6502 0.5155	0.6933 0.4881	0.4396 0.6602	0.9196 0.3578	-0.8141 0.4156	0.5582 0.5756	0.9112 0.3622
22: LC	χ^2=4.1572 p=0.3851	4	1.1078 0.2679	1.7356 0.0826	1.9255 0.0542	1.6749 0.0940	0.0000 1.0000	0.1343 0.8931	0.3503 0.7261	0.3036 0.7614	0.5128 0.6081	0.3540 0.7233
23: LI2	χ^2=6.3871 p=0.1720	4	0.0000 1.0000	1.5984 0.1100	0.0000 1.0000	0.0000 1.0000	1.2141 0.2247	0.0000 1.0000	0.0000 1.0000	-2.3163 *0.0205**	-1.2141 0.2247	0.0000 1.0000
24: LI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix A2.11: Age 15

Table A2.11.1: Sex comparisons for age 15 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	0.0536	1	0.8168	-0.2316
10: UI2	4.3011	1	*0.0381**	2.0739
11: UC	0.0768	1	0.7817	-0.2771
12: UP1	0.1064	1	0.7442	-0.3263
13: UP2	0.0938	1	0.7593	0.3063
14: UM1	N/A	1	N/A	N/A
15: UM2	0.1909	1	0.6622	0.4369
16: UM3	0.7295	1	0.3930	0.8541
17: LM3	1.2297	1	0.2675	1.1089
18: LM2	0.1841	1	0.6679	-0.4290
19: LM1	N/A	1	N/A	N/A
20: LP2	0.0216	1	0.8832	0.1469
21: LP1	0.0258	1	0.8724	-0.1606
22: LC	0.9413	1	0.3319	0.9702
23: LI2	N/A	1	N/A	N/A
24: LI1	0.7333	1	0.3918	0.8563

Table A2.11.2: Ancestry comparisons for age 15 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=1.6042 p=0.8080	4	0.0000 1.0000	0.3546 0.7229	0.0000 1.0000	0.0000 1.0000	0.6751 0.4996	0.0000 1.0000	0.0000 1.0000	-1.1277 0.2594	-0.4930 0.6220	0.0000 1.0000
10: UI2	χ^2=2.3955 p=0.6634	4	0.0000 1.0000	0.5392 0.5897	0.1984 0.8428	0.0000 1.0000	1.1303 0.2583	0.3967 0.6916	0.0000 1.0000	-1.0748 0.2825	-0.7498 0.4534	-0.2722 0.7855
11: UC	χ^2=5.0702 p=0.2802	4	0.5576 0.5771	1.3997 0.1616	1.5770 0.1148	0.0000 1.0000	0.8596 0.3900	1.0825 0.2790	-0.5576 0.5771	0.4261 0.6700	-1.3997 0.1616	-1.5770 0.1148
12: UP1	χ^2=4.1549 p=0.2452	3	N/A	N/A	N/A	N/A	1.6371 0.1016	1.1868 0.2353	0.0000 1.0000	-0.5842 0.5591	-1.4496 0.1472	-1.0615 0.2885
13: UP2	χ^2=2.4046 p=0.6618	4	0.9326 0.3510	1.4437 0.1488	1.4612 0.1440	1.0836 0.2785	0.4837 0.6286	0.5207 0.6026	0.2178 0.8276	0.0780 0.9378	-0.1765 0.8599	-0.2178 0.8276
14: UM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=2.3408 p=0.6733	4	0.5511 0.5815	-0.2178 0.8276	-0.2188 0.8268	-0.8753 0.3814	-1.0123 0.3114	-0.9604 0.3369	-1.5130 0.1303	-0.0237 0.9811	-0.9856 0.3243	-0.9073 0.3642
16: UM3	χ^2=1.8520 p=0.7630	4	0.6944 0.4874	-0.0476 0.9620	-0.3629 0.7167	-0.6719 0.5017	-0.8537 0.3933	-1.0723 0.2836	-1.2295 0.2189	-0.5550 0.5789	-0.8112 0.4172	-0.4907 0.6236
17: LM3	χ^2=1.2855 p=0.8638	4	0.6655 0.5057	0.3349 0.7377	0.0170 0.9865	-0.2840 0.7764	-0.5425 0.5875	-0.8515 0.3945	-0.9603 0.3369	-0.5478 0.5838	-0.7082 0.4788	-0.3790 0.7047
18: LM2	χ^2=6.5394 p=0.1623	4	-0.1703 0.8648	1.2384 0.2156	0.9009 0.3676	-0.5742 0.5658	1.5566 0.1196	1.1807 0.2377	-0.4256 0.6704	-0.5300 0.5961	-1.9991 *0.0456**	-1.6329 0.1025
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=2.3153 p=0.6780	4	0.0000 1.0000	1.1258 0.2602	0.6818 0.4954	0.5835 0.5595	1.1258 0.2602	0.6818 0.4954	0.5835 0.5595	-0.7172 0.4732	-0.3576 0.7207	0.0593 0.9527
21: LP1	χ^2=1.7789 p=0.7763	4	1.0828 0.2789	0.6426 0.5205	0.7717 0.4403	0.0000 1.0000	-0.7853 0.4322	-0.5788 0.5628	-1.0828 0.2789	0.2817 0.7782	-0.6426 0.5205	-0.7717 0.4403
22: LC	χ^2=2.8750 p=0.5790	4	0.6889 0.4909	1.6064 0.1082	1.2594 0.2079	0.8119 0.4169	0.6920 0.4889	0.4030 0.6869	0.1624 0.8710	-0.4255 0.6704	-0.4195 0.6749	-0.1729 0.8627
23: LI2	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	χ^2=12.000 *p=0.0174**	4	2.5495 *0.0108**	0.0000 1.0000	0.0000 1.0000	0.0000 1.0000	-3.3800 *0.0007**	-3.1530 *0.0016**	-2.0817 *0.0374**	0.0000 1.0000	0.0000 1.0000	0.0000 1.0000

Table A2.11.3: Ancestry comparisons for females at age 15 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=0.7500 p=0.8614	3	N/A	N/A	N/A	N/A	0.5000 0.6171	0.0000 1.0000	0.0000 1.0000	-0.7638 0.4450	-0.3669 0.7137	0.0000 1.0000
10: UI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=2.4386 p=0.4865	3	N/A	N/A	N/A	N/A	0.6786 0.4974	0.8865 0.3753	0.0000 1.0000	0.5541 0.5795	-1.1082 0.2678	-1.4018 0.1610
12: UP1	χ^2=1.2078 p=0.5467	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.2101 0.8336	-0.9630 0.3356	-1.0851 0.2779
13: UP2	χ^2=1.8769 p=0.7584	4	0.0000 1.0000	0.7332 0.4634	0.9681 0.3330	0.5818 0.5607	0.7332 0.4634	0.9681 0.3330	0.5818 0.5607	0.6597 0.5095	-0.1335 0.8938	-0.5204 0.6028
14: UM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=2.5255 p=0.6401	4	1.4107 0.1583	0.9015 0.3673	0.6309 0.5281	0.5759 0.5647	-1.0303 0.3029	-1.2618 0.2070	-1.1519 0.2494	-0.6309 0.5281	-0.4206 0.6740	0.0000 1.0000
16: UM3	χ^2=1.9887 p=0.7378	4	-0.5351 0.5926	0.4760 0.6340	0.4966 0.6194	-0.2393 0.8109	0.9837 0.3252	0.9930 0.3207	0.3784 0.7051	0.0736 0.9414	-0.9213 0.3569	-0.9215 0.3568
17: LM3	χ^2=1.6754 p=0.7952	4	-0.9466 0.3439	-0.3148 0.7529	-0.3344 0.7381	-0.7753 0.4382	0.9585 0.3378	0.9118 0.3619	0.3177 0.7507	-0.0555 0.9558	-0.7951 0.4266	-0.7300 0.4654
18: LM2	χ^2=7.6330 p=0.1060	4	0.0000 1.0000	1.8292 0.0674	1.4047 0.1601	0.5720 0.5673	1.8292 0.0674	1.4047 0.1601	0.5720 0.5673	-0.8120 0.4168	-1.5741 0.1155	-0.9996 0.3175
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=2.2256 p=0.6943	4	0.0000 1.0000	1.0338 0.3012	1.0127 0.3112	0.5774 0.5637	1.0338 0.3012	1.0127 0.3112	0.5774 0.5637	0.0072 0.9943	-0.4869 0.6264	-0.4709 0.6377
21: LP1	χ^2=3.2493 p=0.5170	4	0.0000 1.0000	0.2325 0.8161	1.0273 0.3043	0.0000 1.0000	0.1681 0.8665	0.7618 0.4462	0.0000 1.0000	1.5837 0.1133	-0.3154 0.7524	-1.3363 0.1814
22: LC	χ^2=1.3810 p=0.8475	4	0.0000 1.0000	0.5028 0.6151	0.5479 0.5838	0.9490 0.3426	0.5028 0.6151	0.5479 0.5838	0.9490 0.3426	0.1520 0.8792	0.8663 0.3863	0.7351 0.4623
23: LI2	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.11.4: Ancestry comparisons for males at age 15 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=0.8125 p=0.9368	4	0.0000 1.0000	0.3265 0.7440	0.0000 1.0000	0.0000 1.0000	0.4488 0.6536	0.0000 1.0000	0.0000 1.0000	-0.8078 0.4192	-0.3265 0.7440	0.0000 1.0000
10: UI2	χ^2=2.6065 p=0.6257	4	0.0000 1.0000	0.7117 0.4766	0.2625 0.7930	0.0000 1.0000	1.1695 0.2422	0.4150 0.6781	0.0000 1.0000	-1.1054 0.2690	-0.7117 0.4766	-0.2625 0.7930
11: UC	χ^2=2.7835 p=0.5947	4	0.6487 0.5165	1.3819 0.1670	1.3551 0.1754	0.0000 1.0000	0.6541 0.5131	0.6601 0.5092	-0.3972 0.6912	0.0601 0.9520	-0.7463 0.4555	-0.7575 0.4487
12: UP1	χ^2=3.5985 p=0.3082	3	N/A	N/A	N/A	N/A	1.6845 0.0921	0.6086 0.5428	0.0000 1.0000	-1.0666 0.2862	-0.9416 0.3464	-0.3727 0.7094
13: UP2	χ^2=1.9234 p=0.7498	4	0.9126 0.3614	1.3399 0.1803	0.9857 0.3243	0.9544 0.3390	0.4881 0.6255	0.0000 1.0000	0.2282 0.8195	-0.6068 0.5440	-0.0903 0.9281	0.2464 0.8053
14: UM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=2.7547 p=0.5997	4	-0.1220 0.9029	-0.7514 0.4524	-0.2623 0.7931	-1.3880 0.1651	-0.6792 0.4970	-0.1402 0.8885	-1.3555 0.1752	0.6464 0.5180	-1.0765 0.2817	-1.3546 0.1755
16: UM3	χ^2=6.9948 p=0.1362	4	1.7157 0.0862	-0.1157 0.9079	-0.8291 0.4071	-0.3857 0.6997	-2.0844 *0.0371**	-2.5803 *0.0099**	-1.8199 0.0688	-1.1401 0.2542	-0.3637 0.7161	0.1843 0.8538
17: LM3	χ^2=3.5297 p=0.4734	4	1.4911 0.1359	0.7449 0.4564	0.1623 0.8711	0.3691 0.7120	-1.1748 0.2401	-1.7244 0.0846	-0.8135 0.4160	-0.8806 0.3785	-0.1219 0.9035	0.2987 0.7652
18: LM2	χ^2=2.2523 p=0.6895	4	-0.2949 0.7681	0.0863 0.9312	0.1331 0.8941	-1.1421 0.2534	0.4922 0.6226	0.5205 0.6027	-0.9457 0.3443	0.0821 0.9345	-1.4002 0.1615	-1.4023 0.1608
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=1.6208 p=0.8050	4	0.0000 1.0000	0.6958 0.4865	0.0000 1.0000	0.5832 0.5598	0.6958 0.4865	0.0000 1.0000	0.5832 0.5598	-1.0381 0.2992	0.1645 0.8693	0.6613 0.5084
21: LP1	χ^2=2.8883 p=0.5767	4	1.1438 0.2527	0.7341 0.4629	0.0000 1.0000	0.0000 1.0000	-0.7231 0.4696	-1.4415 0.1495	-0.9171 0.3591	-1.0952 0.2734	-0.5432 0.5870	0.0000 1.0000
22: LC	χ^2=4.6108 p=0.3296	4	0.7354 0.4621	1.7909 0.0733	1.1537 0.2486	0.0000 1.0000	0.8457 0.3977	0.2884 0.7730	-0.6004 0.5482	-0.7214 0.4707	-1.3253 0.1851	-0.8869 0.3751
23: LI2	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	χ^2=9.0000 p=0.0611	4	2.3905 *0.0168**	0.0000 1.0000	0.0000 1.0000	0.0000 1.0000	-2.8697 *0.0041**	-2.6968 *0.0070**	-1.5811 0.1138	0.0000 1.0000	0.0000 1.0000	0.0000 1.0000

Appendix A2.12: Age 16

Table A2.12.1: Sex comparisons for age 16 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	0.5556	1	0.4561	0.7454
10: UI2	0.9500	1	0.3297	0.9747
11: UC	1.5011	1	0.2205	1.2252
12: UP1	0.4851	1	0.4861	-0.6965
13: UP2	0.7492	1	0.3867	-0.8655
14: UM1	0.7778	1	0.3778	0.8819
15: UM2	0.0481	1	0.8263	0.2194
16: UM3	0.0164	1	0.8980	0.1282
17: LM3	0.0007	1	0.9791	0.0262
18: LM2	0.0387	1	0.8440	-0.1968
19: LM1	0.8611	1	0.3534	0.9280
20: LP2	0.3781	1	0.5387	-0.6149
21: LP1	0.1903	1	0.6627	0.4362
22: LC	0.0016	1	0.9683	0.0398
23: LI2	1.8421	1	0.1747	1.3572
24: LI1	N/A	1	N/A	N/A

Table A2.12.2: Ancestry comparisons for age 16 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=3.0000 p=0.3916	3	0.0000 1.0000	0.0000 1.0000	0.7071 0.4795	N/A	0.0000 1.0000	0.9428 0.3458	N/A	1.6971 0.0897	N/A	N/A
10: UI2	χ^2=1.6000 p=0.8088	4	0.0000 1.0000	0.0000 1.0000	0.5531 0.5802	0.0000 1.0000	0.0000 1.0000	0.5531 0.5802	0.0000 1.0000	1.2054 0.2281	0.0000 1.0000	-0.4031 0.6869
11: UC	χ^2=2.7300 p=0.6040	4	0.0000 1.0000	1.0575 0.2903	1.3351 0.1818	0.6987 0.4847	0.8769 0.3806	1.1200 0.2627	0.6162 0.5378	0.6448 0.5190	-0.2005 0.8411	-0.5480 0.5837
12: UP1	χ^2=3.7507 p=0.4408	4	0.0000 1.0000	0.0000 1.0000	0.6840 0.4940	1.1744 0.2402	0.0000 1.0000	0.6840 0.4940	1.1744 0.2402	1.2682 0.2047	1.6460 0.0998	0.8627 0.3883
13: UP2	χ^2=3.0466 p=0.5501	4	0.0000 1.0000	0.7502 0.4532	1.1202 0.2626	0.5548 0.5791	0.7502 0.4532	1.1202 0.2626	0.5548 0.5791	1.1216 0.2620	-0.2069 0.8361	-0.8157 0.4147
14: UM1	χ^2=2.4286 p=0.6575	4	0.0000 1.0000	0.0000 1.0000	0.8729 0.3827	0.0000 1.0000	0.0000 1.0000	0.6547 0.5127	0.0000 1.0000	1.5026 0.1329	0.0000 1.0000	-0.4781 0.6326
15: UM2	χ^2=0.5030 p=0.7776	2	N/A	N/A	N/A	N/A	-0.3449 0.7301	-0.0207 0.9835	N/A	0.6622 0.5078	N/A	N/A
16: UM3	χ^2=2.5426 p=0.6370	4	0.3416 0.7326	1.2427 0.2140	0.8762 0.3809	1.4316 0.1522	0.4983 0.6183	0.2620 0.7933	0.7943 0.4270	-0.5303 0.5959	0.6267 0.5309	0.9049 0.3655
17: LM3	χ^2=3.2592 p=0.5154	4	0.7685 0.4422	1.4591 0.1445	1.6211 0.1050	1.6842 0.0922	0.1453 0.8845	0.2998 0.7644	0.5163 0.6057	0.4137 0.6791	0.7132 0.4757	0.4280 0.6686
18: LM2	χ^2=4.6950 p=0.3200	4	1.1448 0.2523	1.4255 0.1540	1.7037 0.0884	2.0480 *0.0406**	-0.3322 0.7397	-0.0786 0.9373	0.4048 0.6857	0.6588 0.5100	1.2989 0.1940	0.8353 0.4036
19: LM1	χ^2=2.3500 p=0.6717	4	0.0000 1.0000	0.0000 1.0000	0.7472 0.4549	0.0000 1.0000	0.0000 1.0000	0.5519 0.5810	0.0000 1.0000	1.4601 0.1443	0.0000 1.0000	-0.8792 0.3793
20: LP2	χ^2=6.8153 p=0.1460	4	0.0000 1.0000	1.3499 0.1770	0.4765 0.6337	1.9409 0.0523	0.7025 0.4823	0.2555 0.7983	1.1886 0.2346	-1.5805 0.1140	1.2331 0.2176	2.0689 *0.0386**
21: LP1	χ^2=6.9345 p=0.1394	4	0.0000 1.0000	0.6193 0.5357	0.2774 0.7815	2.0170 *0.0437**	0.5128 0.6081	0.2316 0.8169	1.7788 0.0753	-0.7119 0.4766	2.2043 *0.0275**	2.4990 *0.0125**
22: LC	χ^2=2.7865 p=0.5942	4	-0.8597 0.3899	-0.4614 0.6445	-0.6467 0.5178	0.5138 0.6074	0.6893 0.4906	0.4939 0.6214	1.3593 0.1740	-0.4007 0.6886	1.2585 0.2082	1.4179 0.1562
23: LI2	χ^2=5.3529 p=0.2530	4	0.0000 1.0000	0.0000 1.0000	0.8209 0.4117	0.0000 1.0000	0.0000 1.0000	1.1114 0.2664	0.0000 1.0000	2.2573 *0.0240**	0.0000 1.0000	-0.8209 0.4117
24: LI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.12.3: Ancestry comparisons for females at age 16 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=3.2442 p=0.3555	3	N/A	0.3662 0.7142	1.2053 0.2281	1.3203 0.1867	N/A	N/A	N/A	1.2241 0.2209	1.2448 0.2132	0.5139 0.6073
12: UP1	χ^2=6.5000 p=0.8966	3	N/A	0.0000 1.0000	0.3680 0.7129	1.9472 0.0515	N/A	N/A	N/A	0.6719 0.5017	2.5139 *0.0119**	2.2079 *0.0272**
13: UP2	χ^2=5.2963 p=0.1513	3	N/A	0.6146 0.5388	1.4996 0.1337	1.3744 0.1693	N/A	N/A	N/A	1.8439 0.0652	1.2293 0.2190	0.2999 0.7642
14: UM1	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=0.3000 p=0.5839	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5477 0.5839	N/A	N/A
16: UM3	χ^2=4.6392 p=0.2002	3	N/A	1.2241 0.2209	1.0809 0.2797	2.1409 *0.0323**	N/A	N/A	N/A	-0.0814 0.9351	1.5050 0.1323	1.4512 0.1464
17: LM3	χ^2=4.5798 p=0.2053	3	N/A	0.7813 0.4346	0.8019 0.4226	1.9698 *0.0489**	N/A	N/A	N/A	0.0900 0.9283	1.8118 0.0700	1.6507 0.0988
18: LM2	χ^2=7.5850 p=0.0554	3	N/A	1.1876 0.2350	1.2107 0.2260	2.6088 *0.0091**	N/A	N/A	N/A	0.1236 0.9017	2.2276 *0.0259**	2.0207 *0.0433**
19: LM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=9.5644 *p=0.0227**	3	N/A	1.1308 0.2581	0.3576 0.7207	2.6277 *0.0086**	N/A	N/A	N/A	-1.1308 0.2581	2.2616 *0.0237**	2.8607 *0.0042**
21: LP1	χ^2=12.240 p=0.0066	3	N/A	0.2773 0.7816	0.0000 1.0000	2.4300 *0.0151**	N/A	N/A	N/A	-0.5159 0.6059	3.1952 *0.0014**	3.3698 *0.0008**
22: LC	χ^2=5.9852 p=0.1123	3	N/A	0.8412 0.4002	0.0000 1.0000	1.7316 0.0833	N/A	N/A	N/A	-1.3375 0.1811	1.4341 0.1515	2.2907 *0.0220**
23: LI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.12.4: Ancestry comparisons for males at age 16 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=3.5000 p=0.1738	2	N/A	N/A	N/A	N/A	0.0000 1.0000	1.2247 0.2207	N/A	1.8371 0.0662	N/A	N/A
10: UI2	χ^2=2.3333 p=0.5062	3	N/A	N/A	N/A	N/A	0.0000 1.0000	0.9129 0.3613	0.0000 1.0000	1.4686 0.1419	0.0000 1.0000	-0.6901 0.4902
11: UC	χ^2=2.5380 p=0.4685	3	N/A	N/A	N/A	N/A	1.0646 0.2870	1.1840 0.2364	0.0000 1.0000	0.3639 0.7160	-1.0646 0.2870	-1.1840 0.2364
12: UP1	χ^2=1.8333 p=0.7664	4	0.0000 1.0000	0.0000 1.0000	0.6362 0.5246	0.0000 1.0000	0.0000 1.0000	0.8416 0.4000	0.0000 1.0000	1.1902 0.2340	0.0000 1.0000	-0.8416 0.4000
13: UP2	χ^2=1.8700 p=0.5998	3	N/A	N/A	N/A	N/A	0.8343 0.4041	0.7638 0.4450	0.0000 1.0000	-0.1317 0.8952	-1.1336 0.2570	-1.0248 0.3055
14: UM1	χ^2=2.8571 p=0.5820	4	0.0000 1.0000	0.0000 1.0000	0.6944 0.4875	0.0000 1.0000	0.0000 1.0000	0.9258 0.3545	0.0000 1.0000	1.6381 0.1014	0.0000 1.0000	-0.6944 0.4875
15: UM2	χ^2=0.2288 p=0.8919	2	N/A	N/A	N/A	N/A	-0.2834 0.7768	-0.0261 0.9792	N/A	0.4274 0.6691	N/A	N/A
16: UM3	χ^2=1.0222 p=0.9064	4	-0.2908 0.7712	0.0759 0.9395	-0.1873 0.8515	-0.3803 0.7037	0.5838 0.5593	0.1993 0.8421	-0.1096 0.9127	-0.6560 0.5118	-0.7312 0.4646	-0.3379 0.7355
17: LM3	χ^2=3.9353 p=0.4148	4	1.1259 0.2602	1.4885 0.1366	1.6435 0.1003	0.6063 0.5443	0.2016 0.8402	0.4451 0.6563	-0.6364 0.5245	0.4931 0.6220	-1.0555 0.2912	-1.2667 0.2053
18: LM2	χ^2=2.6768 p=0.6133	4	0.7963 0.4259	0.7260 0.4679	1.0042 0.3153	0.0000 1.0000	-0.3138 0.7537	0.1007 0.9198	-0.9752 0.3294	0.8074 0.4194	-1.0041 0.3153	-1.3597 0.1739
19: LM1	χ^2=2.6000 p=0.6268	4	0.0000 1.0000	0.0000 1.0000	0.5721 0.5673	0.0000 1.0000	0.0000 1.0000	0.7746 0.4386	0.0000 1.0000	1.5616 0.1184	0.0000 1.0000	-0.7746 0.4386
20: LP2	χ^2=2.3003 p=0.6807	4	0.0000 1.0000	0.6876 0.4917	0.2714 0.7861	0.0000 1.0000	0.6876 0.4917	0.2714 0.7861	0.0000 1.0000	-1.0841 0.2783	-0.9500 0.3421	-0.3675 0.7133
21: LP1	χ^2=0.8578 p=0.9305	4	0.0000 1.0000	0.4862 0.6269	0.3063 0.7594	0.0000 1.0000	0.6692 0.5034	0.4148 0.6783	0.0000 1.0000	-0.4491 0.6534	-0.4862 0.6269	-0.3063 0.7594
22: LC	χ^2=4.5016 p=0.3424	4	-1.8766 0.0606	-1.8395 0.0658	-1.4674 0.1423	-1.6252 0.1041	0.5426 0.5874	0.9100 0.3628	0.0000 1.0000	0.7216 0.4706	-0.3942 0.6935	-0.6825 0.4949
23: LI2	χ^2=5.9294 p=0.0516	2	N/A	N/A	N/A	N/A	0.0000 1.0000	1.5163 0.1294	N/A	2.3833 *0.0172**	N/A	N/A
24: LI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix A2.13: Age 17

Table A2.13.1: Sex comparisons for age 17 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	N/A	1	N/A	N/A
10: UI2	N/A	1	N/A	N/A
11: UC	0.4376	1	0.5083	0.6615
12: UP1	1.1111	1	0.2918	-1.0541
13: UP2	0.0224	1	0.8809	-0.1498
14: UM1	N/A	1	N/A	N/A
15: UM2	0.5129	1	0.4739	-0.7162
16: UM3	0.8253	1	0.3636	-0.9085
17: LM3	2.5700	1	0.1089	-1.6031
18: LM2	0.5867	1	0.4437	0.7660
19: LM1	N/A	1	N/A	N/A
20: LP2	0.0033	1	0.9544	0.0572
21: LP1	0.8750	1	0.3496	-0.9354
22: LC	0.0000	1	1.0000	0.0000
23: LI2	N/A	1	N/A	N/A
24: LI1	N/A	1	N/A	N/A

Table A2.13.2: Ancestry comparisons for age 17 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=3.0154 p=0.5553	4	0.0000 1.0000	0.8572 0.3913	0.0000 1.0000	0.0000 1.0000	0.8572 0.3913	0.0000 1.0000	0.0000 1.0000	-1.4740 0.1405	0.8572 0.3913	0.0000 1.0000
12: UP1	χ^2=1.1111 p=0.8925	4	0.0000 1.0000	0.6195 0.5356	0.0000 1.0000	0.0000 1.0000	0.6195 0.5356	0.0000 1.0000	0.0000 1.0000	-0.8683 0.3852	-0.4595 0.6459	0.0000 1.0000
13: UP2	χ^2=2.5527 p=0.6352	4	0.0000 1.0000	0.7854 0.4322	0.0000 1.0000	0.0000 1.0000	0.9314 0.3516	0.0000 1.0000	0.0000 1.0000	-1.3758 0.1689	-0.7854 0.4322	0.0000 1.0000
14: UM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=2.7756 p=0.5960	4	1.3378 0.1811	0.4458 0.6558	0.7603 0.4471	0.0000 1.0000	-1.3373 0.1811	-0.9504 0.3419	-1.3373 0.1811	0.6241 0.5326	-0.4458 0.6558	-0.7603 0.4471
16: UM3	χ^2=3.9162 p=0.4175	4	0.9098 0.3629	1.4845 0.1377	1.8846 0.0595	1.0549 0.2915	-0.0154 0.9877	0.2903 0.7716	-0.1310 0.8957	0.9490 0.3426	-0.2197 0.8261	-0.7161 0.4739
17: LM3	χ^2=4.8504 p=0.3030	4	1.7314 0.0834	1.7584 0.0787	2.0986 *0.0359**	1.2657 0.2056	-0.4832 0.6290	-0.0262 0.9791	-0.5207 0.6026	0.9175 0.3589	-0.2166 0.8285	-0.6555 0.5122
18: LM2	χ^2=6.2078 p=0.1842	4	0.7922 0.4282	0.5293 0.5966	1.4554 0.1456	0.7922 0.4282	-0.5527 0.5805	0.5799 0.5620	0.0000 1.0000	2.3084 *0.0210**	0.5527 0.5805	-0.5799 0.5620
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=0.4411 p=0.9790	4	0.0000 1.0000	0.2648 0.7912	0.3975 0.6910	0.0000 1.0000	0.3187 0.7500	0.4745 0.6351	0.0000 1.0000	0.3298 0.7416	-0.2648 0.7912	-0.3975 0.6910
21: LP1	χ^2=1.8125 p=0.7702	4	0.0000 1.0000	0.0000 1.0000	0.5590 0.5762	0.0000 1.0000	0.0000 1.0000	0.5590 0.5762	0.0000 1.0000	1.2760 0.2019	0.0000 1.0000	-0.6664 0.5052
22: LC	χ^2=2.9218 p=0.5710	4	0.0000 1.0000	0.4611 0.6447	0.6678 0.5042	1.4118 0.1580	0.4611 0.6447	0.6678 0.5042	1.4118 0.1580	0.4824 0.6295	1.4601 0.1443	1.1687 0.2425
23: LI2	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.13.3: Ancestry comparisons for females at age 17 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=1.1429 p=0.7667	3	N/A	N/A	N/A	N/A	0.5175 0.6048	0.0000 1.0000	0.0000 1.0000	-0.9449 0.3447	-0.6901 0.4902	0.0000 1.0000
12: UP1	χ^2=0.5000 p=0.7788	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-0.6124 0.5403	-0.4629 0.6434	0.0000 1.0000
13: UP2	χ^2=1.1667 p=0.7610	3	N/A	N/A	N/A	N/A	0.5563 0.5780	0.0000 1.0000	0.0000 1.0000	-0.9309 0.3519	-0.7360 0.4617	0.0000 1.0000
14: UM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=1.2343 p=0.7448	3	N/A	N/A	N/A	N/A	0.4288 0.6681	0.7247 0.4686	0.0000 1.0000	0.5171 0.6051	-0.5614 0.5745	-0.9587 0.3377
16: UM3	χ^2=1.2090 p=0.7508	3	N/A	N/A	N/A	N/A	0.4480 0.6542	0.0324 0.9742	-0.0627 0.9500	-0.9651 0.3345	-0.7086 0.4786	-0.1419 0.8871
17: LM3	χ^2=3.3460 p=0.3413	3	N/A	N/A	N/A	N/A	1.5048 0.1324	1.4835 0.1379	0.6140 0.5392	-0.0202 0.9839	-1.0658 0.2865	-1.0375 0.2995
18: LM2	χ^2=4.1577 p=0.2449	3	N/A	N/A	N/A	N/A	0.3130 0.7543	0.9869 0.3237	0.0000 1.0000	1.7543 0.0794	-0.4286 0.6682	-1.3410 0.1799
19: LM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=1.6000 p=0.6594	3	N/A	N/A	N/A	N/A	0.0000 1.0000	0.4862 0.6268	0.0000 1.0000	1.2315 0.2181	0.0000 1.0000	-0.4862 0.6268
21: LP1	χ^2=1.4000 p=0.7055	3	N/A	N/A	N/A	N/A	0.0000 1.0000	0.4671 0.6404	0.0000 1.0000	1.1212 0.2622	0.0000 1.0000	-0.6325 0.5271
22: LC	χ^2=0.3561 p=0.9491	3	N/A	N/A	N/A	N/A	0.4134 0.6793	0.4303 0..6670	0.0000 1.0000	0.0724 0.9422	-0.4134 0.6793	-0.4303 0.6670
23: LI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.13.4: Ancestry comparisons for males at age 17 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=1.6250 p=0.6537	3	0.0000 1.0000	0.8708 0.3839	0.0000 1.0000	N/A	0.6491 0.5163	0.0000 1.0000	N/A	-1.0169 0.3092	N/A	N/A
12: UP1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13: UP2	χ^2=1.2857 p=0.7325	3	0.0000 1.0000	0.7127 0.4760	0.0000 1.0000	N/A	0.7127 0.4760	0.0000 1.0000	N/A	-0.9759 0.3291	N/A	N/A
14: UM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=7.7576 p=0.0513	3	2.4585 *0.0140**	0.3561 0.7218	0.0000 1.0000	N/A	-2.6208 *0.0088**	-2.6077 *0.0091**	N/A	-0.4203 0.6743	N/A	N/A
16: UM3	χ^2=8.0908 *p=0.0442**	3	0.9052 0.3654	2.3246 *0.0201**	1.0145 0.3103	N/A	2.3593 *0.0183**	0.5162 0.6057	N/A	-0.5812 0.5611	N/A	N/A
17: LM3	χ^2=7.2581 p=0.1229	4	2.4035 *0.0162**	1.3754 0.1690	1.8456 0.0649	1.6031 0.1089	-1.8041 0.0712	-1.1520 0.2493	-0.3593 0.7194	0.9507 0.3418	0.8924 0.3722	0.4524 0.6510
18: LM2	χ^2=5.5789 p=0.2329	4	1.0306 0.3027	0.5843 0.5590	1.4690 0.1418	1.6829 0.0924	-0.7790 0.4360	0.1836 0.8543	0.8415 0.4001	1.5902 0.1118	1.5646 0.1177	0.8263 0.4086
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=1.0000 p=0.9098	4	0.0000 1.0000	0.5345 0.5930	0.0000 1.0000	0.0000 1.0000	0.5345 0.5930	0.0000 1.0000	0.0000 1.0000	-0.8584 0.3907	-0.3922 0.6949	0.0000 1.0000
21: LP1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22: LC	χ^2=6.6481 p=0.1557	4	0.0000 1.0000	0.3043 0.7609	0.6667 0.5050	2.2771 *0.0228**	0.2233 0.8233	0.5092 0.6106	1.9720 *0.0486**	0.6113 0.5410	2.4562 *0.0140**	2.0367 *0.0417**
23: LI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix A2.14: Age 18

Table A2.14.1: Sex comparisons for age 18 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	N/A	1	N/A	N/A
10: UI2	0.7674	1	0.3819	-0.8745
11: UC	1.3846	1	0.2393	1.1767
12: UP1	N/A	1	N/A	N/A
13: UP2	1.5385	1	0.2148	1.2403
14: UM1	N/A	1	N/A	N/A
15: UM2	2.7000	1	0.1003	-1.6432
16: UM3	1.4948	1	0.2215	-1.2226
17: LM3	3.6024	1	0.0577	-1.8980
18: LM2	0.5439	1	0.4608	-0.7375
19: LM1	N/A	1	N/A	N/A
20: LP2	0.1490	1	0.6995	0.3860
21: LP1	N/A	1	N/A	N/A
22: LC	N/A	1	N/A	N/A
23: LI2	N/A	1	N/A	N/A
24: LI1	N/A	1	N/A	N/A

Table A2.14.2: Ancestry comparisons for age 18 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	χ^2=0.3636 p=0.9476	3	0.0000 1.0000	0.3371 0.7360	0.0000 1.0000	N/A	0.3371 0.7360	0.0000 1.0000	N/A	-0.4580 0.6489	N/A	N/A
11: UC	χ^2=5.2000 p=0.1577	3	1.3310 0.1832	0.0000 1.0000	0.0000 1.0000	N/A	-2.2028 0.0276	-1.8390 0.0659	N/A	0.0000 1.0000	N/A	N/A
12: UP1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13: UP2	χ^2=0.7368 p=0.8645	3	0.0000 1.0000	0.4867 0.6265	0.0000 1.0000	N/A	0.6015 0.5475	0.0000 1.0000	N/A	-0.6456 0.5185	N/A	N/A
14: UM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=11.748 *p=0.0193**	4	0.0000 1.0000	0.4829 0.6292	0.0000 1.0000	3.2322 *0.0012**	0.2536 0.7998	0.0000 1.0000	2.5553 *0.0106**	-0.4249 0.6709	3.2972 *0.0010**	3.1296 *0.0018**
16: UM3	χ^2=4.1737 p=0.3830	4	1.7553 0.0792	1.1369 0.2556	0.3195 0.7493	0.0000 1.0000	-1.2065 0.2276	-1.6042 0.1087	-1.1610 0.2456	-0.8924 0.3722	-0.5971 0.5504	-0.1909 0.8486
17: LM3	χ^2=5.8011 p=0.2145	4	1.8974 0.0578	1.7294 0.0837	0.7584 0.4482	1.5788 0.1144	-0.7661 0.4436	-1.3466 0.1781	0.4833 0.6289	-1.0101 0.3124	0.8841 0.3766	1.2229 0.2214
18: LM2	χ^2=4.3747 p=0.3577	4	0.0000 1.0000	-0.0952 0.9242	-0.3306 0.7410	1.8351 0.0665	-0.0952 0.9242	-0.3306 0.7410	1.8351 0.0665	-0.3623 0.7171	2.0255 *0.0428**	2.0730 *0.0382**
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=2.0217 p=0.7318	4	1.0777 0.2812	0.6390 0.5228	0.0000 1.0000	0.0000 1.0000	-0.7987 0.4245	-1.2347 0.2169	-0.6600 0.5093	-0.8122 0.4167	-0.3337 0.7386	0.0000 1.0000
21: LP1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22: LC	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23: LI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.14.3: Ancestry comparisons for females at age 18 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	χ^2=0.5455 p=0.9088	3	0.0000 1.0000	0.4876 0.6258	0.0000 1.0000	N/A	0.3589 0.7197	0.0000 1.0000	N/A	-0.5755 0.5650	N/A	N/A
11: UC	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12: UP1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13: UP2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14: UM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=6.0850 p=0.1929	4	0.0000 1.0000	0.3524 0.7245	0.0000 1.0000	1.9302 0.0536	0.3524 0.7245	0.0000 1.0000	1.9302 0.0536	-0.4834 0.6288	2.2906 *0.0220**	2.2287 *0.0258**
16: UM3	χ^2=1.3317 p=0.8560	4	0.7217 0.4705	0.8084 0.4188	0.5600 0.5755	0.0000 1.0000	-0.0695 0.9446	-0.2977 0.7660	-0.7217 0.4705	-0.3703 0.7111	-0.8084 0.4188	-0.5600 0.5755
17: LM3	χ^2=4.2850 p=0.3688	4	1.3559 0.1751	1.5683 0.1168	0.7219 0.4704	1.4437 0.1488	-0.1103 0.9122	-0.9169 0.3592	0.4594 0.6460	-1.2295 0.2189	0.5832 0.5597	1.0914 0.2751
18: LM2	χ^2=4.9922 p=0.2881	4	0.0000 1.0000	0.8329 0.4049	0.4803 0.6310	1.9211 0.0547	0.9966 0.3189	0.5546 0.5792	2.0376 *0.0416**	-0.4848 0.6278	1.6898 0.0911	1.8152 0.0695
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=3.7737 p=0.4375	4	1.4160 0.1568	0.2890 0.7726	0.0000 1.0000	0.0000 1.0000	-1.7273 0.0841	-1.7699 0.0767	-1.1194 0.2630	-0.4262 0.6700	-0.2097 0.8339	0.0000 1.0000
21: LP1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22: LC	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23: LI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.14.4: Ancestry comparisons for males at age 18 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=5.5000 p=0.1386	3	1.4720 0.1410	0.0000 1.0000	0.0000 1.0000	N/A	-2.2804 *0.0226**	-1.8028 0.0714	N/A	0.0000 1.0000	N/A	N/A
12: UP1	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13: UP2	χ^2=0.6250 p=0.8907	3	0.0000 1.0000	0.4249 0.6709	0.0000 1.0000	N/A	0.5701 0.5686	0.0000 1.0000	N/A	-0.5701 0.5686	N/A	N/A
14: UM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16: UM3	χ^2=4.6427 p=0.1999	3	1.6809 0.0928	0.4214 0.6735	-0.7087 0.4785	N/A	-1.5956 0.1106	-2.1131 *0.3460**	N/A	-1.1987 0.2306	N/A	N/A
17: LM3	χ^2=1.5953 p=0.6605	3	1.1481 0.2509	0.5883 0.5563	0.0000 1.0000	N/A	-0.8913 0.3728	-1.0480 0.2946	N/A	-0.4952 0.6205	N/A	N/A
18: LM2	χ^2=3.7037 p=0.2953	3	0.5092 0.6106	-1.1481 0.2509	-1.0184 0.3085	N/A	-1.5811 0.1138	-1.3944 0.1632	N/A	-0.2635 0.7921	N/A	N/A
19: LM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=0.9048 p=0.8243	3	0.0000 1.0000	0.6140 0.5392	0.0000 1.0000	N/A	0.6140 0.5392	0.0000 1.0000	N/A	-0.6140 0.5392	N/A	N/A
21: LP1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22: LC	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23: LI2	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix A2.15: Age 19

Table A2.15.1: Sex comparisons for age 19 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	N/A	1	N/A	N/A
10: UI2	N/A	1	N/A	N/A
11: UC	0.8605	1	0.3536	0.9276
12: UP1	N/A	1	N/A	N/A
13: UP2	0.4128	1	0.5206	-0.6425
14: UM1	N/A	1	N/A	N/A
15: UM2	2.4714	1	0.1159	-1.5721
16: UM3	3.5943	1	0.0580	-1.8959
17: LM3	1.5732	1	0.2097	-1.2543
18: LM2	0.2195	1	0.6394	-0.4685
19: LM1	N/A	1	N/A	N/A
20: LP2	0.0464	1	0.8295	0.2154
21: LP1	N/A	1	N/A	N/A
22: LC	0.0855	1	0.7699	0.2924
23: LI2	N/A	1	N/A	N/A
24: LI1	N/A	1	N/A	N/A

Table A2.15.2: Ancestry comparisons for age 19 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=0.9048 p=0.9239	4	0.0000 1.0000	0.4673 0.6403	0.7669 0.4432	0.0000 1.0000	0.3883 0.6978	0.6600 0.5092	0.0000 1.0000	0.5736 0.5662	-0.2796 0.7798	-0.4950 0.6206
12: UP1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13: UP2	χ^2=1.4443 p=0.8365	4	0.0000 1.0000	0.4559 0.6485	0.9897 0.3223	0.0000 1.0000	0.3788 0.7048	0.8638 0.3877	0.0000 1.0000	0.9108 0.3624	-0.2728 0.7850	-0.6598 0.5094
14: UM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=6.3661 p=0.1734	4	0.0000 1.0000	0.1917 0.8480	0.5997 0.5487	1.8964 0.0579	0.1917 0.8480	0.5997 0.5487	1.8964 0.0579	0.8288 0.4072	2.3961 *0.0166**	1.7991 0.0720
16: UM3	χ^2=3.6571 p=0.4544	4	0.4427 0.6580	0.7163 0.4738	1.6077 0.1079	0.5712 0.5679	0.0398 0.9683	0.8656 0.3867	0.1173 0.9066	1.6526 0.0984	0.1210 0.9037	-0.7172 0.4732
17: LM3	χ^2=1.3846 p=0.8469	4	0.0477 0.9619	-0.1122 0.9106	0.3571 0.7210	0.5866 0.5575	-0.1767 0.8598	0.2987 0.7652	0.5356 0.5922	0.8080 0.4191	0.9720 0.3315	0.3494 0.7268
18: LM2	χ^2=8.3575 p=0.0793	4	0.0000 1.0000	0.3027 0.7621	1.0333 0.3015	2.0293 *0.0424**	0.2506 0.8021	0.8812 0.3782	1.7897 0.0735	1.3512 0.1766	2.5872 *0.0097**	1.4329 0.1519
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=10.717 *p=0.0299**	4	0.0000 1.0000	0.2537 0.7998	0.0000 1.0000	2.6845 *0.0073**	0.2537 0.7998	0.0000 1.0000	2.6845 *0.0073**	-0.3671 0.7136	3.1521 *0.0016**	3.0565 *0.0022**
21: LP1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22: LC	χ^2=5.5789 p=0.2329	4	0.0000 1.0000	0.2375 0.8123	0.0000 1.0000	1.6543 0.0981	0.2375 0.8123	0.0000 1.0000	1.6543 0.0981	-0.4092 0.6824	2.1910 *0.0285**	2.1885 *0.0286**
23: LI2	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.15.3: Ancestry comparisons for females at age 19 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=0.7692 p=0.8568	3	0.0000 1.0000	0.5760 0.5646	0.0000 1.0000	N/A	0.3555 0.7222	0.0000 1.0000	N/A	-0.7475 0.4548	N/A	N/A
12: UP1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13: UP2	χ^2=1.2219 p=0.7478	3	0.0000 1.0000	0.4698 0.6385	1.0122 0.3114	N/A	0.2948 0.7681	0.6915 0.4893	N/A	0.7840 0.4330	N/A	N/A
14: UM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=7.0409 p=0.1337	4	0.0000 1.0000	0.3169 0.7514	0.5174 0.6049	2.3711 *0.0177**	0.2325 0.8161	0.3881 0.6980	2.0535 *0.0400**	0.3635 0.7163	2.5576 *0.0105**	2.3284 *0.0199**
16: UM3	χ^2=5.2582 p=0.1538	3	0.2971 0.7664	1.1428 0.2531	2.1165 *0.0343**	N/A	0.3676 0.7132	1.0453 0.2959	N/A	1.6118 0.1070	N/A	N/A
17: LM3	χ^2=3.3338 p=0.5036	4	-0.0505 0.9597	0.0984 0.9216	0.3408 0.7333	1.6384 0.1013	0.1439 0.8856	0.3502 0.7262	1.5824 0.1136	0.3793 0.7045	1.7672 0.0772	1.5661 0.1173
18: LM2	χ^2=8.5786 p=0.0725	4	0.0000 1.0000	0.2717 0.7859	1.0681 0.2855	2.5048 *0.0123**	0.1653 0.8687	0.6817 0.4954	2.0452 *0.0408**	1.2897 0.1972	2.6455 *0.0082**	2.0452 *0.0408**
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=0.6875 p=0.8761	3	0.0000 1.0000	0.5162 0.6057	0.0000 1.0000	N/A	0.4330 0.6650	0.0000 1.0000	N/A	-0.6784 0.4975	N/A	N/A
21: LP1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22: LC	χ^2=0.6000 p=0.8964	3	0.0000 1.0000	0.4339 0.6644	0.0000 1.0000	N/A	0.3162 0.7518	0.0000 1.0000	N/A	-0.6761 0.4990	N/A	N/A
23: LI2	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.15.4: Ancestry comparisons for males at age 19 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=7.0879 p=0.0692	3	N/A	N/A	N/A	N/A	0.2170 0.8282	2.0702 *0.0384**	0.0000 1.0000	2.6042 *0.0092**	-0.2170 0.8282	-2.0702 *0.0384**
12: UP1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13: UP2	χ^2=0.1875 p=0.9796	3	N/A	N/A	N/A	N/A	0.2643 0.7916	0.0000 1.0000	0.0000 1.0000	-0.2643 0.7916	-0.2643 0.7916	0.0000 1.0000
14: UM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16: UM3	χ^2=1.3829 p=0.7096	3	N/A	N/A	N/A	N/A	-0.3291 0.7421	-1.0234 0.3061	-0.1477 0.8826	-1.0750 0.2824	0.2111 0.8328	1.0340 0.3011
17: LM3	χ^2=0.2238 p=0.9737	3	N/A	N/A	N/A	N/A	-0.3052 0.7602	0.0000 1.0000	-0.1263 0.8995	0.3052 0.7602	0.2685 0.7883	-0.1263 0.8995
18: LM2	χ^2=2.4294 p=0.4882	3	N/A	N/A	N/A	N/A	0.1943 0.8460	0.0000 1.0000	0.9811 0.3266	-0.1943 0.8460	1.4898 0.1363	0.9811 0.3266
19: LM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=9.0000 *p=0.0293**	3	N/A	N/A	N/A	N/A	0.0000 1.0000	0.0000 1.0000	1.8257 0.0679	0.0000 1.0000	2.9814 *0.0029**	1.8257 0.0679
21: LP1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22: LC	χ^2=4.3333 p=0.2276	3	N/A	N/A	N/A	N/A	0.0000 1.0000	0.0000 1.0000	1.1547 0.2482	0.0000 1.0000	2.0471 *0.0407**	1.1547 0.2482
23: LI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix A2.16: Age 20

Table A2.16.1: Sex comparisons for age 20 using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	N/A	1	N/A	N/A
10: UI2	N/A	1	N/A	N/A
11: UC	1.5401	1	0.2146	-1.2410
12: UP1	1.4000	1	0.2367	1.1832
13: UP2	1.1029	1	0.2936	-1.0502
14: UM1	N/A	1	N/A	N/A
15: UM2	1.8000	1	0.1797	-1.3416
16: UM3	8.0747	1	*0.0045**	-2.8416
17: LM3	2.6494	1	0.1036	-1.6277
18: LM2	2.6561	1	0.1032	-1.6298
19: LM1	N/A	1	N/A	N/A
20: LP2	1.3419	1	0.2467	-1.1584
21: LP1	N/A	1	N/A	N/A
22: LC	N/A	1	N/A	N/A
23: LI2	N/A	1	N/A	N/A
24: LI1	N/A	1	N/A	N/A

Table A2.16.2: Ancestry comparisons for age 20 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=1.5401 p=0.8195	4	0.0000 1.0000	0.8497 0.3955	0.0000 1.0000	0.0000 1.0000	0.8497 0.3955	0.0000 1.0000	0.0000 1.0000	-0.5171 0.6051	-0.5171 0.6051	0.0000 1.0000
12: UP1	χ^2=11.000 *p=0.0117**	3	0.0000 1.0000	0.0000 1.0000	2.4495 *0.0143**	N/A	0.0000 1.0000	2.8284 *0.0047**	N/A	3.2660 *0.0011**	N/A	N/A
13: UP2	χ^2=0.6250 p=0.9602	4	0.0000 1.0000	0.4962 0.6198	0.0000 1.0000	0.0000 1.0000	0.4962 0.6198	0.0000 1.0000	0.0000 1.0000	-0.3591 0.7195	-0.3591 0.7195	0.0000 1.0000
14: UM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=1.0800 p=0.8974	4	0.0000 1.0000	0.6129 0.5399	0.0000 1.0000	0.0000 1.0000	0.7348 0.4624	0.0000 1.0000	0.0000 1.0000	-0.4431 0.6577	-0.4431 0.6577	0.0000 1.0000
16: UM3	χ^2=3.3806 p=0.4963	4	-1.2808 0.2003	-0.1101 0.9123	0.6774 0.4982	0.0000 1.0000	1.4530 0.1462	1.8339 0.0667	1.1092 0.2673	1.0255 0.3051	0.0796 0.9365	-0.5531 0.5802
17: LM3	χ^2=3.0884 p=0.5431	4	0.2637 0.7920	1.2852 0.1987	1.2761 0.2019	0.5896 0.5555	1.1516 0.2495	1.1320 0.2577	0.4169 0.6768	0.3577 0.7206	-0.2193 0.8264	-0.3835 0.7013
18: LM2	χ^2=1.6162 p=0.8059	4	0.0000 1.0000	0.7733 0.4393	0.0000 1.0000	0.0000 1.0000	0.7733 0.4393	0.0000 1.0000	0.0000 1.0000	-0.7733 0.4393	-0.4621 0.6440	0.0000 1.0000
19: LM1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=0.7742 p=0.9419	4	0.0000 1.0000	0.4673 0.6403	0.0000 1.0000	0.0000 1.0000	0.5616 0.5744	0.0000 1.0000	0.0000 1.0000	-0.5616 0.5744	-0.3370 0.7361	0.0000 1.0000
21: LP1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22: LC	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23: LI2	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.16.3: Ancestry comparisons for females at age 20 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	χ^2=1.8701 p=0.5998	3	0.0000 1.0000	1.0656 0.2866	0.0000 1.0000	N/A	0.9029 0.3666	0.0000 1.0000	N/A	-0.6645 0.5064	N/A	N/A
12: UP1	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13: UP2	χ^2=0.6564 p=0.8834	3	0.0000 1.0000	0.6099 0.5419	0.0000 1.0000	N/A	0.4464 0.6553	0.0000 1.0000	N/A	-0.4464 0.6553	N/A	N/A
14: UM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	χ^2=1.3077 p=0.7273	3	0.0000 1.0000	0.7923 0.4282	0.0000 1.0000	N/A	0.7923 0.4282	0.0000 1.0000	N/A	-0.5799 0.5620	N/A	N/A
16: UM3	χ^2=1.7876 p=0.4091	2	N/A	0.5932 0.5531	1.3288 0.1839	N/A	N/A	N/A	N/A	1.1391 0.2547	N/A	N/A
17: LM3	χ^2=2.8980 p=0.4076	3	0.5669 0.5708	1.4286 0.1531	1.3887 0.1649	N/A	0.6786 0.4974	0.9258 0.3545	N/A	0.5999 0.5486	N/A	N/A
18: LM2	χ^2=1.6347 p=0.6516	3	0.0000 1.0000	0.9695 0.3323	0.0000 1.0000	N/A	0.8122 0.4167	0.0000 1.0000	N/A	-0.5900 0.5552	N/A	N/A
19: LM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	χ^2=0.7037 p=0.8723	3	0.0000 1.0000	0.5755 0.5650	0.0000 1.0000	N/A	0.5755 0.5650	0.0000 1.0000	N/A	-0.4194 0.6749	N/A	N/A
21: LP1	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22: LC	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23: LI2	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A2.16.4: Ancestry comparisons for males at age 20 using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11: UC	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12: UP1	χ^2=4.0000 p=0.1353	2	N/A	N/A	N/A	N/A	0.0000 1.0000	1.5811 0.1138	N/A	1.9365 0.0528	N/A	N/A
13: UP2	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14: UM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15: UM2	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16: UM3	χ^2=2.8286 p=0.4188	3	N/A	N/A	N/A	N/A	0.7606 0.4469	1.3416 0.1797	1.3416 0.1797	1.0142 0.3105	1.0142 0.3105	0.0000 1.0000
17: LM3	χ^2=3.0795 p=0.3795	3	N/A	N/A	N/A	N/A	1.6530 0.0983	1.6002 0.1096	1.3858 0.1658	0.2919 0.7703	0.2156 0.8293	0.0000 1.0000
18: LM2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19: LM1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20: LP2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21: LP1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22: LC	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23: LI2	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Appendix A2.17: Childhood Period (Years 5-6)

Table A2.17.1: Sex comparisons for childhood period (years 5-6) using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	0.3263	1	0.5678	-0.5713
10: UI2	0.2953	1	0.5869	0.5434
11: UC	1.4123	1	0.2347	1.1884
12: UP1	0.2431	1	0.6220	-0.4931
13: UP2	1.1305	1	0.2877	1.0632
14: UM1	0.1127	1	0.7371	-0.3357
15: UM2	0.4107	1	0.5216	-0.6409
16: UM3	N/A	0	N/A	N/A
17: LM3	0.1429	1	0.7055	-0.3780
18: LM2	0.0360	1	0.8496	-0.1897
19: LM1	0.2755	1	0.5996	0.5249
20: LP2	0.1191	1	0.7300	-0.3451
21: LP1	0.6254	1	0.4291	0.7908
22: LC	0.8257	1	0.3635	0.9087
23: LI2	0.1171	1	0.7322	0.3422
24: LI1	0.0009	1	0.9259	-0.0930

Table A2.17.2: Ancestry comparisons for childhood period (years 5-6) using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=6.3878 p=0.0942	3	0.0952 0.9241	0.2937 0.7690	-0.8528 0.3938	N/A	0.2242 0.8226	-1.1998 0.2302	N/A	-2.4863 *0.0129**	N/A	N/A
10: UI2	χ^2=4.2301 p=0.2377	3	0.1979 0.8431	0.0702 0.9440	-0.9703 0.3319	N/A	-0.1873 0.8514	-1.3344 0.1821	N/A	-1.8202 0.0687	N/A	N/A
11: UC	χ^2=5.2773 p=0.1526	3	1.1220 0.2619	0.6995 0.4842	-0.1341 0.8933	N/A	-0.8090 0.4185	-1.7919 0.0732	N/A	-1.8342 0.0666	N/A	N/A
12: UP1	χ^2=10.488 *p=0.0148**	3	0.6030 0.5465	1.6582 0.0973	-0.1568 0.8754	N/A	0.8844 0.3765	-0.9393 0.3476	N/A	-3.1523 *0.0016**	N/A	N/A
13: UP2	χ^2=9.0338 *p=0.0288**	3	0.5990 0.5492	0.8889 0.3741	-0.7085 0.4786	N/A	0.1201 0.9044	-1.4984 0.1340	N/A	-2.8817 *0.0040**	N/A	N/A
14: UM1	χ^2=5.8391 p=0.1197	3	0.9915 0.3215	1.1155 0.2646	0.0853 0.9320	N/A	-0.0596 0.9525	-1.4008 0.1613	N/A	-2.2003 *0.0278**	N/A	N/A
15: UM2	χ^2=3.3130 p=0.3458	3	-0.6294 0.5291	0.0779 0.9379	-0.6845 0.4937	N/A	1.0164 0.3095	0.0980 0.9212	N/A	-1.6848 0.0920	N/A	N/A
16: UM3	χ^2=0.0000 p=1.0000	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0000 1.0000	N/A	N/A
17: LM3	χ^2=1.0000 p=0.3173	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-1.0000 0.3173	N/A	N/A
18: LM2	χ^2=2.0303 p=0.5661	3	0.3014 0.7631	0.6829 0.4946	0.0723 0.9424	N/A	0.3740 0.7084	-0.3530 0.7241	N/A	-1.3653 0.1722	N/A	N/A
19: LM1	χ^2=9.1602 *p=0.0272**	3	1.2508 0.2110	1.4024 0.1608	0.1713 0.8640	N/A	-0.1621 0.8712	-1.6189 0.1055	N/A	-2.7522 *0.0059**	N/A	N/A
20: LP2	χ^2=8.0126 *p=0.0458**	3	1.2774 0.2015	2.0044 *0.0450**	0.9281 0.3533	N/A	0.5236 0.6006	-0.7542 0.4507	N/A	-2.3757 *0.0175**	N/A	N/A
21: LP1	χ^2=3.8345 p=0.2799	3	0.9013 0.3674	1.0752 0.2823	0.2970 0.7665	N/A	-0.0395 0.9685	-0.9594 0.3374	N/A	-1.7368 0.0824	N/A	N/A
22: LC	χ^2=7.0168 p=0.0714	3	0.1031 0.9179	0.7741 0.4389	-0.2650 0.7910	N/A	0.8172 0.4138	-0.4905 0.6238	N/A	-2.6277 *0.0086**	N/A	N/A
23: LI2	χ^2=7.5167 p=0.0571	3	1.7194 0.0855	1.5779 0.1146	0.6234 0.5330	N/A	-0.5466 0.5847	-1.8532 0.0639	N/A	-2.0921 *0.0364**	N/A	N/A
24: LI1	χ^2=6.5055 p=0.0895	3	0.4416 0.6588	0.5564 0.5779	-0.7334 0.4633	N/A	0.0106 0.9916	-1.4133 0.1576	N/A	-2.4292 *0.0151**	N/A	N/A

Table A2.17.3: Ancestry comparisons for females during childhood period (years 5-6) using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=7.2628 p=0.0640	3	0.3593 0.7194	0.6066 0.5441	-0.9642 0.3350	N/A	-0.0340 0.9729	-0.9966 0.3190	N/A	-2.6582 *0.0079**	N/A	N/A
10: UI2	χ^2=7.7113 p=0.0524	3	0.7835 0.4333	0.6917 0.4891	-0.9258 0.3546	N/A	-0.4349 0.6636	-1.4431 0.1490	N/A	-2.5799 *0.0099**	N/A	N/A
11: UC	χ^2=5.9115 p=0.1160	3	0.5865 0.5576	0.9409 0.3467	-0.2619 0.7934	N/A	-0.0975 0.9223	-0.8181 0.4133	N/A	-2.3542 *0.0186**	N/A	N/A
12: UP1	χ^2=8.3704 *p=0.0152**	2	N/A	1.5886 0.1122	-0.1360 0.8918	N/A	N/A	N/A	N/A	-2.8034 *0.0051**	N/A	N/A
13: UP2	χ^2=8.8001 *p=0.0123**	2	N/A	0.7486 0.4541	-1.1929 0.2329	N/A	N/A	N/A	N/A	-2.9494 *0.0032**	N/A	N/A
14: UM1	χ^2=8.7922 *p=0.0322**	3	1.9039 0.0569	1.1459 0.2518	-0.2054 0.8373	N/A	-1.4569 0.1451	-2.2329 *0.0256**	N/A	-2.2596 *0.0238**	N/A	N/A
15: UM2	χ^2=8.1106 *p=0.0438**	3	1.3337 0.1823	0.0738 0.9412	-1.0419 0.2974	N/A	-1.4167 0.1438	-2.1313 *0.0331**	N/A	-2.1873 *0.0287**	N/A	N/A
16: UM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17: LM3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18: LM2	χ^2=6.3580 p=0.0954	3	-0.1142 0.9091	0.9006 0.3678	-0.3464 0.7290	N/A	0.6703 0.5027	-0.0812 0.9353	N/A	-2.4774 *0.0132**	N/A	N/A
19: LM1	χ^2=10.971 *p=0.0119**	3	1.9788 *0.0478**	1.8236 0.0682	0.4874 0.6260	N/A	-1.1410 0.2539	-1.9319 0.0534	N/A	-2.6341 *0.0084**	N/A	N/A
20: LP2	χ^2=12.436 *p=0.0060**	3	1.2294 0.2189	2.0699 *0.0385**	0.4433 0.6576	N/A	-0.1424 0.8867	-1.1152 0.2647	N/A	-3.1884 *0.0014**	N/A	N/A
21: LP1	χ^2=8.5539 *p=0.0359**	3	0.4122 0.6802	1.3999 0.1615	-0.0237 0.9811	N/A	0.3753 0.7074	-0.4782 0.6325	N/A	-2.8195 *0.0048**	N/A	N/A
22: LC	χ^2=10.014 *p=0.0185**	3	1.2875 0.1979	1.8377 0.0661	0.6452 0.5188	N/A	-0.2149 0.8299	-1.0695 0.2849	N/A	-2.8021 *0.0051**	N/A	N/A
23: LI2	χ^2=8.7261 *p=0.0332**	3	1.2961 0.1950	1.6470 0.0996	0.1356 0.8922	N/A	-0.4521 0.6512	-1.3625 0.1730	N/A	-2.6188 *0.0088**	N/A	N/A
24: LI1	χ^2=6.8710 p=0.0761	3	1.3694 0.1709	0.8299 0.4066	-0.4265 0.6698	N/A	-1.0317 0.3022	-1.7898 0.0735	N/A	-2.1917 *0.0284**	N/A	N/A

Table A2.17.4: Ancestry comparisons for males during childhood period (years 5-6) using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=0.5649 p=0.7539	2	N/A	N/A	N/A	N/A	-0.1423 0.8869	-0.6070 0.5438	N/A	-0.6469 0.5177	N/A	N/A
10: UI2	χ^2=0.6208 p=0.8917	3	-0.5681 0.5700	-0.7672 0.4430	-0.7029 0.4821	N/A	-0.2917 0.7705	-0.1761 0.8602	N/A	0.1498 0.8810	N/A	N/A
11: UC	χ^2=1.1919 p=0.7549	3	0.2932 0.7694	-0.1337 0.8936	-0.2287 0.8191	N/A	-0.8821 0.3777	-1.0794 0.2804	N/A	-0.2632 0.7294	N/A	N/A
12: UP1	χ^2=2.4092 p=0.4919	3	0.4330 0.6650	0.6943 0.4875	-0.0716 0.9429	N/A	0.3535 0.7237	-0.8354 0.4035	N/A	-1.4855 0.1374	N/A	N/A
13: UP2	χ^2=1.1517 p=0.5622	2	N/A	N/A	N/A	N/A	0.1812 0.8562	-0.6918 0.4890	N/A	-0.9908 0.3218	N/A	N/A
14: UM1	χ^2=0.2702 p=0.8736	2	N/A	N/A	N/A	N/A	0.1775 0.8591	-0.2458 0.8058	N/A	-0.5185 0.6041	N/A	N/A
15: UM2	χ^2=1.9121 p=0.5908	3	-0.4256 0.6704	0.2028 0.8393	0.1832 0.8546	N/A	1.3085 0.1907	1.2692 0.2044	N/A	-0.0555 0.9557	N/A	N/A
16: UM3	χ^2=0.0000 p=1.0000	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0000 1.0000	N/A	N/A
17: LM3	χ^2=1.3333 p=0.2482	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-1.1547 0.2482	N/A	N/A
18: LM2	χ^2=0.6909 p=0.8754	3	0.3402 0.7337	0.1546 0.8771	0.4178 0.6761	N/A	-0.4163 0.6772	0.1139 0.9093	N/A	0.7571 0.4490	N/A	N/A
19: LM1	χ^2=1.5688 p=0.6665	3	-0.6139 0.5393	-0.5498 0.5824	-0.9010 0.3676	N/A	0.2063 0.8365	-0.4998 0.6172	N/A	-1.0123 0.3114	N/A	N/A
20: LP2	χ^2=0.5523 p=0.9073	3	0.6569 0.5112	0.6967 0.4860	0.7432 0.4574	N/A	0.0000 1.0000	0.0929 0.9260	N/A	0.1314 0.8955	N/A	N/A
21: LP1	χ^2=0.2505 p=0.9691	3	0.3224 0.7472	0.1249 0.9006	0.2216 0.8246	N/A	-0.4380 0.6614	-0.2406 0.8098	N/A	0.2786 0.7805	N/A	N/A
22: LC	χ^2=3.6650 p=0.3000	3	-1.7290 0.0838	-1.3760 0.1688	-1.6660 0.0957	N/A	0.9099 0.3629	0.3776 0.7058	N/A	-0.8203 0.4120	N/A	N/A
23: LI2	χ^2=1.2908 p=0.5244	2	N/A	N/A	N/A	N/A	-1.0685 0.2853	-0.9874 0.3235	N/A	0.2262 0.8211	N/A	N/A
24: LI1	χ^2=1.7605 p=0.6236	3	-0.6762 0.4989	-0.4666 0.6408	-0.9812 0.3265	N/A	0.3904 0.6962	-0.4594 0.6459	N/A	-1.0345 0.3009	N/A	N/A

Appendix A2.18: Juvenile Period (Years 7-11)

Table A2.18.1: Sex comparisons for juvenile period (years 7-11) using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	0.7815	1	0.3767	0.8840
10: UI2	0.0346	1	0.8525	-0.1860
11: UC	22.377	1	***<0.0000*****	4.7304
12: UP1	0.0466	1	0.8292	0.2158
13: UP2	0.0168	1	0.8970	-0.1295
14: UM1	2.7482	1	0.0974	1.6578
15: UM2	2.1813	1	0.1397	1.4769
16: UM3	4.7739	1	*0.0289**	2.1849
17: LM3	2.0396	1	0.1532	1.4282
18: LM2	0.9254	1	0.3361	0.9620
19: LM1	4.5772	1	*0.0324**	2.1394
20: LP2	1.2792	1	0.2580	1.1310
21: LP1	5.2228	1	*0.0223**	2.2853
22: LC	22.709	1	***<0.0000*****	4.7654
23: LI2	1.0378	1	0.3083	1.0187
24: LI1	0.0264	1	0.8709	0.1625

Table A2.18.2: Ancestry comparisons for juvenile period (years 7-11) using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=13.585 *p=0.0087**	4	1.1756 0.2398	1.0337 0.3013	-0.1247 0.9008	0.5199 0.6031	-0.5436 0.5867	-1.8900 0.0588	-0.4086 0.6828	-3.4354 *0.0006**	-0.1299 0.8966	0.7254 0.4682
10: UI2	χ^2=13.631 *p=0.0086**	4	0.6483 0.5168	0.4687 0.6393	-0.5950 0.5518	-1.3221 0.1861	-0.4154 0.6778	-1.6515 0.0986	-2.0448 0.0409	-3.0613 *0.0022**	-2.2123 *0.0269**	-1.2025 0.2292
11: UC	χ^2=10.319 *p=0.0354**	4	0.9720 0.3310	0.9784 0.3279	0.0419 0.9666	-0.7616 0.4463	-0.3271 0.7436	-1.3363 0.1814	-1.2935 0.0904	-2.6629 *0.0077**	-1.8602 0.0629	-1.0265 0.3047
12: UP1	χ^2=24.431 ***p<0.0000****	4	0.0185 0.9852	-0.1028 0.9181	-1.8039 0.0713	-1.4463 0.1481	-0.1281 0.8981	-1.8292 0.0674	-1.4651 0.1429	-4.6112 ***0.0000****	-1.8921 0.0585	-0.1491 0.8815
13: UP2	χ^2=26.822 ***p<0.0000****	4	-0.1862 0.8523	0.3856 0.6998	-1.4806 0.1387	-1.0947 0.2736	0.6706 0.5025	-1.3095 0.1904	-0.9459 0.3442	-5.0444 ***0.0000****	-1.8332 0.0668	-0.0484 0.9614
14: UM1	χ^2=11.270 *p=0.0237**	4	0.0080 0.9936	0.2571 0.7971	-0.7542 0.4507	-1.3257 0.1850	0.2269 0.8205	-0.7075 0.4793	-1.2891 0.1974	-2.9939 *0.0028**	-1.8579 0.0632	-1.0566 0.2907
15: UM2	χ^2=23.077 ***p=0.0001****	4	0.7236 0.4693	0.4421 0.6584	-0.9551 0.3395	-1.7672 0.0772	-0.5549 0.5789	-2.0737 *0.0381**	-2.5153 *0.0119**	-4.0725 ***0.0000****	-2.7135 *0.0067**	-1.4521 0.1465
16: UM3	χ^2=2.2130 p=0.6967	4	1.0735 0.2831	0.3086 0.7577	-0.0192 0.9847	0.4378 0.6615	-1.0659 0.2865	-1.3245 0.1853	-0.5837 0.5594	-0.7274 0.4670	0.2899 0.7719	0.5554 0.5786
17: LM3	χ^2=0.7979 p=0.9386	4	0.2032 0.8390	0.2082 0.8351	0.3171 0.7511	-0.5049 0.6136	-0.0812 0.9353	0.0056 0.9955	-0.6366 0.5244	0.2347 0.8144	-0.7683 0.4423	-0.8529 0.3937
18: LM2	χ^2=21.968 ***p=0.0002****	4	0.6763 0.4988	1.0002 0.3172	-0.6645 0.5064	-0.4615 0.6444	0.0918 0.9268	-1.6196 0.1053	-1.0820 0.2792	-4.5547 ***0.0000****	-1.4398 0.1499	-0.0227 0.9819
19: LM1	χ^2=9.8227 *p=0.0435**	4	-0.1517 0.8794	0.4928 0.6221	-0.6188 0.5361	-0.6020 0.5472	0.7178 0.4729	-0.4271 0.6693	-0.4718 0.6370	-3.0410 *0.0024**	-1.1877 0.2350	-0.2406 0.8099
20: LP2	χ^2=39.859 ***p<0.0000****	4	1.3082 0.1908	2.0953 *0.0361**	-0.0669 0.9466	-0.7361 0.4617	0.3254 0.7449	-1.8650 0.0622	-1.9312 0.0535	-5.8899 ***0.0000****	-2.7216 *0.0065**	-0.8810 0.3783
21: LP1	χ^2=43.347 ***p<0.0000****	4	1.0131 0.3110	1.3817 0.1671	-0.8572 0.3913	-1.2988 0.1940	0.0177 0.9859	-2.2868 *0.0222**	-2.2186 *0.0265**	-6.1854 ***0.0000****	-2.7803 *0.0054**	-0.9299 0.3524
22: LC	χ^2=10.992 *p=0.0267**	4	0.1902 0.8491	0.4940 0.6213	-0.5908 0.5547	-0.7170 0.4734	0.2522 0.8009	-0.8889 0.3740	-0.9135 0.3610	-3.1662 *0.0015**	-1.3879 0.1652	-0.4057 0.6849
23: LI2	χ^2=20.312 *p=0.0004**	4	1.0120 0.3115	2.0185 *0.0435**	0.3775 0.7058	0.5301 0.5961	0.7239 0.4691	-1.0180 0.3087	-0.3965 0.6917	-4.3226 ***0.0000****	-1.1040 0.2696	0.3511 0.7255
24: LI1	χ^2=7.8038 p=0.0990	4	1.5942 0.1109	1.1294 0.2587	0.3046 0.7607	0.7485 0.4541	-1.0232 0.3062	-1.9274 0.0539	-0.5183 0.6043	-2.1618 *0.0306**	0.0820 0.9346	0.6817 0.4954

Table A2.18.3: Ancestry comparisons for females during juvenile period (years 7-11) using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=4.4242 p=0.3516	4	0.0021 0.4838	0.3413 0.7329	-0.1805 0.8567	-0.8406 0.4006	-0.6453 0.5205	-1.2446 0.2133	-1.3732 0.1697	-1.5470 0.1219	-1.1878 0.2349	-0.8615 0.3889
10: UI2	χ^2=10.301 *p=0.0357**	4	1.5555 0.1198	1.0956 0.2732	0.6469 0.5177	-0.8863 0.3755	-1.0411 0.2978	-1.5599 0.1188	-2.6609 *0.0078**	-1.3964 0.1629	-2.5911 *0.0096**	-2.0681 *0.0386**
11: UC	χ^2=4.3209 p=0.3643	4	-0.0631 0.9497	-0.8717 0.3834	-0.9189 0.3582	-1.7338 0.0830	-0.9446 0.3448	-1.0006 0.3170	-1.8360 0.0664	-0.1537 0.8779	-1.5446 0.1224	-1.4911 0.1359
12: UP1	χ^2=17.429 *p=0.0016**	4	-0.8743 0.3819	-1.0154 0.3099	-2.1365 *0.0326**	-2.0521 *0.0402**	0.1028 0.9181	-1.2529 0.2102	-1.2818 0.1999	-3.5845 *0.0003**	-1.9805 *0.0476**	-0.4361 0.6628
13: UP2	χ^2=18.623 *p=0.0009**	4	-0.0261 0.9792	-0.0911 0.9274	-1.2842 0.1991	-1.5581 0.1192	-0.0705 0.9438	-1.5147 0.1298	-1.7128 0.0867	-3.8591 ***0.0001****	-2.2648 *0.0235**	-0.8221 0.4110
14: UM1	χ^2=5.8069 p=0.2140	4	-1.2227 0.2215	-1.0115 0.3118	-1.3476 0.1778	-2.1376 *0.0326**	0.6799 0.4966	0.3731 0.7091	-0.9436 0.3454	-0.9654 0.3343	-1.8717 0.0612	-1.5936 0.1110
15: UM2	χ^2=10.314 *p=0.0355**	4	-0.7151 0.4745	-1.1631 0.2448	-1.7776 0.0755	-2.3417 *0.0192**	-0.3404 0.7336	-1.1069 0.2683	-1.8659 0.0621	-2.0292 *0.0424**	-2.1278 *0.0334**	-1.4333 0.1518
16: UM3	χ^2=7.4976 p=0.1118	4	-0.8952 0.3707	-2.4268 *0.0152**	-1.7805 0.0750	-1.6001 0.1096	-0.7577 0.4486	-0.2529 0.8004	-0.4571 0.6476	1.6949 0.0901	0.2660 0.7902	-0.4045 0.6859
17: LM3	χ^2=6.0758 p=0.1936	4	-0.6780 0.4978	-1.3631 0.1728	-0.4631 0.6433	-0.7518 0.4522	-0.3010 0.7634	0.4705 0.6380	-0.0225 0.9821	2.2901 *0.0220**	0.3056 0.7599	-0.5628 0.5736
18: LM2	χ^2=9.5514 *p=0.0487**	4	-0.1866 0.8519	-0.6581 0.5105	-1.4281 0.1532	-1.6585 0.0972	-0.4780 0.6326	-1.3599 0.1739	-1.5872 0.1125	-2.4250 *0.0153**	-1.6443 0.1001	-0.8444 0.3984
19: LM1	χ^2=7.9122 p=0.0949	4	-0.1071 0.9147	-0.4396 0.6603	-1.0520 0.2928	-1.7698 0.0768	-0.3452 0.7299	-1.0465 0.2953	-1.7879 0.0738	-1.9285 0.0538	-2.0275 *0.0426**	-1.3914 0.1641
20: LP2	χ^2=13.785 *p=0.0080**	4	0.2092 0.8343	-0.0916 0.9270	-1.1617 0.2453	-1.1641 0.2444	-0.4135 0.6793	-1.6389 0.1012	-1.4620 0.1438	-3.3520 *0.0008**	-1.5382 0.1240	-0.4269 0.6695
21: LP1	χ^2=23.587 ***p<0.0000****	4	0.7568 0.4492	0.0107 0.9915	-1.2191 0.2228	-1.9806 0.0476	-1.1038 0.2697	-2.5132 0.0120	-2.8973 *0.0038**	-3.8467 ***0.0001****	-2.7889 *0.0053**	-1.5136 0.1301
22: LC	χ^2=1.7502 p=0.7816	4	0.0606 0.9517	-0.4328 0.6652	-0.6460 0.5183	-0.9145 0.3604	-0.5519 0.5810	-0.7812 0.4347	-1.0097 0.3127	-0.6566 0.5115	-0.8259 0.4089	-0.6130 0.5399
23: LI2	χ^2=8.589 p=0.0722	4	0.9609 0.3366	1.3560 0.1751	0.4607 0.6450	0.0000 1.0000	0.1717 0.8637	-0.8937 0.3715	-0.9609 0.3366	-2.6057 *0.0092**	-1.3560 0.1751	-0.4607 0.6450
24: LI1	χ^2=2.8403 p=0.5849	4	1.1437 0.2528	0.6819 0.4953	0.3394 0.7343	0.7161 0.4739	-0.8890 0.3740	-1.3444 0.1788	-0.2008 0.8409	-0.9522 0.3410	0.3427 0.7318	0.6253 0.5318

Table A2.18.4: Ancestry comparisons for males during juvenile period (years 7-11) using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=13.176 *p=0.0105**	4	0.9466 0.3439	1.1210 0.2623	-0.0022 0.9983	1.2469 0.2124	-0.0960 0.9235	-1.4127 0.1578	0.4813 0.6303	-3.3302 *0.0009**	0.6476 0.5173	1.5972 0.1102
10: UI2	χ^2=10.140 *p=0.0381**	4	-0.5574 0.5773	-0.3648 0.7153	-1.4904 0.1361	-0.1603 0.8727	0.3976 0.6909	-0.9190 0.3581	0.2745 0.7837	-3.0153 *0.0026**	0.0694 0.9447	0.8815 0.3781
11: UC	χ^2=15.481 *p=0.0038**	4	1.2387 0.2154	2.2308 *0.0257**	0.8292 0.4070	0.7947 0.4268	0.5412 0.5884	-0.8500 0.3953	-0.2168 0.8284	-3.5807 *0.0003**	-0.6502 0.5156	0.3538 0.7235
12: UP1	χ^2=9.0134 p=0.0608	4	0.7120 0.4765	0.6765 0.4987	-0.5279 0.5976	0.1763 0.8600	-0.3216 0.7477	-1.3478 0.1777	-0.4343 0.6641	-2.8616 *0.0042**	-0.2797 0.7797	0.5924 0.5536
13: UP2	χ^2=10.806 *p=0.0288**	4	-0.3744 0.7081	0.5174 0.6049	-0.8611 0.3892	0.2524 0.8007	0.9977 0.3184	-0.3352 0.7374	0.5699 0.5687	-3.2330 *0.0012**	-0.0911 0.9274	0.9718 0.3312
14: UM1	χ^2=11.903 *p=0.0181**	4	1.3348 0.1819	1.3795 0.1678	0.3218 0.7476	0.4354 0.6633	-0.5016 0.6159	-1.4681 0.1421	-0.6852 0.4932	-3.1799 *0.0015**	-0.4627 0.6436	0.2945 0.7684
15: UM2	χ^2=16.819 *p=0.0021**	4	1.5158 0.1296	1.6128 0.1068	0.2043 0.8381	-0.2919 0.7704	-0.4785 0.6323	-1.8301 0.0672	-1.5054 0.1322	-3.6675 ***0.0002****	-1.4697 0.1416	-0.4892 0.6247
16: UM3	χ^2=10.938 *p=0.0273**	4	2.0466 *0.0407**	2.3925 *0.0167**	1.2461 0.2127	1.8688 0.0617	-0.5920 0.5539	-1.4815 0.1385	0.0755 0.9398	-2.2341 *0.0255**	0.5844 0.5590	1.3220 0.1862
17: LM3	χ^2=4.9808 p=0.2893	4	0.7660 0.4437	1.4742 0.1404	0.5852 0.5584	-0.2521 0.8010	0.2349 0.8143	-0.4611 0.6447	-0.8229 0.4105	-1.7185 0.0857	-1.2001 0.2301	-0.6495 0.5160
18: LM2	χ^2=17.642 *p=0.0015**	4	0.8914 0.3727	1.9051 0.0568	0.2515 0.8015	0.9766 0.3287	0.6266 0.5309	-0.9370 0.3488	0.2368 0.8128	-4.0137 ***0.0001****	-0.1766 0.8599	0.9814 0.3264
19: LM1	χ^2=7.6564 p=0.1050	4	-0.2524 0.8007	1.1067 0.2684	0.1713 0.8640	1.2363 0.2163	1.3862 0.1657	0.4958 0.6200	1.4180 0.1562	-2.2666 0.0234	0.6937 0.4879	1.3459 0.1783
20: LP2	χ^2=30.881 ***p<0.0000****	4	1.3488 0.1774	2.8869 *0.0039**	0.8401 0.4008	-0.2055 0.8372	0.8978 0.3693	-0.9823 0.3259	-1.2979 0.1943	-4.9518 ***0.0000****	-2.2740 *0.0230**	-0.8362 0.4030
21: LP1	χ^2=24.661 ***p<0.0000****	4	0.5071 0.6121	1.9898 *0.0466**	0.0400 0.9681	0.5620 0.5741	1.2110 0.2259	-0.6314 0.5278	0.1680 0.8666	-4.8302 ***0.0000****	-0.6183 05364	0.6249 0.5320
22: LC	χ^2=14.287 *p=0.0064**	4	0.2759 0.7827	1.2852 0.1987	-0.0527 0.9580	0.1427 0.8865	0.9434 0.3455	-0.4363 0.6626	-0.0985 0.9215	-3.6910 ***0.0002****	-0.8625 0.3884	0.2214 0.8248
23: LI2	χ^2=13.083 *p=0.0109**	4	0.4691 0.6390	1.5433 0.1228	0.1069 0.9148	0.8769 0.3805	0.8630 0.3882	-0.5208 0.6025	0.4519 0.6513	-3.4817 *0.0005**	-0.1463 0.8837	0.9983 0.3181
24: LI1	χ^2=5.6901 p=0.2235	4	1.1143 0.2652	0.9152 0.3601	0.0767 0.9389	0.3128 0.7544	-0.6179 0.5367	-1.3773 0.1684	-0.5609 0.5748	-2.0862 *0.0370**	-0.2304 0.8178	0.3143 0.7533

Appendix A2.19: Adolescent Period (Years 12-20)

Table A2.19.1: Sex comparisons for adolescent period (years 12-20) using Kruskal-Wallis and Dunn's post-hoc test (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W chi-square	df	p-value	Female-Male z-score
9: UI1	2.6218	1	0.1054	1.6192
10: UI2	4.4389	1	*0.0351**	2.1069
11: UC	3.1497	1	0.0644	1.8492
12: UP1	0.7459	1	0.3878	0.8636
13: UP2	0.0024	1	0.9609	0.0490
14: UM1	0.7175	1	0.3970	0.8470
15: UM2	0.3713	1	0.5423	-0.6093
16: UM3	0.3683	1	0.5439	-0.6069
17: LM3	0.4940	1	0.4821	-0.7029
18: LM2	0.0972	1	0.7553	0.3117
19: LM1	0.0189	1	0.8905	0.1376
20: LP2	1.1302	1	0.2877	1.0631
21: LP1	3.0914	1	0.0787	1.7582
22: LC	19.2060	1	<0.0000**	4.3825
23: LI2	2.7134	1	0.0995	1.6472
24: LI1	0.2447	1	0.6209	-0.4946

Table A2.19.2: Ancestry comparisons for adolescent period (years 12-20) using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=1.1083 p=0.8929	4	0.1050 0.9164	0.0095 0.9925	0.3457 0.7296	-0.5803 0.5617	-0.1280 0.8981	0.1925 0.8473	-0.6540 0.5131	0.6613 0.5084	-0.7075 0.4793	-0.9509 0.3417
10: UI2	χ^2=5.4125 p=0.2475	4	0.9558 0.3392	1.7861 0.0741	1.4078 0.1592	2.1656 *0.0303**	0.5227 0.6012	0.1776 0.8591	1.2814 0.2001	-0.6639 0.5068	1.1767 0.2393	1.4406 0.1497
11: UC	χ^2=11.913 *p=0.0180**	4	-0.0145 0.9884	1.8271 0.0677	2.6950 *0.0070**	1.4349 0.1513	1.6931 0.0904	2.5007 *0.0124**	1.3873 0.1653	1.7785 0.0753	0.2187 0.8269	-0.5997 0.5487
12: UP1	χ^2=5.3590 p=0.2524	4	-0.4391 0.6606	1.0659 0.2865	1.2941 0.1956	0.5618 0.5743	1.7962 0.0725	2.0319 *0.0422**	1.0396 0.2985	0.5245 0.5999	-0.3308 0.7408	-0.5766 0.5642
13: UP2	χ^2=14.178 *p=0.0067**	4	-0.3659 0.7144	1.7453 0.0809	2.5309 *0.0114**	1.1710 0.2416	2.3050 *0.0212**	3.0992 *0.0019**	1.5499 0.1212	1.7387 0.0821	-0.1312 0.8956	-0.9298 0.3525
14: UM1	χ^2=3.3755 p=0.4971	4	0.2766 0.7821	-0.9293 0.3528	-0.1461 0.8838	-0.7499 0.4533	-1.1656 0.2438	-0.4681 0.6397	-0.9374 0.3486	1.3822 0.1669	-0.2341 0.8149	-0.7568 0.4492
15: UM2	χ^2=5.1966 p=0.2677	4	0.0953 0.9241	-0.1236 0.9016	1.0569 0.2906	0.3940 0.6936	-0.2330 0.8158	0.8391 0.4014	0.2812 0.7786	2.2400 *0.0251**	0.6209 0.5347	-0.4833 0.6289
16: UM3	χ^2=11.920 *p=0.0180**	4	1.6208 0.1051	1.5021 0.1331	2.8360 *0.0046**	1.8222 0.0684	-0.7966 0.4257	0.3073 0.7586	-0.0207 0.9835	2.6411 *0.0083**	0.9467 0.3438	-0.4040 0.6862
17: LM3	χ^2=15.928 *p=0.0031**	4	0.8394 0.4013	1.4832 0.1380	3.0761 *0.0021**	2.1194 *0.0341**	0.2492 0.8032	1.7026 0.0886	1.1438 0.2527	3.1283 *0.0018**	1.3439 0.1790	-0.3009 0.7635
18: LM2	χ^2=12.809 *p=0.0123**	4	-0.2361 0.8134	1.5349 0.1248	2.6357 *0.0084**	1.4693 0.1417	1.6316 0.1028	2.5999 *0.0093**	1.5878 0.1123	2.2237 *0.0262**	0.4562 0.6483	-0.6709 0.5023
19: LM1	χ^2=2.4551 p=0.6527	4	0.0000 1.0000	1.1563 0.2475	1.1889 0.2345	0.7062 0.4801	1.0151 0.3101	1.0518 0.2929	0.6560 0.5118	0.1395 0.8890	-0.1813 0.8561	-0.2448 0.8066
20: LP2	χ^2=7.2855 p=0.1215	4	-0.7581 0.4484	1.1030 0.2700	1.4337 0.1517	1.5856 0.1128	1.9044 0.0569	2.1756 *0.0296**	2.1845 *0.0289**	0.7079 0.4790	1.0337 0.3013	0.6702 0.5027
21: LP1	χ^2=5.5790 p=0.2329	4	-1.3773 0.1684	0.0692 0.9448	0.5582 0.5767	0.7248 0.4686	1.7935 0.0729	2.1726 *0.0298**	1.9833 *0.0473**	0.9774 0.3284	0.8723 0.3831	0.3970 0.6914
22: LC	χ^2=6.2533 p=0.1810	4	-0.2877 0.7736	0.8207 0.4118	1.5828 0.1135	1.3605 0.1737	1.1054 0.2690	1.7880 0.0738	1.5605 0.1186	1.5641 0.1178	1.0087 0.3131	0.2319 0.8167
23: LI2	χ^2=2.6491 p=0.6182	4	0.0000 1.0000	0.9673 0.3334	1.0845 0.2781	0.0000 1.0000	0.9297 0.3525	1.0449 0.2961	0.0000 1.0000	0.3066 0.7592	-0.8021 0.4225	-0.9084 0.3637
24: LI1	χ^2=5.5826 p=0.2326	4	1.7820 0.0748	0.4682 0.6396	0.0000 1.0000	0.0000 1.0000	-1.9209 0.0547	-2.2939 *0.0218**	-1.4607 0.1441	-0.9139 0.3608	-0.3389 0.7347	0.0000 1.0000

Table A2.19.3: Ancestry comparisons for females during adolescent period (years 12-20) using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=2.9595 p=0.5646	4	-1.1775 0.2390	-1.2755 0.2021	-0.6743 0.5001	-0.9539 0.3401	0.3318 0.7401	0.8549 0.3926	0.0000 1.0000	1.1137 0.2654	-0.2400 0.8104	-0.6280 0.5300
10: UI2	χ^2=4.7524 p=0.3137	4	0.7769 0.4372	0.9280 0.3534	0.9931 0.3207	2.1430 *0.0321**	-0.1352 0.8925	-0.0443 0.9647	1.4373 0.1506	0.1874 0.8514	1.8942 0.0582	1.7904 0.0734
11: UC	χ^2=5.5243 p=0.2376	4	-0.2709 0.7865	1.1005 0.2711	1.5446 0.1224	1.5992 0.1098	1.2518 0.2106	1.6264 0.1039	1.7052 0.0882	0.9119 0.3618	1.0499 0.2938	0.5936 0.5528
12: UP1	χ^2=3.4482 p=0.4858	4	-0.8863 0.3755	-0.3380 0.7353	0.3257 0.7446	0.0000 1.0000	0.8425 0.3995	1.4581 0.1448	0.8863 0.3755	1.4510 0.1468	0.3380 0.7353	-0.3257 0.7446
13: UP2	χ^2=10.569 *p=0.0319**	4	-0.8370 0.4026	1.2639 0.2063	1.9865 0.0470	1.0499 0.2938	2.1578 *0.0309**	2.7738 *0.0055**	1.8027 0.0714	1.5559 0.1197	0.1477 0.8826	-0.6153 0.5384
14: UM1	χ^2=3.6342 p=0.4578	4	-1.4170 0.1565	-1.8461 0.0649	-1.6222 0.1048	-1.1202 0.2626	0.2202 0.8257	0.3508 0.7257	0.0000 1.0000	0.3073 0.7586	-0.1588 0.8738	-0.2559 0.7980
15: UM2	χ^2=1.3743 p=0.8486	4	-0.7798 0.4355	0.1431 0.8862	0.1823 0.8553	-0.0976 0.9222	1.1152 0.2648	1.1214 0.2621	0.6782 0.4976	0.0909 0.9276	-0.2685 0.7883	-0.3022 0.7625
16: UM3	χ^2=6.7325 p=0.1507	4	0.4688 0.6392	1.3223 0.1861	2.1978 *0.0280**	1.4534 0.1461	0.4023 0.6874	1.0715 0.2839	0.7270 0.4672	1.8044 0.0712	0.6332 0.5266	-0.2832 0.7770
17: LM3	χ^2=10.145 *p=0.0381**	4	-0.7801 0.4353	0.7548 0.4504	1.7024 0.0887	1.6582 0.0973	1.6051 0.1085	2.3946 *0.0166**	2.2733 *0.0230**	1.8700 0.0615	1.4533 0.1461	0.4461 0.6555
18: LM2	χ^2=11.711 *p=0.0196**	4	-0.5189 0.6038	2.1044 *0.0353**	2.3774 *0.0174**	2.1196 *0.0340**	2.2753 *0.0229**	2.4997 *0.0124**	2.3393 *0.0193**	0.6705 0.5025	0.7473 0.4549	0.3855 0.6999
19: LM1	χ^2=1.5580 p=0.8163	4	0.0000 1.0000	0.7239 0.4691	0.9184 0.3584	0.9632 0.3354	0.5656 0.5716	0.7268 0.4674	0.8316 0.4056	0.4240 0.6716	0.5696 0.5690	0.3421 0.7323
20: LP2	χ^2=3.9565 p=0.4119	4	-0.9430 0.3457	0.2847 0.7759	0.5891 0.5558	1.0551 0.2914	1.3813 0.1672	1.6043 0.1087	1.8431 0.0653	0.6060 0.5445	1.1049 0.2692	0.7752 0.4382
21: LP1	χ^2=8.7761 p=0.0670	4	-2.0748 *0.0380**	-1.0881 0.2765	-0.3593 0.7193	0.4850 0.6277	1.6910 0.0908	2.2013 *0.0277**	2.4499 *0.0143**	1.4317 0.1522	1.6739 0.0941	0.9631 0.3355
22: LC	χ^2=6.4350 p=0.1689	4	-0.5935 0.5528	0.6238 0.5327	0.7523 0.4519	1.9291 0.0537	1.2969 0.1947	1.3917 0.1640	2.3595 *0.0183**	0.3184 0.7501	1.9536 0.0507	1.7410 0.0817
23: LI2	χ^2=2.0631 p=0.7242	4	0.0000 1.0000	0.3304 0.7411	0.8497 0.3955	0.0000 1.0000	0.3162 0.7519	0.8148 0.4152	0.0000 1.0000	1.1871 0.2352	-0.2484 0.8039	-0.6464 0.5180
24: LI1	χ^2=1.3787 p=0.8479	4	0.0000 1.0000	0.4844 0.6281	0.0000 1.0000	0.0000 1.0000	0.4844 0.6281	0.0000 1.0000	0.0000 1.0000	-1.0657 0.2866	-0.3293 0.7419	0.0000 1.0000

Table A2.19.4: Ancestry comparisons for males during adolescent period (years 12-20) using Kruskal-Wallis and Dunn's post-hoc tests (Kruskal and Wallis 1952; Dunn 1964).

Tooth	K-W	df	AfA-AsA	AfA-EA	AfA-H	AfA-N	AsA-EA	AsA-H	AsA-N	EA-H	EA-N	H-N
9: UI1	χ^2=1.6558 p=0.7987	4	0.9702 0.3320	0.9264 0.3542	0.8939 0.3713	0.0000 1.0000	-0.4029 0.6870	-0.3880 0.6981	-0.8653 0.3869	0.0046 0.9963	-0.7537 0.4510	-0.7365 0.4614
10: UI2	χ^2=3.2114 p=0.5231	4	0.6199 0.5353	1.5391 0.1238	1.0231 0.3063	1.1500 0.2502	0.8010 0.4231	0.2708 0.7866	0.5678 0.5702	-0.9464 0.3439	-0.0231 0.9816	0.4564 0.6481
11: UC	χ^2=8.8712 p=0.0644	4	0.2057 0.8371	1.4941 0.1351	2.2829 *0.0224**	0.4355 0.6632	1.2194 0.2227	2.0174 *0.0436**	0.2499 0.8027	1.6211 0.1050	-0.7168 0.4735	-1.4138 0.1574
12: UP1	χ^2=5.8759 p=0.2086	4	0.2728 0.7850	1.7733 0.0762	1.4280 0.1533	0.7809 0.4349	1.7874 0.0739	1.3529 0.1761	0.5923 0.5536	-0.6342 0.5260	-0.7941 0.4271	-0.4539 0.6499
13: UP2	χ^2=4.8300 p=0.3052	4	0.1465 0.8836	1.2111 0.2259	1.5911 0.1116	0.5750 0.5653	1.2523 0.2105	1.7010 0.0890	0.4895 0.6245	0.8750 0.3816	-0.3589 0.7197	-0.7243 0.4689
14: UM1	χ^2=4.5035 p=0.3421	4	1.3324 0.1827	0.2251 0.8219	1.0778 0.2811	0.0000 1.0000	-1.4954 0.1348	-0.6447 0.5192	-1.1410 0.2539	1.5392 0.1237	-0.1727 0.8629	-0.8407 0.4005
15: UM2	χ^2=11.396 *p=0.0225**	4	0.7641 0.4448	-0.4611 0.6447	1.3434 0.1791	0.6298 0.5288	-1.4073 0.1593	0.3090 0.7573	-0.1000 0.9203	3.2034 *0.0014**	1.1882 0.2347	-0.4165 0.6770
16: UM3	χ^2=7.1340 p=0.1290	4	1.7711 0.0765	0.8100 0.4179	1.8454 0.0650	1.0760 0.2819	-1.5120 0.1305	-0.5929 0.5532	-0.7491 0.4538	1.9662 *0.0493**	0.6310 0.5281	-0.3800 0.7039
17: LM3	χ^2=10.698 *p=0.0302**	4	1.8199 0.0688	1.3047 0.1920	2.6180 *0.0088**	1.2571 0.2087	-1.1365 0.2558	0.1683 0.8664	-0.5675 0.5704	2.5603 *0.0105**	0.3953 0.6926	-0.9183 0.3585
18: LM2	χ^2=7.3193 p=0.1199	4	-0.0988 0.9213	0.0575 0.9541	1.3812 0.1672	-0.0675 0.9461	0.1843 0.8537	1.4498 0.1471	0.0291 0.9768	2.5080 *0.0121**	-0.1412 0.8877	-1.3799 0.1676
19: LM1	χ^2=2.0370 p=0.7290	4	0.0000 1.0000	0.9160 0.3597	0.7569 0.4491	0.0000 1.0000	0.8951 0.3707	0.7409 0.4588	0.0000 1.0000	-0.2435 0.8076	-0.8736 0.3823	-0.7242 0.4689
20: LP2	χ^2=4.2621 p=0.3717	4	-0.1199 0.9046	1.3005 0.1934	1.4623 0.1437	1.1896 0.2342	1.3641 0.1725	1.5162 0.1295	1.2581 0.2083	0.3964 0.6918	0.3811 0.7031	0.1926 0.8473
21: LP1	χ^2=2.6722 p=0.6141	4	-0.0679 0.9459	1.1620 0.2452	1.0772 0.2814	0.4377 0.6616	1.1634 0.2447	1.0872 0.2770	0.4842 0.6282	-0.0856 0.9318	-0.4603 0.6453	-0.4088 0.6827
22: LC	χ^2=4.9701 p=0.2904	4	0.0277 0.9779	0.7599 0.4473	1.5820 0.1137	0.2023 0.8397	0.6647 0.5062	1.4321 0.1521	0.1671 0.8673	1.5899 0.1119	-0.4401 0.6599	-1.2150 0.2244
23: LI2	χ^2=2.4666 p=0.6506	4	0.0000 1.0000	1.0423 0.2973	0.7348 0.4624	0.0000 1.0000	1.0057 0.3146	0.7108 0.4772	0.0000 1.0000	-0.5093 0.6106	-0.9260 0.3544	-0.6580 0.5106
24: LI1	χ^2=14.417 *p=0.0061**	4	2.8314 *0.0046**	0.0000 1.0000	0.0000 1.0000	0.0000 1.0000	-3.7040 ***0.0002*****	-3.5632 *0.0004**	-2.3832 *0.0172**	0.0000 1.0000	0.0000 1.0000	0.0000 1.0000

Appendix 3: Confidence Intervals for Demirjian et al. (1973) Developmental Scores

Confidence intervals for the dispersion of age around each Demirjian et al. (1973) score. Means produced through 1000 runs of bootstrapped sampling; confidence intervals built around bootstrapped mean using t-distribution to allow for non-normal distribution.

Values presented in each cell include 51% confidence interval, 95% confidence interval, bootstrapped mean from 1000 runs, and number of individuals in the sample that express the specific Demirjian et al. (1973) score at each tooth.

Confidence intervals for Demirjian et al. (1973) scores of H with an asterisk (*) have been adjusted to reflect the age range during which development for each tooth is still occurring. For example, tooth 9 exhibits only scores of H from ages 17-20. Therefore, the set of individuals used to create the confidence intervals are those between the ages of 5 and 17, such that the confidence intervals are describing the developmental process and not years during which development is complete.

Age ranges for a Demirjian et al. (1973) score of H:

Tooth 9 – years 5-17*
Tooth 10 – years 5-19*
Tooth 11 – years 5-20
Tooth 12 – years 5-20
Tooth 13 – years 5-20
Tooth 14 – years 5-17*
Tooth 15 – years 5-20
Tooth 16 – years 5-20
Tooth 17 – years 5-20
Tooth 18 – years 5-20
Tooth 19 – years 5-17*
Tooth 20 – years 5-20
Tooth 21 – years 5-18*
Tooth 22 – years 5-20
Tooth 23 – years 5-17*
Tooth 24 – years 5-16*

Table A3.1: Confidence intervals of total training sample (sex and ancestry not specified) for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	5.00-5.50 4.75-5.50 x=5.245 n=4	5.92-6.23 5.69-6.46 x=6.073 n=13	6.65-6.85 6.41-7.06 x=6.735 n=34	7.67-7.78 7.58-7.87 x=7.727 n=200	9.10-9.24 8.95-9.36 x=9.167 n=218	12.63-12.80* 12.49-12.93* x=12.71 n=362
10: UI2	51% 95% x n	NA	NA	5.57-5.86 5.14-6.28 x=5.71 n=7	6.26-6.52 6.09-6.74 x=6.4 n=23	7.27-7.44 7.09-7.61 x=7.345 n=64	8.10-8.20 8.00-8.30 x=8.151 n=250	10.01-10.16 9.86-10.33 x=10.09 n=249	13.84-14.04* 13.65-14.20* x=13.94 n=406
11: UC	51% 95% x n	NA	NA	5.56-5.78 5.34-6.00 x=5.66 n=9	6.77-6.89 6.67-7.00 x=6.831 n=129	7.87-7.98 7.77-8.07 x=7.925 n=177	9.32-9.41 9.24-9.49 x=9.361 n=496	12.00-12.17 11.84-12.32 x=12.08 n=335	15.78-15.99 15.60-16.17 x=15.88 n=284
12: UP1	51% 95% x n	NA	NA	5.67-6.00 5.39-6.28 x=5.835 n=18	7.25-7.45 7.05-7.61 x=7.334 n=56	8.33-8.52 8.15-8.71 x=8.428 n=87	9.45-9.60 9.33-9.72 x=9.53 n=222	11.15-11.34 10.95-11.50 x=11.23 n=213	15.57-15.81 15.36-16.08 x=15.71 n=202
13: UP2	51% 95% x n	NA	5.50-5.50 5.00-6.00 x=5.502 n=2	6.84-7.05 6.68-7.25 x=6.957 n=44	7.91-8.04 7.81-8.16 x=7.975 n=172	9.08-9.24 8.92-9.39 x=9.152 n=174	10.07-10.20 9.96-10.31 x=10.14 n=264	12.67-12.85 12.51-13.02 x=12.76 n=251	16.28-16.50 16.07-16.70 x=16.38 n=228
14: UM1	51% 95% x n	NA	NA	NA	5.50-5.50 5.00-6.00 x=5.502 n=2	5.82-6.18 5.47-6.53 x=6.008 n=17	6.82-7.12 6.52-7.39 x=6.955 n=33	8.10-8.23 7.98-8.34 x=8.162 n=288	12.84-12.98* 12.69-13.09* x=12.9 n=523
15: UM2	51% 95% x n	6.00-7.00 4.00-7.00 x=5.971 n=3	6.14-6.41 5.89-6.62 x=6.277 n=37	7.35-7.47 7.21-7.58 x=7.4 n=182	8.38-8.47 8.29-8.55 x=8.415 n=287	9.44-9.57 9.33-9.68 x=9.515 n=199	10.69-10.85 10.56-10.97 x=10.77 n=191	12.78-12.95 12.61-13.10 x=12.86 n=295	16.84-17.05 16.67-17.24 x=16.94 n=204

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	9.11-9.27 8.96-9.45 x=9.193 n=162	10.59-10.76 10.44-10.90 x=10.68 n=291	11.96-12.13 11.80-12.29 x=12.04 n=198	14.07-14.32 13.84-14.54 x=14.18 n=125	14.97-15.25 14.70-15.49 x=15.1 n=79	15.81-16.14 15.50-16.46 x=15.98 n=70	17.70-17.97 17.51-18.21 x=17.83 n=87	18.86-19.14 18.68-19.32 x=19 n=22
17: LM3	51% 95% x n	9.12-9.24 8.99-9.36 x=9.178 n=267	11.07-11.23 10.93-11.36 x=11.15 n=316	12.61-12.81 12.43-12.99 x=12.71 n=162	14.58-14.91 14.23-15.24 x=14.75 n=74	15.46-15.69 15.21-15.94 x=15.57 n=108	15.80-16.10 15.49-16.35 x=15.96 n=69	18.04-18.26 17.86-18.52 x=18.15 n=97	19.00-19.21 18.79-19.42 x=19.11 n=19
18: LM2	51% 95% x n	6.00-6.00 5.00-7.00 x=6.003 n=2	6.23-6.42 6.04-6.62 x=6.331 n=52	7.48-7.60 7.35-7.71 x=7.538 n=193	8.21-8.34 8.10-8.44 x= 8.276 n=182	9.27-9.37 9.17-9.47 x=9.321 n=317	10.55-10.67 10.44-10.78 x=10.62 n=235	13.29-13.43 13.15-13.58 x=13.36 n=404	16.84-17.01 16.68-17.18 x=16.93 n=270
19: LM1	51% 95% x n	NA	NA	NA	NA n=1	5.58-5.92 5.25-6.17 x=5.754 n=12	6.60-6.79 6.40-6.94 x= 6.679 n=62	8.46-8.54 8.38-8.61 x=8.499 n=598	12.43-12.56* 12.32-12.64* x=12.49 n=840
20: LP2	51% 95% x n	NA N=1	5.70-6.30 5.20-6.70 x=5.998 n=10	7.09-7.23 6.95-7.39 x=7.163 n=117	7.88-7.99 7.77-8.09 x=7.937 n=237	8.78-8.92 8.64-9.06 x=8.845 n=192	10.25-10.36 10.15-10.46 x=10.3 n=450	12.82-12.99 12.64-13.16 x=12.9 n=244	16.17-16.34 16.03-16.50 x=16.25 n=351
21: LP1	51% 95% x n	NA	NA	5.65-5.92 5.39-6.08 x=5.767 n=26	7.35-7.47 7.25-7.57 x=7.416 n=201	8.12-8.27 8.00-8.38 x=8.203 n=187	9.52-9.61 9.41-9.69 x=9.565 n=435	11.44-11.57 11.32-11.70 x=11.5 n=278	14.77-14.92* 14.63-15.04* x=14.85 n=371
22: LC	51% 95% x n	NA	NA	5.50-5.83 5.25-6.08 x=5.672 n=12	6.69-6.86 6.56-7.01 x=6.774 n=84	7.61-7.73 7.49-7.84 x=7.667 n=141	9.07-9.15 8.97-9.23 x=9.107 n=545	11.68-11.85 11.54-12.00 x=11.77 n=311	15.28-15.49 15.11-15.66 x=15.39 n=369
23: LI2	51% 95% x n	NA	NA	NA	5.17-5.50 5.00-5.67 x=5.336 n=6	5.90-6.19 5.70-6.40 x=6.051 n=20	7.39-7.50 7.27-7.60 x=7.451 n=168	8.96-9.09 8.82-9.22 x=9.03 n=238	12.15-12.30* 12.00-12.43* x=12.22 n=553

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	5.00-6.00 5.00-6.00 x=5.498 n=2	5.25-5.75 4.75-6.00 x=5.499 n=8	6.69-6.88 6.50-7.04 x=6.775 n=48	7.89-8.02 7.76-8.14 x=7.962 n=216	11.55-11.69* 11.41-11.82* x=11.62 n=524

Table A3.2: Confidence intervals from female subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	5.00-5.67 4.67-5.67 x=5.324 n=3	5.83-6.17 5.33-6.67 x=5.992 n=6	6.18-6.47 5.94-6.71 x=6.302 n=17	7.60-7.56 7.47-7.89 x=7.68 n=103	8.72-8.92 8.54-9.07 x=8.816 n=112	12.41-12.63* 12.20-12.84* x=12.52 n=191
10: UI2	51% 95% x n	NA	NA	5.75-6.25 5.25-6.75 x=6.002 n=4	6.17-6.50 5.83-6.83 x=6.348 n=12	6.97-7.17 6.81-7.39 x=7.075 n=36	7.88-8.01 7.75-8.12 x=7.938 n=130	9.58-9.81 9.40-10.02 x=9.693 n=122	13.75-14.02* 13.52-14.28* x=13.88 n=222
11: UC	51% 95% x n	NA	NA	5.25-5.75 5.00-6.00 x=5.50 n=4	6.53-6.70 6.38-6.85 x=6.609 n=60	7.47-7.60 7.37-7.72 x=7.536 n=78	8.98-9.09 8.85-9.21 x=9.036 n=254	11.60-11.81 11.38-12.01 x=11.71 n=198	15.77-16.06 15.52-16.34 x=15.90 n=155
12: UP1	51% 95% x n	NA	NA	5.55-5.91 5.27-6.18 x=5.731 n=11	7.39-7.64 7.18-7.85 x=7.506 n=33	8.12-8.39 7.90-8.63 x=8.268 n=41	9.17-9.36 8.99-9.52 x=9.27 n=108	10.98-11.23 12.38-13.08 x=11.09 n=121	15.58-15.94 15.24-16.27 x=15.80 n=106
13: UP2	51% 95% x n	NA	5.50-5.50 5.00-6.00 x=5.502 n=2	6.96-7.21 6.75-7.46 x=7.077 n=24	7.68-7.85 7.53-7.99 x=7.766 n=97	8.87-9.09 8.69-9.30 x=8.989 n=86	9.98-10.15 9.81-10.29 x=10.06 n=141	12.61-12.86 12.38-13.08 x=12.73 n=146	16.22-16.55 15.93-16.85 x=16.36 n=122
14: UM1	51% 95% x n	NA	NA	NA	5.50-5.50 5.00-6.00 x=5.502 n=2	5.67-6.15 5.33-6.50 x=5.912 n=12	6.36-6.73 6.09-7.00 x=6.54 n=11	7.83-7.97 7.69-8.12 x=7.911 n=149	12.55-12.74* 12.39-12.89* x=12.65 n=280
15: UM2	51% 95% x n	6.00-7.00 4.00-7.00 x=5.971 n=3	5.94-6.35 5.53-6.59 x=6.125 n=17	7.15-7.32 7.01-7.47 x=7.232 n=92	8.14-8.28 8.01-8.41 x=8.21 n=146	9.37-9.53 9.22-9.68 x=9.447 n=108	10.64-10.84 10.45-11.04 x=10.74 n=109	12.72-12.97 12.47-13.19 x=12.84 n=156	16.77-17.08 16.50-17.38 x=16.93 n=103

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	8.97-9.20 8.73-9.42 x=9.093 n=69	10.57-10.77 10.40-10.95 x=10.68 n=156	11.85-12.08 11.67-12.26 x=11.97 n=110	14.17-14.62 13.79-14.95 x=14.4 n=63	14.71-15.23 14.26-15.68 x=14.97 n=35	15.98-16.45 15.57-16.86 x=16.22 n=44	17.76-18.14 17.44-18.48 x=17.97 n=50	18.43-18.86 18.14-19.43 x=18.73 n=7
17: LM3	51% 95% x n	9.08-9.27 8.88-9.45 x=9.182 n=128	10.88-11.07 10.70-11.22 x=10.97 n=169	12.45-12.74 12.16-13.00 x=12.63 n=86	14.85-15.30 14.42-15.75 x=15.06 n=40	15.72-16.03 15.38-16.38 x=15.87 n=60	15.72-16.17 15.32-16.50 x=15.95 n=40	18.21-18.46 17.96-18.71 x=18.33 n=48	19.12-19.38 18.75-19.75 x=19.26 n=8
18: LM2	51% 95% x n	6.00-7.00 5.00-7.00 x=6.003 n=2	6.18-6.46 5.93-6.68 x=6.311 n=28	7.17-7.32 7.03-7.46 x=7.248 n=90	8.05-8.20 7.92-8.36 x=8.138 n=103	9.17-9.32 9.03-9.45 x=9.236 n=161	10.32-10.48 10.18-10.64 x=10.4 n=119	13.22-13.42 13.02-13.60 x=13.32 n=231	16.85-17.11 16.64-17.35 x=16.98 n=147
19: LM1	51% 95% x n	NA	NA	NA	NA n=1	5.56-6.00 5.11-6.33 x=5.777 n=9	6.42-6.67 6.13-6.92 x=6.537 n=24	8.26-8.36 8.15-8.45 x=8.312 n=303	12.22-12.39* 12.07-12.53* x=12.30 n=458
20: LP2	51% 95% x n	NA	5.50-6.17 5.00-6.50 x=5.833 n=6	7.00-7.13 6.80-7.42 x=7.11 n=60	7.66-7.81 7.54-7.94 x=7.736 n=119	8.53-8.73 8.34-8.92 x=8.63 n=91	10.08-10.22 9.95-10.35 x=10.15 n=241	12.70-12.96 12.46-13.17 x=12.83 n=140	16.17-16.40 15.91-16.65 x=16.27 n=191
21: LP1	51% 95% x n	NA	NA	5.55-5.91 5.09-6.27 x=5.737 n=11	7.14-7.29 7.01-7.41 x=7.215 n=104	7.78-7.94 7.63-8.09 x=7.858 n=86	9.28-9.40 9.16-9.52 x=9.336 n=224	11.27-11.46 11.11-11.63 x=11.36 n=161	14.64-14.84* 14.45-15.02* x=14.75 n=205
22: LC	51% 95% x n	NA	NA	5.33-5.67 4.83-6.00 x=5.513 n=6	6.54-6.76 6.34-6.93 x=6.632 n=41	7.27-7.45 7.09-7.61 x=7.364 n=56	8.67-8.79 8.54-8.89 x=8.731 n=274	11.19-11.42 10.98-11.60 x=11.31 n=166	15.14-15.42 14.88-15.67 x=15.27 n=217
23: LI2	51% 95% x n	NA	NA	NA	5.25-5.75 5.00-6.00 x=5.511 n=4	5.83-6.17 5.58-6.42 x=6.006 n=12	7.11-7.24 7.01-7.36 x=7.17 n=76	8.55-8.74 8.34-8.90 x=8.654 n=122	11.99-12.17* 11.81-12.35* x=12.09 n=298

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	5.00-6.00 5.00-6.00 x=5.498 n=2	5.00-5.80 4.60-5.80 x=5.407 n=5	6.59-6.82 6.37-7.04 x=6.697 n=27	7.66-7.83 7.46-7.99 x=7.753 n=108	11.37-11.57* 11.18-11.76* x=11.48 n=273

Table A3.3: Confidence intervals from male subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA n=1	6.00-6.29 5.58-6.57 x=6.144 n=7	7.06-7.35 6.77-7.65 x=7.167 n=17	7.69-7.86 7.54-8.00 x=7.78 n=97	9.43-9.64 9.23-9.84 x=9.536 n=106	12.78-13.05* 12.54-13.30* x=12.91 n=171
10: UI2	51% 95% x n	NA	NA	5.00-5.67 4.67-5.67 x=5.329 n=3	6.27-6.64 6.00-6.91 x=6.461 n=11	7.54-7.82 7.29-8.11 x=7.689 n=28	8.31-8.46 8.18-8.59 x=8.386 n=120	10.35-10.59 10.14-10.79 x=10.47 n=127	13.87-14.16* 13.57-14.41* x=14.01 n=184
11: UC	51% 95% x n	NA	NA	5.60-6.00 5.60-6.20 x=5.798 n=5	6.93-7.10 6.75-7.29 x=7.013 n=69	8.16-8.30 8.03-8.44 x=8.231 n=99	9.65-9.77 9.53-9.88 x=9.703 n=242	12.49-12.77 12.25-12.99 x=12.62 n=137	15.73-15.98 15.46-16.22 x=15.84 n=129
12: UP1	51% 95% x n	NA	NA	5.71-6.29 5.14-6.71 x=5.983 n=7	6.96-7.22 6.65-7.48 x=7.084 n=23	8.44-8.70 8.17-8.96 x=8.574 n=46	9.68-9.87 9.47-10.03 x=9.776 n=114	11.27-11.54 10.97-11.80 x=11.40 n=92	15.41-15.79 15.13-16.08 x=15.60 n=96
13: UP2	51% 95% x n	NA	NA	6.65-6.95 6.40-7.25 x=6.792 n=20	8.16-8.35 7.97-8.52 x=8.253 n=75	9.22-9.43 8.98-9.63 x=9.314 n=88	10.13-10.32 9.96-10.48 x=10.22 n=123	12.67-12.93 12.36-13.20 x=12.78 n=105	16.25-16.56 15.97-16.82 x=16.40 n=106
14: UM1	51% 95% x n	NA	NA	NA	NA	5.80-6.60 5.20-7.20 x=6.207 n=5	6.96-7.41 6.50-7.77 x=7.161 n=22	8.35-8.53 8.17-8.71 x=8.438 n=139	13.09-13.30* 12.89-13.49* x=13.19 n=243
15: UM2	51% 95% x n	NA	6.25-6.60 5.95-6.85 x=6.396 n=20	7.47-7.68 7.27-7.83 x=7.576 n=90	8.57-8.70 8.42-8.83 x=8.631 n=141	9.48-9.67 9.31-9.86 x=9.585 n=91	10.70-10.91 10.51-11.11 x=10.81 n=82	12.78-13.01 12.57-13.21 x=12.89 n=139	16.82-17.08 16.57-17.31 x=16.94 n=101

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	9.16-9.37 8.96-9.56 x=9.266 n=93	10.58-10.81 10.37-11.04 x=10.68 n=135	12.01-12.28 11.78-12.47 x=12.15 n=88	13.84-14.11 13.56-14.39 x=13.99 n=62	15.05-15.41 14.70-15.70 x=15.24 n=44	15.42-15.81 15.04-16.15 x=15.62 n=26	17.49-17.84 17.14-18.24 x=17.67 n=37	19.00-19.27 18.73-19.47 x=19.13 n=15
17: LM3	51% 95% x n	9.10-9.28 8.93-9.45 x=9.195 n=139	11.25-11.48 11.03-11.66 x=11.35 n=147	12.67-12.96 12.40-13.24 x=12.81 n=76	14.09-14.56 13.65-15.03 x=14.36 n=34	15.04-15.38 14.73-15.69 x=15.20 n=48	15.72-16.14 15.34-16.48 x=15.94 n=29	17.82-18.14 17.51-18.49 x=17.98 n=49	18.82-19.18 18.75-19.75 x=19.02 n=11
18: LM2	51% 95% x n	NA	6.17-6.50 5.86-6.75 x=6.329 n=24	7.71-7.88 7.53-8.03 x=7.805 n=103	8.37-8.54 8.19-8.73 x=8.453 n=79	9.33-9.47 9.20-9.62 x=9.407 n=156	10.74-10.91 10.58-11.09 x=10.82 n=116	13.30-13.52 13.10-13.73 x=13.40 n=173	16.73-16.98 16.49-17.21 x=16.86 n=123
19: LM1	51% 95% x n	NA	NA	NA	NA	5.33-6.00 5.33-6.33 x=5.662 n=3	6.63-6.90 6.42-7.11 x=6.755 n=38	8.63-8.75 8.52-8.86 x=8.689 n=295	12.63-12.80* 12.47-12.94* x=12.72 n=382
20: LP2	51% 95% x n	NA	5.75-6.75 4.75-7.50 x=6.239 n=4	7.09-7.33 6.86-7.53 x=7.214 n=57	8.06-8.21 7.90-8.36 x=8.129 n=118	8.94-9.14 8.75-9.32 x=9.042 n=101	10.40-10.55 10.25-10.69 x=10.47 n=209	12.86-13.12 12.58-13.35 x=12.98 n=104	16.11-16.32 15.86-16.58 x=16.22 n=160
21: LP1	51% 95% x n	NA	NA	5.67-5.93 5.33-6.27 x=5.803 n=15	7.56-7.70 7.41-7.86 x=7.627 n=97	8.41-8.59 8.21-8.75 x=8.496 n=101	9.74-9.87 9.60-10.00 x=9.808 n=211	11.61-11.79 11.41-11.99 x=11.70 n=117	14.87-15.08* 14.70-15.30* x=14.98 n=166
22: LC	51% 95% x n	NA	NA	5.67-6.00 5.33-6.33 x=5.829 n=6	6.79-7.02 6.54-7.26 x=6.904 n=43	7.79-7.94 7.65-8.08 x=7.868 n=85	9.43-9.55 9.31-9.66 x=9.489 n=271	12.15-12.41 11.93-12.63 x=12.28 n=145	15.39-15.66 15.13-15.91 x=15.53 n=152
23: LI2	51% 95% x n	NA	NA	NA	NA n=2	5.88-6.38 5.50-6.75 x=6.138 n=8	7.60-7.76 7.41-7.90 x=7.674 n=92	9.33-9.55 9.10-9.72 x=9.429 n=116	12.27-12.49* 12.08-12.68* x=12.37 n=255

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	5.00-6.33 4.33-6.33 x=5.669 n=3	6.71-7.00 6.43-7.29 x=6.846 n=21	8.08-8.27 7.91-8.44 x=8.164 n=108	11.68-11.88* 11.49-12.08* x=11.78 n=251

Table A3.4: Confidence intervals from African American subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA	NA	NA n=2	7.20-7.60 6.80-8.20 x=7.392 n=5	9.11-9.67 8.44-10.11 x=9.343 n=9	12.94-13.76* 12.24-14.59* x=13.37 n=17
10: UI2	51% 95% x n	NA	NA	NA	NA n=2	6.00-7.00 6.00-7.00 x=6.474 n=2	8.25-8.75 7.75-9.38 x=8.52 n=8	8.70-9.30 8.10-9.80 x=8.993 n=10	15.05-15.75* 14.40-16.45* x=15.40 n=20
11: UC	51% 95% x n	NA	NA	NA	6.40-6.80 5.80-7.20 x=6.591 n=5	8.50-9.00 8.00-9.50 x=8.764 n=4	8.83-9.44 8.22-9.94 x=9.182 n=18	11.92-12.42 11.50-12.83 x=12.18 n=12	15.75-16.46 15.13-17.12 x=16.11 n=24
12: UP1	51% 95% x n	NA	NA	NA	6.00-7.00 5.50-7.00 x=6.494 n=4	7.50-8.00 7.50-8.25 x=7.754 n=4	9.33-9.78 8.89-10.22 x=9.552 n=9	11.80-12.60 11.00-13.60 x=12.22 n=5	15.82-16.91 15.00-17.91 x=16.37 n=11
13: UP2	51% 95% x n	NA	NA	NA n=1	7.00-7.57 6.71-8.00 x=7.294 n=7	8.89-9.44 8.44-10.00 x=9.223 n=9	9.75-10.25 9.25-10.88 x=9.982 n=8	13.00-13.25 12.75-13.50 x=13.11 n=8	16.31-17.19 15.56-17.94 x=16.74 n=16
14: UM1	51% 95% x n	NA	NA	NA	NA	NA	NA n=1	7.82-8.18 7.36-8.73 x=7.983 n=11	13.38-13.92* 12.93-14.41* x=13.64 n=29
15: UM2	51% 95% x n	NA	NA n=1	6.40-6.80 5.80-7.20 x=6.59 n=5	8.39-8.69 8.08-9.00 x=8.539 n=13	9.40-10.20 8.80-10.80 x=9.786 n=5	11.33-11.78 10.89-12.22 x=11.56 n=9	13.15-13.62 12.85-13.92 x=13.40 n=13	16.85-17.62 16.08-18.31 x=17.24 n=13

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	8.11-8.56 7.67-9.00 x=8.343 n=9	9.78-10.44 9.22-10.89 x=10.11 n=9	12.07-12.47 11.60-12.93 x=12.25 n=15	12.29-13.57 11.43-14.85 x=12.99 n=7	14.80-15.40 14.20-15.80 x=14.99 n=5	14.00-15.33 13.33-15.33 x=14.68 n=3	17.25-17.92 16.58-18.67 x=17.58 n=12	 NA n=1
17: LM3	51% 95% x n	8.29-8.57 8.00-8.93 x=8.436 n=14	10.77-11.38 10.23-12.00 x=11.07 n=13	11.58-12.25 10.92-12.92 x=11.90 n=12	12.00-15.00 12.00-15.00 x=13.54 n=2	14.78-15.67 14.11-16.22 x=15.23 n=9	14.33-14.67 13.67-14.67 x=14.34 n=3	17.09-17.64 16.45-18.27 x=17.36 n=11	19.00-19.50 19.00-20.00 x=19.47 n=2
18: LM2	51% 95% x n	NA	NA n=1	6.50-7.50 6.00-8.00 x=7.014 n=4	8.08-8.54 7.69-8.92 x=8.318 n=13	9.55-10.27 8.91-10.82 x=9.906 n=11	10.60-11.40 10.00-11.80 x=11.01 n=5	12.96-13.47 12.42-13.89 x=13.23 n=19	15.92-16.70 15.29-17.42 x=16.29 n=24
19: LM1	51% 95% x n	NA	NA	NA	NA	NA	NA n=1	8.25-8.63 7.96-9.00 x=8.463 n=24	12.78-13.22* 12.41-13.68* x=12.99 n=41
20: LP2	51% 95% x n	NA	NA	NA n=2	7.18-7.73 6.73-8.18 x=7.445 n=11	8.40-9.20 7.80-9.80 x=8.805 n=5	9.64-10.07 9.29-10.50 x=9.854 n=14	12.61-12.94 12.33-13.22 x=12.79 n=18	15.64-16.36 15.00-17.00 x=15.98 n=25
21: LP1	51% 95% x n	NA	NA	NA n=1	6.40-7.20 6.00-7.60 x=6.813 n=5	7.71-8.29 7.14-9.00 x=7.983 n=7	9.47-9.95 9.05-10.32 x=9.676 n=19	12.09-12.64 11.73-13.09 x=12.36 n=11	14.52-15.13* 13.96-15.70* x=14.84 n=23
22: LC	51% 95% x n	NA	NA	NA n=1	NA n=1	7.50-8.50 6.50-9.50 x=7.968 n=4	9.00-9.50 8.55-9.95 x=9.236 n=20	11.82-12.55 11.09-13.18 x=12.18 n=11	15.12-15.83 14.58-16.62 x=15.48 n=24
23: LI2	51% 95% x n	NA	NA	NA	NA	NA	6.50-8.00 5.50-8.50 x=7.257 n=4	8.36-8.91 7.82-9.46 x=8.65 n=11	12.18-12.93* 11.57-13.57* x=12.58 n=28

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	NA	NA n=2	7.89-8.56 7.22-9.22 x=8.207 n=9	11.50-12.15* 10.85-12.77* x=11.80 n=26

Table A3.5: Confidence intervals from Asian American subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA	NA n=1	6.00-6.50 5.50-7.25 x=6.241 n=4	7.25-7.75 6.75-8.13 x=7.475 n=8	8.64-9.18 8.09-9.64 x=8.901 n=11	13.29-13.93* 12.79-14.57* x=13.65 n=14
10: UI2	51% 95% x n	NA	NA	NA	NA n=3	6.50-7.00 6.50-7.25 x=6.748 n=4	8.00-8.62 7.39-9.08 x=8.281 n=13	9.00-10.14 8.00-10.71 x=9.584 n=7	14.44-15.24* 13.76-15.95* x=14.85 n=21
11: UC	51% 95% x n	NA	NA	NA n=1	6.29-6.86 6.00-7.29 x=6.552 n=7	7.70-8.40 7.00-8.90 x=8.012 n=10	9.07-9.36 8.79-9.64 x=9.224 n=14	12.30-13.30 11.30-14.10 x=12.79 n=10	16.05-16.81 15.43-17.52 x=16.47 n=21
12: UP1	51% 95% x n	NA	NA	NA	6.25-6.75 6.00-7.00 x=6.497 n=4	7.83-8.83 6.83-9.33 x=8.332 n=6	8.60-9.00 8.20-9.40 x=8.794 n=5	11.33-12.00 10.50-12.67 x=11.67 n=6	15.94-16.88 15.25-17.62 x=16.44 n=16
13: UP2	51% 95% x n	NA	NA	NA n=1	7.70-8.40 6.90-8.90 x=7.969 n=10	8.00-8.57 7.57-9.00 x=8.304 n=7	9.00-9.67 8.50-10.17 x=9.349 n=6	12.25-13.00 11.50-13.62 x=12.64 n=8	16.35-17.05 15.75-17.65 x=16.70 n=20
14: UM1	51% 95% x n	NA	NA	NA	NA n=1	NA	6.00-6.67 5.67-6.67 x=6.327 n=3	7.78-8.67 6.89-9.33 x=8.243 n=9	13.62-14.29* 13.00-15.00* x=13.96 n=21
15: UM2	51% 95% x n	NA n=1	NA	6.50-6.83 6.33-7.00 x=6.655 n=6	8.00-8.35 7.75-8.65 x=8.198 n=20	9.50-10.50 8.75-11.00 x=9.99 n=4	11.75-13.67 10.33-15.33 x=12.73 n=3	13.14-13.86 12.50-14.43 x=13.48 n=14	17.09-18.00 16.27-18.91 x=17.54 n=11

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	8.57-9.43 7.71-10.00 x=9.005 n=7	11.70-12.70 10.40-13.60 x=12.18 n=10	12.50-13.17 11.67-13.83 x=12.83 n=6	14.00-14.60 13.20-15.00 x=14.20 n=5	NA n=1	15.00-17.00 15.00-17.00 x=16.05 n=2	17.50-18.50 17.00-19.25 x=18.00 n=4	NA n=1
17: LM3	51% 95% x n	8.67-9.11 8.44-9.33 x=8.902 n=9	12.50-13.58 11.50-14.42 x=13.07 n=12	12.88-14.00 11.62-14.88 x=13.39 n=8	14.00-16.00 14.00-16.00 x=14.98 n=2	15.00-16.33 14.33-16.33 x=15.40 n=3	15.25-16.25 14.25-17.00 x=15.71 n=4	18.50-19.00 18.12-19.50 x=18.74 n=8	NA n=1
18: LM2	51% 95% x n	NA	NA n=2	6.57-7.14 6.00-7.71 x=6.851 n=7	7.85-8.31 7.54-8.62 x=8.08 n=13	9.00-9.50 8.38-10.00 x=9.235 n=8	10.71-11.00 10.29-11.29 x=10.86 n=7	13.71-14.43 13.07-15.14 x=14.06 n=14	16.94-17.59 16.41-18.24 x=17.29 n=17
19: LM1	51% 95% x n	NA	NA	NA	NA	NA n=2	NA n=2	7.96-8.32 7.59-8.64 x=8.129 n=22	12.66-13.28* 12.09-13.88* x=12.96 n=32
20: LP2	51% 95% x n	NA	NA	6.67-7.50 5.67-8.17 x=7.004 n=6	7.67-8.25 7.00-8.75 x=7.912 n=12	8.13-8.63 7.75-9.25 x=8.40 n=8	9.75-10.25 9.38-10.75 x=10.00 n=8	12.50-13.50 11.60-14.20 x=12.97 n=10	16.71-17.38 16.14-17.95 x=17.03 n=21
21: LP1	51% 95% x n	NA	NA	NA n=1	6.57-7.43 6.00-8.00 x=7.011 n=7	7.93-8.47 7.34-8.87 x=8.202 n=15	9.00-9.40 8.60-9.80 x=9.201 n=10	11.00-12.60 10.20-12.60 x=11.78 n=5	14.94-15.59* 14.35-16.12* x=15.24 n=17
22: LC	51% 95% x n	NA	NA	NA	5.00-5.50 5.00-6.00 x=5.489 n=2	6.83-7.50 6.33-7.83 x=7.173 n=6	8.52-8.91 8.14-9.24 x=8.717 n=21	12.11-12.78 11.44-13.44 x=12.42 n=9	16.15-16.85 15.55-17.50 x=16.50 n=20
23: LI2	51% 95% x n	NA	NA	NA	NA	5.33-6.00 5.33-6.33 x=5.659 n=3	6.63-6.88 6.50-7.13 x=6.745 n=8	8.50-8.90 8.10-9.20 x=8.723 n=10	12.60-13.32* 11.84-14.04* x=12.98 n=25

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	5.00-6.00 5.00-7.00 x=5.996 n=2	6.12-6.50 6.00-7.00 x=6.504 n=2	7.79-8.57 6.93-9.14 x=8.152 n=14	11.90-12.70* 11.15-13.40* x=12.29 n=20

Table A3.6: Confidence intervals from European American subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	5.00-5.50 5.00-6.00 x=5.502 n=2	5.89-6.22 5.56-6.44 x=5.992 n=9	6.50-6.83 6.22-7.11 x=6.666 n=18	7.83-7.97 7.70-8.09 x=7.899 n=110	9.37-9.56 9.17-9.77 x=9.475 n=112	13.03-13.25* 12.81-13.47* x=13.14 n=161
10: UI2	51% 95% x n	NA	NA	NA n=3	6.11-6.33 5.78-6.67 x=6.227 n=9	7.41-7.62 7.19-7.87 x=7.505 n=37	8.31-8.43 8.17-8.55 x=8.368 n=128	10.36-10.62 10.14-10.83 x=10.48 n=115	14.42-14.69* 14.17-14.96* x=14.56 n=193
11: UC	51% 95% x n	NA	NA	5.67-6.00 5.67-6.17 x=5.833 n=6	6.88-7.07 6.72-7.22 x=6.968 n=68	7.93-8.07 7.81-8.18 x=8.001 n=105	9.52-9.64 9.40-9.77 x=9.576 n=206	12.19-12.43 11.97-12.65 x=12.30 n=172	16.14-16.41 15.88-16.67 x=16.27 n=145
12: UP1	51% 95% x n	NA	NA	5.75-6.08 5.42-6.33 x=5.918 n=12	7.64-7.88 7.39-8.09 x=7.754 n=33	8.65-8.93 8.40-9.20 x=8.80 n=40	9.94-10.11 9.77-10.27 x=10.02 n=96	11.49-11.79 11.20-12.06 x=11.63 n=80	16.30-16.66 16.02-17.02 x=16.48 n=94
13: UP2	51% 95% x n	NA	5.50-5.50 5.00-6.00 x=5.502 n=2	7.04-7.23 6.85-7.46 x=7.155 n=26	8.13-8.30 7.98-8.45 x=8.214 n=97	9.70-9.93 9.50-10.13 x=9.817 n=74	10.41-10.58 10.23-10.76 x=10.48 n=108	13.10-13.38 12.87-13.61 x=13.23 n=115	16.89-17.18 16.65-17.47 x=17.05 n=116
14: UM1	51% 95% x n	NA	NA	NA	NA n=1	5.85-6.33 5.42-6.67 x=6.10 n=12	6.86-7.27 6.41-7.64 x=7.026 n=22	8.16-8.31 8.01-8.47 x=8.239 n=138	13.15-13.34* 12.93-13.54* x=13.24 n=235
15: UM2	51% 95% x n	5.37-8.00 5.00-8.00 x=6.504 n=2	6.21-6.54 5.88-6.79 x=6.368 n=24	7.52-7.66 7.36-7.80 x=7.587 n=95	8.41-8.56 8.29-8.69 x=8.494 n=140	9.87-10.04 9.69-10.20 x=9.954 n=91	10.90-11.10 10.74-11.27 x=11.00 n=102	13.31-13.58 13.07-13.80 x=13.45 n=124	17.20-17.46 16.98-17.70 x=17.33 n=125

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	9.31-9.57 9.10-9.79 x=9.434 n=70	10.83-11.04 10.60-11.26 x=10.92 n=139	11.94-12.20 11.70-12.43 x=12.06 n=79	14.35-14.71 13.98-15.00 x=14.53 n=62	14.91-15.39 14.51-15.76 x=15.17 n=41	16.17-16.61 15.78-16.97 x=16.40 n=36	18.14-18.41 17.90-18.71 x=18.28 n=51	19.00-19.24 18.76-19.41 x=19.11 n=17
17: LM3	51% 95% x n	9.22-9.40 9.06-9.61 x=9.318 n=109	11.11-11.31 10.94-11.50 x=11.21 n=139	12.68-13.00 12.43-13.25 x=12.84 n=72	15.00-15.50 14.50-15.89 x=15.23 n=38	15.68-16.06 15.34-16.38 x=15.87 n=53	16.17-16.62 15.81-16.95 x=16.39 n=42	18.53-18.76 18.31-19.02 x=18.66 n=49	18.87-19.13 18.60-19.40 x=19.01 n=15
18: LM2	51% 95% x n	NA n=1	6.31-6.62 6.07-6.90 x=6.487 n=29	7.60-7.74 7.47-7.87 x=7.664 n=111	8.25-8.45 8.07-8.61 x=8.351 n=83	9.56-9.70 9.43-9.83 x=9.63 n=154	10.79-10.96 10.63-11.12 x=10.87 n=104	13.52-13.74 13.32-13.91 x=13.62 n=185	17.38-17.57 17.19-17.75 x=17.48 n=151
19: LM1	51% 95% x n	NA	NA	NA	NA n=1	5.50-5.83 5.00-6.17 x=5.672 n=6	6.59-6.83 6.39-7.02 x=6.709 n=41	8.60-8.72 8.50-8.82 x=8.66 n=290	12.66-12.83* 12.49-12.99* x=12.74 n=386
20: LP2	51% 95% x n	NA n=1	6.14-6.71 5.57-7.29 x=6.425 n=7	7.20-7.38 7.04-7.56 x=7.293 n=82	8.14-8.28 7.99-8.42 x=8.206 n=122	9.09-9.30 8.89-9.51 x=9.201 n=80	10.63-10.78 10.48-10.93 x=10.70 n=204	13.21-13.50 12.93-13.76 x=13.36 n=107	16.67-16.90 16.45-17.09 x=16.77 n=185
21: LP1	51% 95% x n	NA	NA	5.60-5.93 5.27-6.13 x=5.734 n=15	7.51-7.63 7.40-7.75 x=7.568 n=127	8.37-8.53 8.23-8.70 x=8.466 n=89	9.82-9.94 9.71-10.07 x=9.882 n=189	11.73-11.93 11.56-12.32 x=11.82 n=122	15.01-15.21* 14.82-15.39* x=15.12 n=185
22: LC	51% 95% x n	NA	NA	5.50-5.75 5.13-6.13 x=5.627 n=8	6.75-6.96 6.56-7.15 x=6.857 n=48	7.74-7.91 7.61-8.05 x=7.821 n=85	9.24-9.35 9.10-9.47 x=9.297 n=235	11.88-12.11 11.66-12.32 x=11.99 n=154	15.70-15.96 15.47-16.20 x=15.84 n=203
23: LI2	51% 95% x n	NA	NA	NA	5.25-5.75 5.00-6.00 x=5.511 n=4	5.80-6.20 5.40-6.50 x=5.999 n=10	7.51-7.69 7.33-7.80 x=7.59 n=86	9.18-9.37 9.00-9.55 x=9.28 n=121	12.78-13.00* 12.56-13.19* x=12.88 n=233

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	5.00-6.00 5.00-6.00 x=5.498 n=2	5.50-6.00 4.50-6.00 x=5.496 n=4	6.70-7.04 6.39-7.30 x=6.861 n=23	8.07-8.27 7.87-8.46 x=8.173 n=95	12.08-12.28* 11.87-12.47* x=12.18 n=224

Table A3.7: Confidence intervals from Hispanic subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA n=2	5.67-7.00 5.67-7.67 x=6.32 n=3	7.00-7.40 6.80-7.60 x=7.202 n=10	7.38-7.57 7.22-7.73 x=7.474 n=74	8.63-8.89 8.39-9.10 x=8.76 n=82	11.91-12.17* 11.66-12.43* x=12.05 n=160
10: UI2	51% 95% x n	NA	NA	5.00-6.00 4.50-6.00 x=5.488 n=4	6.56-7.00 6.22-7.33 x=6.778 n=9	7.10-7.38 6.76-7.71 x=7.232 n=21	7.72-7.87 7.60-8.00 x=7.792 n=98	9.61-9.85 9.37-10.05 x=9.719 n=103	12.78-13.06* 12.50-13.33* x=12.91 n=159
11: UC	51% 95% x n	NA	NA	NA n=2	6.59-6.80 6.43-6.96 x=6.694 n=49	7.61-7.80 7.45-7.95 x=7.715 n=56	9.10-9.23 8.96-9.36 x=9.164 n=243	11.56-11.83 11.30-12.05 x=11.70 n=128	14.79-15.15 14.48-15.48 x=14.98 n=82
12: UP1	51% 95% x n	NA	NA	5.33-6.00 5.00-6.33 x=5.662 n=6	6.64-6.93 6.50-7.21 x=6.793 n=14	7.97-8.24 7.70-8.51 x=8.109 n=37	8.95-9.18 8.74-9.39 x=9.076 n=101	10.69-10.96 10.46-11.17 x=10.83 n=112	14.28-14.66 13.94-15.00 x=14.48 n=71
13: UP2	51% 95% x n	NA	NA	6.56-6.94 6.25-7.25 x=6.75 n=16	7.52-7.73 7.32-7.91 x=7.619 n=56	8.42-8.68 8.20-8.88 x=8.552 n=76	9.78-9.96 9.60-10.13 x=9.868 n=133	12.06-12.32 11.82-12.60 x=12.19 n=109	15.00-15.35 14.63-15.74 x=15.18 n=65
14: UM1	51% 95% x n	NA	NA	NA	NA	5.40-6.20 5.00-6.60 x=5.788 n=5	6.86-7.43 6.29-8.00 x=7.12 n=7	7.97-8.17 7.80-8.33 x=8.072 n=127	12.22-12.43* 12.00-12.64* x=12.33 n=220
15: UM2	51% 95% x n	NA	5.83-6.25 5.50-6.67 x=6.099 n=12	7.17-7.40 6.92-7.59 x=7.286 n=76	8.23-8.41 8.07-8.57 x=8.311 n=108	8.93-9.11 8.74-9.26 x=9.008 n=93	10.09-10.34 9.84-10.56 x=10.21 n=70	11.97-12.20 11.73-12.43 x=12.09 n=128	15.68-16.09 15.26-16.43 x=15.87 n=47

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	8.93-9.18 8.69-9.39 x=9.051 n=71	10.18-10.37 9.98-10.56 x=10.27 n=122	11.75-12.00 11.52-12.23 x=11.87 n=87	13.53-13.95 13.12-14.40 x=13.73 n=43	14.59-15.07 14.14-15.45 x=14.81 n=29	15.32-15.92 14.80-16.44 x=15.64 n=25	16.62-17.19 16.12-17.75 x=16.94 n=16	18.00-19.00 18.00-19.00 x=18.50 n=2
17: LM3	51% 95% x n	9.03-9.25 8.82-9.43 x=9.144 n=130	10.75-10.99 10.54-11.19 x=10.87 n=134	12.24-12.56 11.94-12.85 x=12.41 n=62	13.89-14.41 13.48-14.89 x=14.15 n=27	14.74-15.17 14.37-15.57 x=14.96 n=35	15.11-15.67 14.56-16.11 x=15.37 n=18	17.25-17.71 16.79-18.17 x=17.44 n=24	NA n=1
18: LM2	51% 95% x n	NA n=1	6.00-6.30 5.75-6.55 x=6.158 n=20	7.29-7.54 7.03-7.73 x=7.405 n=69	8.06-8.26 7.87-8.44 x=8.171 n=69	8.82-8.98 8.68-9.13 x=8.904 n=135	10.17-10.36 10.04-10.53 x=10.27 n=110	12.73-12.97 12.53-13.18 x=12.84 n=164	15.75-16.14 15.45-16.48 x=15.97 n=65
19: LM1	51% 95% x n	NA	NA	NA	NA	5.50-6.00 5.00-6.50 x=5.741 n=4	6.56-6.89 6.17-7.28 x=6.748 n=18	8.23-8.34 8.13-8.46 x=8.289 n=249	11.89-12.08* 11.72-12.25* x=12.00 n=341
20: LP2	51% 95% x n	NA	NA n=3	6.59-6.89 6.33-7.15 x=6.74 n=27	7.53-7.70 7.38-7.84 x=7.621 n=90	8.42-8.61 8.22-8.79 x=8.512 n=92	9.87-10.02 9.73-10.16 x=9.953 n=212	12.04-12.33 11.81-12.60 x=12.17 n=89	15.10-15.41 14.81-15.69 x=15.25 n=109
21: LP1	51% 95% x n	NA	NA	5.33-5.78 5.00-6.11 x=5.542 n=9	7.08-7.28 6.90-7.44 x=7.176 n=61	7.80-8.03 7.58-8.20 x=7.902 n=74	9.13-9.27 9.00-9.40 x=9.206 n=202	10.92-11.12 10.75-11.28 x=11.02 n=128	14.24-14.50* 14.02-14.71* x=14.39 n=131
22: LC	51% 95% x n	NA	NA	5.00-6.33 4.33-6.33 x=5.643 n=3	6.53-6.81 6.28-7.00 x=6.653 n=32	7.27-7.49 7.09-7.64 x=7.377 n=45	8.86-8.99 8.73-9.11 x=8.924 n=255	11.02-11.28 10.76-11.28 x=11.15 n=122	14.19-14.51 13.88-14.84 x=14.34 n=107
23: LI2	51% 95% x n	NA	NA	NA	NA n=2	6.14-6.43 5.86-6.86 x=6.301 n=7	7.25-7.43 7.07-7.59 x=7.337 n=68	8.58-8.86 8.29-9.06 x=8.72 n=87	11.33-11.53* 11.15-11.70* x=11.42 n=249

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	NA n=2	6.67-6.86 6.43-7.10 x=6.769 n=21	7.55-7.70 7.39-7.85 x=7.625 n=93	10.88-11.08* 10.68-11.28* x=10.99 n=242

Table A3.8: Confidence intervals from Native American subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA	NA	NA	8.00-9.33 7.33-9.33 x=8.641 n=3	9.00-10.00 8.50-10.00 x=9.509 n=4	13.50-14.30* 12.70-15.10* x=13.89 n=10
10: UI2	51% 95% x n	NA	NA	NA	NA	NA	8.67-9.33 8.00-10.00 x=9.003 n=3	10.43-10.93 9.79-11.36 x=10.63 n=14	13.31-13.92* 12.69-14.46* x=13.62 n=13
11: UC	51% 95% x n	NA	NA	NA	NA	NA n=2	9.73-10.13 9.33-10.47 x=9.946 n=15	12.08-12.62 11.46-13.08 x=12.30 n=13	15.50-16.17 14.83-16.67 x=15.83 n=12
12: UP1	51% 95% x n	NA	NA	NA	NA n=1	NA	9.55-9.91 9.27-10.18 x=9.731 n=11	11.50-12.30 10.60-13.00 x=11.90 n=10	14.80-15.60 14.20-16.30 x=15.19 n=10
13: UP2	51% 95% x n	NA	NA	NA	8.00-8.50 8.00-9.00 x=8.49 n=2	9.25-9.75 8.88-10.12 x=9.489 n=8	10.33-10.86 9.67-11.33 x=10.53 n=9	12.82-13.55 12.18-14.18 x=13.17 n=11	15.27-16.00 14.45-16.64 x=15.64 n=11
14: UM1	51% 95% x n	NA	NA	NA	NA	NA	NA	8.67-9.33 8.00-10.00 x=9.007 n=3	12.67-13.33* 12.00-14.00* x=13.00 n=18
15: UM2	51% 95% x n	NA	NA	NA	8.67-9.17 8.33-9.67 x=8.992 n=6	9.67-10.00 9.33-10.33 x=9.836 n=6	10.86-11.43 10.43-12.00 x=11.16 n=7	13.12-13.94 12.38-14.56 x=13.58 n=16	15.38-16.38 14.38-17.25 x=15.88 n=8

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	9.20-9.60 9.00-9.80 x=9.411 n=5	10.91-11.45 10.45-12.00 x=11.18 n=11	12.36-12.91 11.82-13.45 x=12.64 n=11	14.62-15.25 14.00-16.12 x=15.01 n=8	16.33-17.58 14.33-18.33 x=16.67 n=3	15.00-16.00 14.50-16.50 x=15.53 n=4	15.50-17.50 14.00-19.00 x=16.56 n=4	NA n=1
17: LM3	51% 95% x n	9.60-10.00 9.20-10.40 x=9.811 n=5	11.33-11.89 10.89-12.33 x=11.62 n=18	14.00-14.75 13.50-15.38 x=14.38 n=8	13.80-15.40 12.40-16.40 x=14.56 n=5	16.38-17.00 15.75-17.50 x=16.61 n=8	14.50-15.00 14.00-15.00 x=14.47 n=2	16.80-18.00 15.80-19.00 x=17.38 n=5	NA
18: LM2	51% 95% x n	NA	NA	8.00-9.00 8.00-9.00 x=8.508 n=2	9.00-9.50 8.50-10.00 x=9.27 n=4	9.56-10.00 9.22-10.33 x=9.776 n=9	11.11-11.56 10.56-12.00 x=11.34 n=9	14.23-14.90 13.55-15.41 x=14.54 n=22	15.54-16.31 14.85-16.92 x=15.91 n=13
19: LM1	51% 95% x n	NA	NA	NA	NA	NA	NA	9.39-9.85 8.92-10.23 x=9.613 n=13	13.20-13.70* 12.72-14.10* x=13.44 n=40
20: LP2	51% 95% x n	NA	NA	NA	8.50-9.00 8.00-9.00 x=8.47 n=2	9.43-10.00 9.00-10.57 x=9.734 n=7	10.25-10.75 9.83-11.17 x=10.48 n=12	13.35-14.00 12.70-14.50 x=13.66 n=20	15.82-16.55 15.18-17.09 x=16.22 n=11
21: LP1	51% 95% x n	NA	NA	NA	NA n=1	8.50-8.50 8.00-9.00 x=8.504 n=2	10.20-10.73 9.73-11.20 x=10.48 n=15	12.08-12.83 11.33-13.42 x=12.41 n=12	15.07-15.60* 14.60-16.07* x=15.32 n=15
22: LC	51% 95% x n	NA	NA	NA	NA n=1	NA n=1	9.57-9.86 9.21-10.21 x=9.707 n=14	13.27-14.13 12.53-14.93 x=13.75 n=15	14.60-15.53 13.73-16.33 x=15.09 n=15
23: LI2	51% 95% x n	NA	NA	NA	NA	NA	NA n=2	9.44-9.67 9.00-9.89 x=9.553 n=9	12.72-13.44* 12.00-14.11* x=13.08 n=18

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	NA	NA	8.80-9.60 8.20-10.20 x=9.221 n=5	12.00-12.83* 11.25-13.50* x=12.42 n=12

Table A3.9: Confidence intervals from African American female subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA	NA	NA n=2	6.67-8.00 6.67-8.67 x=7.373 n=3	9.17-10.00 8.17-10.50 x=9.466 n=6	12.00-14.50* 10.50-16.50* x=12.97 n=4
10: UI2	51% 95% x n	NA	NA	NA	NA n=1	NA n=1	7.00-8.33 6.33-9.33 x=7.703 n=3	8.00-8.50 7.33-8.83 x=8.15 n=6	16.27-17.27* 15.36-18.27* x=16.81 n=11
11: UC	51% 95% x n	NA	NA	NA	6.00-7.33 5.33-7.33 x=6.667 n=3	NA n=1	8.36-9.18 7.55-9.82 x=8.80 n=11	12.33-13.00 12.33-13.33 x=12.66 n=3	16.62-17.62 15.62-18.62 x=17.07 n=13
12: UP1	51% 95% x n	NA	NA	NA	6.00-7.33 5.33-7.33 x=6.667 n=3	NA n=2	8.67-10.00 8.67-10.67 x=9.343 n=3	13.00-14.00 13.00-14.00 x=13.51 n=2	17.80-18.60 17.20-19.60 x=18.21 n=5
13: UP2	51% 95% x n	NA	NA	NA n=1	6.50-7.50 6.00-8.00 x=7.01 n=4	8.25-9.25 7.50-10.00 x=8.761 n=4	8.50-8.50 8.00-9.00 x=8.488 n=2	12.75-13.25 12.25-13.75 x=13.03 n=4	17.30-18.20 16.60-19.10 x=17.77 n=10
14: UM1	51% 95% x n	NA	NA	NA	NA	NA	NA n=1	7.50-8.00 7.00-8.50 x=7.754 n=8	13.08-13.92* 12.25-14.83* x=13.49 n=12
15: UM2	51% 95% x n	NA	NA n=1	6.00-7.33 5.33-7.33 x=6.658 n=3	8.29-8.71 7.71-9.14 x=8.421 n=7	8.00-10.00 8.00-10.00 x=8.992 n=2	12.00-12.50 11.75-12.50 x=12.24 n=4	12.67-13.33 12.00-14.00 x=12.99 n=3	17.29-18.43 16.29-19.71 x=17.87 n=7

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	8.00-8.67 7.50-9.00 x=8.348 n=6	8.00-10.00 8.00-10.00 x=8.961 n=2	12.86-13.43 12.43-13.86 x=13.13 n=7	NA n=2	NA n=1	15.00-15.00 14.00-16.00 x=15.02 n=2	17.71-18.57 16.86-19.57 x=18.14 n=7	NA n=1
17: LM3	51% 95% x n	7.83-8.17 7.50-8.50 x=8.004 n=6	10.43-11.57 9.71-12.43 x=10.98 n=7	10.50-12.50 10.00-13.75 x=11.51 n=4	13.50-15.00 12.00-15.00 x=13.50 n=2	15.60-16.60 14.40-17.40 x=16.00 n=5	NA	17.80-18.60 17.20-19.40 x=18.19 n=5	19.00-19.50 19.00-20.00 x=19.49 n=2
18: LM2	51% 95% x n	NA	NA n=1	6.00-7.00 6.00-8.00 x=7.022 n=2	7.71-8.29 7.14-8.86 x=8.019 n=7	9.00-9.80 8.00-10.60 x=9.404 n=5	NA	12.57-12.86 12.14-13.28 x=12.71 n=7	16.12-17.12 15.19-18.31 x=16.63 n=16
19: LM1	51% 95% x n	NA	NA	NA	NA	NA	NA	7.58-8.08 7.17-8.58 x=7.806 n=12	12.44-13.22* 11.67-14.06* x=12.82 n=18
20: LP2	51% 95% x n	NA	NA	NA n=2	6.67-7.33 6.33-7.67 x=7.019 n=6	8.50-8.50 7.00-10.00 x=8.464 n=2	9.20-10.00 8.40-10.60 x=9.593 n=5	12.62-13.00 12.38-13.38 x=12.87 n=8	15.93-17.21 15.00-18.43 x=16.52 n=14
21: LP1	51% 95% x n	NA	NA	NA n=1	6.50-7.50 6.00-8.00 x=7.013 n=4	6.00-8.00 6.00-8.00 x=7.031 n=2	8.43-9.00 8.00-9.57 x=8.738 n=7	12.67-13.00 12.33-13.33 x=12.82 n=6	14.00-15.33* 12.89-16.78* x=14.67 n=9
22: LC	51% 95% x n	NA	NA	NA	NA n=1	6.00-8.00 6.00-8.00 x=6.993 n=2	8.00-8.67 7.56-9.22 x=8.334 n=9	10.50-12.50 10.00-13.74 x=11.48 n=4	15.25-16.58 14.00-17.92 x=15.95 n=12
23: LI2	51% 95% x n	NA	NA	NA	NA	NA	NA n=2	7.83-8.50 7.17-9.33 x=8.152 n=6	10.89-12.33* 9.67-13.56* x=11.67 n=9

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	NA	NA n=1	7.19-8.41 6.40-9.20 x=7.828 n=5	10.00-11.11* 9.00-12.00* x=10.52 n=9

Table A3.10: Confidence intervals from African American male subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA	NA	NA	7.50-7.50 7.00-8.00 x=7.522 n=2	8.67-9.33 8.00-10.00 x=8.989 n=3	13.00-13.85* 12.31-14.69* x=13.47 n=13
10: UI2	51% 95% x n	NA	NA	NA	NA n=1	NA n=1	8.80-9.35 8.21-9.80 x=8.984 n=5	10.00-10.50 9.50-11.00 x=10.25 n=4	13.90-14.60* 13.30-15.20* x=14.29 n=10
11: UC	51% 95% x n	NA	NA	NA	6.00-7.00 6.00-7.00 x=6.498 n=2	8.67-9.33 8.00-10.00 x=9.013 n=3	9.42-10.00 8.86-10.71 x=9.711 n=7	11.67-12.22 11.22-12.78 x=11.99 n=9	14.64-15.36 14.00-16.00 x=15.00 n=11
12: UP1	51% 95% x n	NA	NA	NA	NA n=1	7.00-7.50 7.00-8.00 x=7.496 n=2	9.33-10.00 8.83-10.50 x=9.654 n=6	10.67-12.00 9.67-12.67 x=11.34 n=3	14.33-15.33 13.33-16.33 x=14.81 n=6
13: UP2	51% 95% x n	NA	NA	NA	7.33-8.00 7.33-8.33 x=7.671 n=3	9.20-10.00 8.80-10.40 x=9.575 n=5	10.33-10.67 10.00-11.17 x=10.50 n=6	13.00-13.50 12.75-13.50 x=13.23 n=4	NA
14: UM1	51% 95% x n	NA	NA	NA	NA	NA	NA	8.33-9.00 8.33-9.33 x=8.664 n=3	13.41-14.12* 12.82-14.76* x=13.76 n=17
15: UM2	51% 95% x n	NA	NA	6.00-6.50 6.00-7.00 x=6.478 n=2	8.50-8.83 8.00-9.17 x=8.675 n=6	9.67-11.00 9.67-11.67 x=10.33 n=3	10.60-11.40 10.00-11.80 x=11.02 n=5	13.30-13.70 12.80-14.10 x=13.50 n=10	16.00-17.00 15.34-17.83 x=16.45 n=6

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	7.67-9.00 6.67-9.67 x=8.318 n=3	10.14-10.71 9.43-11.29 x=10.44 n=7	11.25-11.75 10.75-12.12 x=11.48 n=8	13.80-14.60 13.40-15.00 x=14.21 n=5	14.50-15.00 13.76-15.50 x=14.75 n=4	NA n=1	16.20-17.20 15.80-18.39 x=16.79 n=5	NA
17: LM3	51% 95% x n	8.50-9.00 8.13-9.50 x=8.76 n=8	10.83-11.50 10.33-12.33 x=11.18 n=6	11.75-12.50 11.00-13.12 x=12.11 n=8	NA	14.00-14.50 13.50-15.00 x=14.24 n=4	14.33-14.67 13.67-14.67 x=14.32 n=3	16.33-17.00 15.67-17.67 x=16.67 n=6	NA
18: LM2	51% 95% x n	NA	NA	6.00-7.00 6.00-8.00 x=7.051 n=2	8.33-9.00 7.83-9.50 x=8.66 n=6	10.00-10.67 9.00-11.33 x=10.31 n=6	10.60-11.40 10.00-11.80 x=11.02 n=5	13.08-13.83 12.33-14.50 x=13.49 n=12	15.25-16.00 14.50-16.75 x=15.60 n=8
19: LM1	51% 95% x n	NA	NA	NA	NA	NA	NA n=1	8.83-9.33 8.33-9.75 x=9.077 n=12	12.87-13.39* 12.35-13.91* x=13.12 n=23
20: LP2	51% 95% x n	NA	NA	NA	7.60-8.40 6.80-9.20 x=8.01 n=5	8.67-9.33 8.00-10.00 x=8.996 n=3	9.78-10.22 9.33-10.67 x=9.983 n=9	12.40-12.90 12.00-13.40 x=12.70 n=10	15.00-15.55 14.36-16.09 x=15.27 n=11
21: LP1	51% 95% x n	NA	NA	NA	NA n=1	8.00-8.80 7.40-9.20 x=8.391 n=5	10.00-10.50 9.58-11.00 x=10.26 n=12	11.40-12.20 10.60-13.00 x=11.78 n=5	14.64-15.21* 14.07-15.71* x=14.93 n=14
22: LC	51% 95% x n	NA	NA	NA n=1	NA	9.00-10.00 8.00-10.00 x=8.993 n=2	9.73-10.27 9.18-10.82 x=10.00 n=11	12.14-13.00 11.43-13.57 x=12.56 n=7	14.83-15.42 14.17-15.83 x=15.09 n=12
23: LI2	51% 95% x n	NA	NA	NA	NA	NA	8.50-10.00 7.00-10.00 x=8.52 n=2	8.80-9.60 8.20-10.20 x=9.172 n=5	12.63-13.42* 11.95-14.11* x=12.98 n=19

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	NA	NA n=1	8.16-9.34 7.50-10.00 x=8.743 n=4	12.07-12.82* 11.41-13.59* x=12.44 n=17

Table A3.11: Confidence intervals from Asian American female subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA	NA	5.67-7.00 5.67-7.67 x=6.331 n=3	8.00-9.00 6.00-9.00 x=7.964 n=3	9.00-9.50 8.75-9.50 x=9.254 n=4	12.62-13.50* 11.88-14.25* x=13.01 n=8
10: UI2	51% 95% x n	NA	NA	NA	5.00-6.00 5.00-7.00 x=5.996 n=2	NA n=2	8.20-9.00 7.80-9.60 x=8.585 n=5	11.50-14.00 9.00-14.00 x=11.56 n=2	13.90-15.10* 12.90-16.10* x=14.49 n=10
11: UC	51% 95% x n	NA	NA	NA	5.67-7.00 5.67-7.67 x=6.331 n=3	7.50-8.50 7.00-9.00 x=8.009 n=4	9.14-9.43 8.71-9.86 x=9.285 n=7	11.20-12.40 10.40-13.40 x=11.79 n=5	16.40-17.60 15.40-18.70 x=17.01 n=10
12: UP1	51% 95% x n	NA	NA	NA	NA n=2	7.50-8.00 7.00-8.00 x=7.512 n=2	9.50-9.50 9.00-10.00 x=9.50 n=2	11.00-12.25 9.75-12.75 x=11.48 n=4	16.00-17.67 14.67-19.33 x=16.75 n=6
13: UP2	51% 95% x n	NA	NA	NA	7.40-7.80 6.80-8.20 x=7.566 n=5	9.00-9.67 8.67-9.67 x=9.331 n=3	10.00-10.67 9.67-10.67 x=10.34 n=3	12.00-14.00 12.00-15.00 x=13.00 n=3	16.00-17.22 15.11-18.33 x=16.71 n=9
14: UM1	51% 95% x n	NA	NA	NA	NA n=1	NA	NA	8.00-9.33 7.33-10.33 x=8.687 n=3	12.40-13.40* 11.40-14.40* x=12.88 n=10
15: UM2	51% 95% x n	NA n=1	NA	NA n=3	8.43-9.00 8.14-9.43 x=8.719 n=7	9.00-9.67 8.67-9.67 x=9.341 n=3	11.50-11.50 10.00-13.00 x=11.49 n=2	12.33-13.33 11.67-14.00 x=12.82 n=6	17.33-18.50 16.50-19.67 x=17.95 n=6

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	NA n=1	10.60-11.80 9.80-12.20 x=11.17 n=5	12.50-12.50 12.00-13.00 x=12.51 n=2	NA n=2	NA n=1	NA n=2	18.00-18.50 18.00-19.00 x=18.49 n=2	NA
17: LM3	51% 95% x n	9.00-9.67 8.67-9.67 x=9.329 n=3	11.33-12.17 10.50-12.83 x=11.67 n=6	11.00-18.00 11.00-18.00 x=14.47 n=2	NA n=1	NA n=1	14.67-16.67 13.33-17.33 x=15.65 n=3	18.50-19.17 18.00-19.67 x=18.82 n=6	NA
18: LM2	51% 95% x n	NA	NA	6.60-7.40 5.80-8.20 x=7.016 n=5	8.20-9.00 7.80-9.60 x=8.612 n=5	NA n=3	10.00-11.33 9.33-11.33 x=10.67 n=3	12.00-13.00 11.40-13.80 x=12.61 n=5	17.00-17.90 16.20-18.70 x=17.40 n=10
19: LM1	51% 95% x n	NA	NA	NA	NA	NA n=2	NA	8.40-8.80 8.00-9.30 x=8.589 n=10	12.00-13.00* 11.08-13.92* x=12.51 n=13
20: LP2	51% 95% x n	NA	NA	6.33-7.67 5.00-9.00 x=7.02 n=3	7.40-8.20 7.00-8.60 x=7.816 n=5	8.75-9.25 8.25-9.75 x=8.988 n=4	9.33-10.00 9.33-10.33 x=9.666 n=3	12.50-13.83 11.00-14.83 x=13.14 n=6	17.00-18.00 16.30-18.80 x=17.48 n=10
21: LP1	51% 95% x n	NA	NA	NA	7.00-7.80 6.20-8.60 x=7.46 n=5	8.17-8.83 7.67-9.33 x=8.474 n=6	9.00-9.50 8.50-10.00 x=9.25 n=4	NA n=2	14.86-16.00* 14.00-17.00* x=15.40 n=7
22: LC	51% 95% x n	NA	NA	NA	NA n=1	NA n=2	8.80-9.20 8.50-9.50 x=8.991 n=10	11.00-13.00 10.00-13.00 x=11.95 n=3	15.90-17.00 15.10-18.10 x=16.51 n=10
23: LI2	51% 95% x n	NA	NA	NA	NA	NA n=1	NA n=4	8.75-9.25 8.25-9.75 x=9.006 n=4	11.82-12.91* 10.91-13.82* x=12.34 n=11

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	4.97-7.03 5.00-7.00 x=5.996 n=2	NA	7.81-8.48 7.29-8.86 x=8.125 n=7	11.22-12.11* 10.22-13.11* x=11.66 n=9

Table A3.12: Confidence intervals from Asian American male subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA	NA n=1	NA n=1	7.00-7.40 6.60-7.80 x=7.207 n=5	8.29-9.14 7.57-9.71 x=8.711 n=7	14.00-15.00* 13.33-15.67* x=14.50 n=6
10: UI2	51% 95% x n	NA	NA	NA	NA n=1	6.00-6.50 6.00-7.00 x=6.489 n=2	7.75-8.50 6.88-9.13 x=8.106 n=8	8.60-9.00 8.20-9.40 x=8.802 n=5	14.64-15.64* 13.82-16.55* x=15.20 n=11
11: UC	51% 95% x n	NA	NA	NA n=1	6.50-7.00 5.75-7.50 x=6.76 n=4	7.37-8.67 6.33-9.17 x=8.006 n=6	8.86-9.43 8.43-9.86 x=9.147 n=7	13.00-14.60 11.80-15.80 x=13.83 n=5	15.45-16.55 14.64-17.45 x=16.01 n=11
12: UP1	51% 95% x n	NA	NA	NA	NA n=2	8.00-9.50 6.50-10.25 x=8.755 n=4	8.33-8.67 7.67-8.67 x=8.346 n=3	12.00-13.00 11.00-13.00 x=12.01 n=2	15.80-16.70 14.90-17.50 x=16.17 n=10
13: UP2	51% 95% x n	NA	NA	NA n=1	7.80-9.00 6.60-10.00 x=8.415 n=5	7.25-7.75 7.00-8.00 x=7.483 n=4	8.00-8.67 7.67-8.67 x=8.329 n=3	12.00-12.80 11.00-13.60 x=12.39 n=5	16.36-17.09 15.73-17.73 x=16.71 n=11
14: UM1	51% 95% x n	NA	NA	NA	NA	NA	6.00-6.67 5.67-6.67 x=6.334 n=3	7.33-8.67 6.00-9.50 x=7.97 n=6	14.55-15.27* 14.00-16.00* x=14.90 n=11
15: UM2	51% 95% x n	NA	NA	6.00-6.67 5.67-6.67 x=6.323 n=3	7.69-8.15 7.23-8.54 x=7.933 n=13	NA n=1	NA n=1	13.50-14.50 12.75-15.12 x=13.99 n=8	16.40-17.80 15.20-18.80 x=17.00 n=5

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	8.33-9.33 7.34-10.00 x=8.857 n=6	12.40-14.00 10.40-15.40 x=13.19 n=5	12.50-13.50 11.50-14.50 x=13.01 n=4	14.00-15.00 12.67-15.67 x=14.36 n=3	NA	NA	16.00-19.00 16.00-19.00 x=17.58 n=2	NA n=1
17: LM3	51% 95% x n	8.50-8.83 8.00-9.17 x=8.67 n=6	13.67-15.33 12.33-16.67 x=14.46 n=6	12.54-13.33 11.83-14.17 x=13.01 n=6	NA n=1	NA n=2	NA n=1	18.00-19.00 18.00-19.00 x=18.49 n=2	NA n=1
18: LM2	51% 95% x n	NA	NA n=2	6.50-6.50 6.00-7.00 x=6.504 n=2	7.50-8.00 7.13-8.38 x=7.757 n=8	9.00-9.80 8.00-10.60 x=9.39 n=5	NA n=4	14.56-15.33 13.67-16.00 x=14.87 n=9	16.71-17.57 15.86-18.43 x=17.16 n=7
19: LM1	51% 95% x n	NA	NA	NA	NA	NA	NA n=2	7.58-8.00 7.08-8.42 x=7.752 n=12	12.89-13.63* 12.16-14.42* x=13.25 n=19
20: LP2	51% 95% x n	NA	NA	7.00-8.00 5.00-8.00 x=6.999 n=3	7.57-8.57 6.57-9.14 x=8.024 n=7	7.25-8.25 6.75-9.00 x=7.759 n=4	9.80-10.60 9.40-11.40 x=10.20 n=5	12.25-13.25 11.26-14.00 x=12.74 n=4	16.18-17.00 15.45-17.73 x=16.64 n=11
21: LP1	51% 95% x n	NA	NA	NA n=1	NA n=2	7.67-8.44 6.89-8.89 x=7.985 n=9	8.83-9.50 8.33-10.00 x=9.158 n=6	11.00-13.67 9.67-13.67 x=12.31 n=3	14.70-15.50* 14.10-16.10* x=15.10 n=10
22: LC	51% 95% x n	NA	NA	NA	NA n=1	7.00-7.75 6.00-8.25 x=7.276 n=4	8.18-8.82 7.46-9.27 x=8.464 n=11	12.33-13.17 11.50-13.83 x=12.65 n=6	16.10-16.90 15.40-17.60 x=16.51 n=10
23: LI2	51% 95% x n	NA	NA	NA	NA	NA n=2	6.25-6.75 6.00-7.00 x=6.498 n=4	8.17-8.83 7.67-9.17 x=8.496 n=6	12.93-13.93* 12.07-15.00* x=13.46 n=14

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	NA	5.98-7.02 6.00-7.00 x=6.498 n=2	7.27-9.01 5.86-9.71 x=8.131 n=7	12.27-13.36* 11.27-14.55* x=12.85 n=11

Table A3.13: Confidence intervals from European American female subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	5.00-6.00 5.00-6.00 x=5.502 n=2	5.25-5.75 5.00-6.00 x=5.506 n=4	5.88-6.13 5.50-6.50 x=6.004 n=8	7.81-8.00 7.61-8.19 x=7.893 n=57	8.93-9.17 8.60-9.40 x=9.039 n=53	12.70-12.97* 12.43-13.22* x=12.82 n=92
10: UI2	51% 95% x n	NA	NA	NA n=2	5.50-6.00 5.50-6.25 x=5.753 n=4	7.10-7.40 6.90-7.65 x=7.249 n=20	8.12-8.28 7.93-8.46 x=8.213 n=67	9.92-10.32 9.56-10.64 x=10.10 n=50	14.01-14.36* 13.67-14.67* x=14.17 n=108
11: UC	51% 95% x n	NA	NA	5.33-6.00 5.33-6.33 x=5.67 n=3	6.29-6.57 6.04-6.82 x=6.435 n=28	7.55-7.71 7.39-7.88 x=7.637 n=49	9.11-9.29 8.93-9.45 x=9.202 n=98	11.70-12.03 11.38-12.31 x=11.85 n=108	15.83-16.23 15.43-16.66 x=16.03 n=77
12: UP1	51% 95% x n	NA	NA	5.25-5.71 5.29-6.00 x=5.575 n=7	7.80-8.10 7.55-8.35 x=7.942 n=20	8.38-8.71 8.00-9.00 x=8.514 n=21	9.58-9.79 9.41-10.00 x=9.689 n=42	11.23-11.60 10.91-11.89 x=11.41 n=47	16.16-16.63 15.73-17.08 x=16.41 n=51
13: UP2	51% 95% x n	NA	5.50-5.50 5.00-6.00 x=5.502 n-2	7.07-7.33 6.80-7.60 x=7.201 n=15	7.96-8.18 7.75-8.36 x=8.057 n=56	9.58-9.86 9.28-10.14 x=9.724 n=36	10.35-10.59 10.13-10.85 x=10.45 n=54	12.86-13.22 12.51-13.50 x=13.04 n=72	16.69-17.13 16.37-17.52 x=16.91 n=62
14: UM1	51% 95% x n	NA	NA	NA	NA n=1	5.56-6.00 5.00-6.33 x=5.778 n=9	6.44-6.89 6.11-7.22 x=6.653 n=9	7.88-8.12 7.67-8.30 x=8.016 n=66	12.78-13.04* 12.54-13.28* x=12.91 n=132
15: UM2	51% 95% x n	6.50-8.00 5.00-8.00 x=6.504 n=2	5.82-6.36 5.18-6.64 x=6.085 n=11	7.26-7.55 7.00-7.76 x=7.405 n=42	8.12-8.31 7.96-8.47 x=8.207 n=75	9.84-10.11 9.59-10.32 x=9.983 n=44	10.95-11.22 10.69-11.49 x=11.09 n=55	13.06-13.42 12.73-13.72 x=13.24 n=78	17.13-17.55 16.75-17.98 x=17.35 n=55

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	9.24-9.62 8.81-10.00 x=9.401 n=21	10.99-11.30 10.71-11.54 x=11.15 n=70	11.85-12.21 11.52-12.54 x=12.02 n=48	14.38-14.97 13.78-15.50 x=14.64 n=32	14.58-15.21 13.95-15.68 x=14.89 n=19	16.18-16.77 15.55-17.41 x=16.45 n=22	18.14-18.59 17.76-18.93 x=18.33 n=29	18.80-19.20 18.40-19.60 x=19.00 n=5
17: LM3	51% 95% x n	9.15-9.46 8.90-9.77 x=9.304 n=39	10.97-11.20 10.74-11.43 x=11.08 n=74	12.32-12.68 11.98-13.00 x=12.52 n=41	15.38-16.16 14.89-16.79 x=15.80 n=19	15.84-16.39 15.32-16.84 x=16.09 n=31	15.92-16.48 15.40-17.00 x=16.15 n=22	18.59-18.91 18.32-19.27 x=18.80 n=22	19.00-19.40 18.60-20.00 x=19.19 n=5
18: LM2	51% 95% x n	NA n=1	6.00-6.38 5.63-6.69 x=6.174 n=16	7.38-7.58 7.19-7.79 x=7.48 n=48	8.18-8.44 7.96-8.66 x=8.30 n=50	9.44-9.66 9.26-9.88 x=9.554 n=73	10.55-10.78 10.33-10.98 x=10.67 n=51	13.38-13.68 13.10-13.93 x=13.54 n=116	17.47-17.75 17.19-18.03 x=17.59 n=75
19: LM1	51% 95% x n	NA	NA	NA	NA n=1	5.40-5.80 4.80-6.20 x=5.595 n=5	6.33-6.67 6.06-6.94 x=6.49 n=18	8.45-8.63 8.28-8.77 x=8.538 n=141	12.40-12.63* 12.18-12.83* x=12.52 n=211
20: LP2	51% 95% x n	NA n=1	5.60-6.40 5.00-6.80 x=5.996 n=5	7.03-7.32 6.81-7.59 x=7.189 n=41	7.89-8.07 7.69-8.26 x=7.98 n=55	8.90-9.24 8.58-9.58 x=9.077 n=38	10.44-10.67 10.22-10.86 x=10.55 n=108	13.00-13.39 12.56-13.73 x=13.19 n=62	16.47-16.80 16.17-17.10 x=16.64 n=102
21: LP1	51% 95% x n	NA	NA	5.25-5.50 5.00-6.63 x=5.376 n=8	7.33-7.53 7.15-7.71 x=7.409 n=61	7.97-8.21 7.77-8.39 x=8.078 n=39	9.56-9.74 9.39-9.90 x=9.651 n=97	11.52-11.79 11.29-12.05 x=11.64 n=66	14.65-14.92* 14.41-15.14* x=14.78 n=111
22: LC	51% 95% x n	NA	NA	5.00-5.50 4.75-5.50 x=5.254 n=4	6.41-6.68 6.09-6.91 x=6.544 n=22	7.47-7.71 7.27-7.94 x=7.58 n=34	8.76-8.93 8.60-9.07 x=8.844 n=109	11.35-11.67 11.08-11.96 x=11.49 n=91	15.50-15.88 15.17-16.20 x=15.69 n=121
23: LI2	51% 95% x n	NA	NA	NA	5.25-5.75 5.00-6.00 x=5.511 n=4	5.71-6.00 5.43-6.29 x=5.848 n=7	7.22-7.38 7.05-7.57 x=7.298 n=37	8.75-9.00 8.53-9.23 x=8.868 n=61	12.57-12.84* 12.35-13.07* x=12.70 n=134

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	4.98-6.02 5.00-6.00 x=5.498 n=2	NA n=3	6.60-6.97 6.29-7.29 x=6.787 n=14	7.65-8.02 7.31-8.29 x=7.829 n=42	12.03-12.30* 11.77-12.54* x=12.17 n=122

Table A3.14: Confidence intervals from European American male subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA	6.20-6.60 6.00-6.80 x=6.399 n=5	7.00-7.40 6.70-7.70 x=7.223 n=10	7.79-8.00 7.60-8.19 x=7.901 n=53	9.70-9.98 9.46-10.20 x=9.847 n=59	13.39-13.78* 13.01-14.14* x=13.56 n=69
10: UI2	51% 95% x n	NA	NA	NA n=1	6.40-6.80 6.20-7.00 x=6.599 n=5	7.65-8.00 7.35-8.29 x=7.824 n=17	8.44-8.64 8.26-8.82 x=8.544 n=61	10.60-10.92 10.28-11.23 x=10.77 n=65	14.84-15.24* 14.42-15.65* x=15.04 n=85
11: UC	51% 95% x n	NA	NA	NA n=3	7.25-7.45 7.05-7.63 x=7.347 n=40	8.23-8.41 8.05-8.61 x=8.327 n=56	9.82-10.00 9.65-10.18 x=9.919 n=108	12.86-13.22 12.52-13.58 x=13.04 n=64	16.34-16.74 16.01-17.07 x=16.55 n=68
12: UP1	51% 95% x n	NA	NA	6.00-6.60 5.60-7.20 x=6.418 n=5	7.23-7.62 6.92-8.00 x=7.469 n=13	8.90-9.32 8.58-9.63 x=9.114 n=19	10.13-10.43 9.91-10.69 x=10.27 n=54	11.70-12.18 11.27-12.67 x=11.94 n=33	16.28-16.81 15.86-17.30 x=16.55 n=43
13: UP2	51% 95% x n	NA	NA	6.91-7.27 6.64-7.55 x=7.101 n=11	8.34-8.54 8.15-8.78 x=8.43 n=41	9.74-10.08 9.45-10.39 x=9.894 n=38	10.39-10.65 10.15-10.91 x=10.52 n=54	13.33-13.79 12.91-14.21 x=13.57 n=43	16.96-17.41 16.61-17.76 x=17.18 n=54
14: UM1	51% 95% x n	NA	NA	NA	NA	6.67-7.33 6.00-8.00 x=6.977 n=3	7.00-7.62 6.39-8.15 x=7.324 n=13	8.33-8.54 8.13-8.74 x=8.446 n=72	13.50-13.84* 13.23-14.14* x=13.66 n=103
15: UM2	51% 95% x n	NA	6.46-6.85 6.08-7.15 x=6.616 n=13	7.64-7.83 7.47-8.00 x=7.739 n=53	8.71-8.91 8.54-9.09 x=8.812 n=65	9.79-10.06 9.58-10.30 x=9.944 n=47	10.77-11.02 10.55-11.26 x=10.89 n=47	13.65-13.96 13.37-14.24 x=13.80 n=46	17.17-17.44 16.91-17.73 x=17.31 n=70

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	9.31-9.61 9.02-9.84 x=9.449 n=49	10.57-10.86 10.26-11.14 x=10.72 n=69	11.94-12.29 11.55-12.68 x=12.12 n=31	14.20-14.57 13.87-14.90 x=14.40 n=30	15.09-15.64 14.59-16.14 x=15.37 n=22	16.07-16.50 15.64-16.93 x=16.30 n=14	18.00-18.36 17.68-18.73 x=18.19 n=22	19.00-19.33 18.75-19.58 x=19.17 n=12
17: LM3	51% 95% x n	9.21-9.44 9.00-9.66 x=9.324 n=70	11.23-11.51 10.94-11.75 x=11.35 n=65	13.03-13.48 12.58-13.90 x=13.27 n=31	14.42-15.00 13.79-15.47 x=14.68 n=19	15.32-15.77 14.95-16.23 x=15.55 n=22	16.47-16.94 16.06-17.35 x=16.70 n=17	18.37-18.70 18.07-19.00 x=18.56 n=27	18.80-19.00 18.50-19.30 x=18.91 n=10
18: LM2	51% 95% x n	NA	6.62-7.08 6.23-7.46 x=6.859 n=13	7.71-7.91 7.54-8.05 x=7.813 n=63	8.30-8.55 8.03-8.79 x=8.417 n=33	9.61-9.79 9.43-9.99 x=9.706 n=81	10.94-11.21 10.70-11.43 x=11.08 n=53	13.62-13.95 13.36-14.20 x=13.80 n=69	17.22-17.53 16.97-17.79 x=17.37 n=76
19: LM1	51% 95% x n	NA	NA	NA	NA	NA n=1	6.74-7.00 6.44-7.30 x=6.861 n=23	8.71-8.85 8.56-9.01 x=8.776 n=149	12.87-13.14* 12.65-13.39* x=13.01 n=175
20: LP2	51% 95% x n	NA	7.00-7.50 7.00-8.00 x=7.498 n=2	7.27-7.51 7.05-7.73 x=7.402 n=41	8.28-8.49 8.09-8.67 x=8.385 n=67	9.17-9.45 8.93-9.74 x=9.318 n=42	10.77-10.98 10.54-11.20 x=10.87 n=96	13.40-13.80 13.04-14.16 x=13.61 n=45	16.81-17.11 16.53-17.41 x=16.98 n=83
21: LP1	51% 95% x n	NA	NA	5.86-6.43 5.43-6.86 x=6.148 n=7	7.64-7.79 7.49-7.94 x=7.705 n=66	8.64-8.86 8.44-9.10 x=8.761 n=50	10.03-10.22 9.86-10.39 x=10.14 n=92	11.88-12.21 11.57-12.55 x=12.03 n=56	15.46-15.74* 15.23-15.96* x=15.58 n=74
22: LC	51% 95% x n	NA	NA	5.75-6.25 5.25-6.75 x=5.987 n=4	6.96-7.23 6.77-7.46 x=7.122 n=26	7.88-8.08 7.73-8.26 x=7.979 n=51	9.60-9.86 9.44-9.93 x=9.678 n=126	12.54-12.84 12.25-13.16 x=12.71 n=63	15.84-16.22 15.49-16.56 x=16.05 n=82
23: LI2	51% 95% x n	NA	NA	NA	NA	6.00-6.67 4.67-7.67 x=6.301 n=3	7.71-7.96 7.45-8.14 x=7.831 n=49	9.57-9.83 9.32-10.08 x=9.704 n=60	12.98-13.31* 12.65-13.66* x=13.12 n=99

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	NA n=1	6.68-7.32 6.22-7.78 x=7.001 n=9	8.31-8.56 8.09-8.77 x=8.445 n=53	12.03-12.33* 11.71-12.63* x=12.18 n=102

Table A3.15: Confidence intervals from Hispanic female subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA n=2	NA n=2	6.75-7.25 6.25-7.75 x=7.004 n=4	7.25-7.50 7.05-7.70 x=7.374 n=40	8.23-8.53 8.00-8.75 x=8.377 n=47	11.82-12.20* 11.51-12.54* x=12.00 n=82
10: UI2	51% 95% x n	NA	NA	5.00-6.00 5.00-7.00 x=5.997 n=2	6.80-7.20 6.40-7.60 x=6.997 n=5	6.77-7.08 6.46-7.46 x=6.937 n=13	7.47-7.67 7.31-7.82 x=7.564 n=55	9.06-9.37 8.81-9.64 x=9.214 n=52	12.99-13.40* 12.61-13.75* x=13.20 n=88
11: UC	51% 95% x n	NA	NA	NA n=1	6.73-6.96 6.54-7.19 x=6.846 n=26	7.17-7.38 6.96-7.54 x=7.261 n=24	8.72-8.91 8.56-9.07 x=8.823 n=128	11.19-11.53 10.90-11.82 x=11.38 n=72	14.96-15.51 14.51-15.88 x=15.19 n=49
12: UP1	51% 95% x n	NA	NA	5.50-6.50 5.00-7.00 x=5.989 n=4	6.63-7.00 6.38-7.50 x=6.875 n=8	7.81-8.31 7.31-8.69 x=8.046 n=16	8.68-8.98 8.34-9.26 x=8.836 n=53	10.51-10.80 10.16-11.08 x=10.64 n=61	14.26-14.77 13.72-15.26 x=14.51 n=39
13: UP2	51% 95% x n	NA	NA	6.75-7.25 6.50-7.63 x=6.982 n=8	7.19-7.45 6.97-7.68 x=7.33 n=31	8.10-8.40 7.80-8.68 x=8.256 n=40	9.60-9.84 9.37-10.09 x=9.734 n=74	12.10-12.49 11.75-12.83 x=12.27 n=59	14.91-15.50 14.35-16.03 x=15.20 n=34
14: UM1	51% 95% x n	NA	NA	NA	NA	5.67-7.00 5.67-7.67 x=6.323 n=3	NA n=1	7.68-7.88 7.47-8.06 x=7.781 n=71	12.06-12.34* 11.79-12.66* x=12.22 n=117
15: UM2	51% 95% x n	NA	5.80-6.60 5.40-7.00 x=6.208 n=5	7.00-7.23 6.75-7.43 x=7.106 n=44	7.91-8.15 7.69-8.37 x=8.037 n=54	8.89-9.09 8.67-9.32 x=9.007 n=54	9.93-10.23 9.61-10.50 x=10.05 n=44	11.97-12.33 11.62-12.68 x=12.15 n=60	15.70-16.27 15.20-16.83 x=16.00 n=30

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	8.82-9.15 8.46-9.49 x=8.963 n=39	10.07-10.32 9.82-10.58 x=10.21 n=72	11.48-11.80 11.22-12.07 x=11.62 n=46	13.81-14.48 13.19-15.05 x=14.13 n=21	14.43-15.21 13.57-15.79 x=14.80 n=14	15.76-16.47 15.12-17.18 x=16.10 n=17	17.03-17.67 16.44-18.22 x=17.30 n=9	NA
17: LM3	51% 95% x n	9.01-9.27 8.74-9.51 x=9.15 n=77	10.56-10.87 10.24-11.13 x=10.71 n=71	12.09-12.58 11.70-12.97 x=12.35 n=33	14.07-14.67 13.53-15.27 x=14.40 n=15	15.11-15.63 14.47-16.21 x=15.34 n=19	15.27-16.09 14.55-16.64 x=15.60 n=11	17.54-18.00 17.15-18.54 x=17.77 n=13	NA n=1
18: LM2	51% 95% x n	NA n=1	6.36-6.73 6.09-7.09 x=6.552 n=11	6.86-7.09 6.66-7.23 x=6.97 n=35	7.72-7.92 7.54-8.08 x=7.817 n=39	8.78-8.99 8.58-9.18 x=8.878 n=74	9.95-10.19 9.71-10.41 x=10.06 n=58	12.75-13.04 12.46-13.35 x=12.90 n=89	15.82-16.30 15.40-16.70 x=16.09 n=40
19: LM1	51% 95% x n	NA	NA	NA	NA	6.00-7.00 5.00-7.00 x=6.015 n=2	6.33-6.83 6.00-7.50 x=6.664 n=6	7.94-8.10 7.78-8.25 x=8.024 n=134	11.72-11.99* 11.48-12.22* x=11.85 n=190
20: LP2	51% 95% x n	NA	NA n=1	6.64-6.93 6.43-7.21 x=6.791 n=14	7.42-7.64 7.23-7.85 x=7.542 n=52	7.88-8.12 7.67-8.33 x=8.008 n=42	9.68-9.89 9.49-10.08 x=9.782 n=118	11.98-12.39 11.71-12.71 x=12.19 n=51	15.22-15.64 14.90-16.00 x=15.44 n=59
21: LP1	51% 95% x n	NA	NA	6.00-7.00 5.00-7.00 x=6.009 n=2	6.77-6.94 6.59-7.12 x=6.853 n=34	7.46-7.69 7.26-7.90 x=7.589 n=39	8.89-9.08 8.70-9.25 x=8.974 n=105	10.76-11.03 10.50-11.24 x=10.89 n=78	14.33-14.67* 14.01-14.96* x=14.49 n=69
22: LC	51% 95% x n	NA	NA	6.00-7.00 5.00-7.00 x=5.993 n=2	6.65-6.88 6.41-7.18 x=6.754 n=17	6.89-7.17 6.67-7.44 x=7.002 n=18	8.47-8.65 8.32-8.81 x=8.563 n=137	10.58-10.87 10.28-11.13 x=10.72 n=60	14.10-14.54 13.72-14.96 x=14.31 n=67
23: LI2	51% 95% x n	NA	NA	NA	NA	6.25-6.75 6.00-7.00 x=6.506 n=4	7.03-7.21 6.85-7.39 x=7.126 n=33	8.13-8.46 7.78-8.74 x=8.276 n=46	11.25-11.55* 11.01-11.81* x=11.41 n=134

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	NA	6.51-6.83 6.25-7.08 x=6.659 n=12	7.40-7.58 7.22-7.75 x=7.50 n=51	10.70-10.98* 10.43-11.23* x=10.81 n=128

Table A3.16: Confidence intervals from Hispanic male subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA n=1	NA n=1	7.17-7.50 6.83-8.00 x=7.328 n=6	7.42-7.74 7.12-8.03 x=7.592 n=34	9.06-9.49 8.60-9.80 x=9.253 n=35	11.92-12.31* 11.56-12.67* x=12.09 n=78
10: UI2	51% 95% x n	NA	NA	NA n=2	6.25-7.00 5.50-7.50 x=6.513 n=4	7.50-8.00 6.88-8.50 x=7.763 n=8	8.00-8.19 7.79-8.42 x=8.098 n=43	10.06-10.41 9.71-10.71 x=10.23 n=51	12.38-12.82* 11.99-13.27* x=12.61 n=71
11: UC	51% 95% x n	NA	NA	NA n=1	6.39-6.65 6.13-6.91 x=6.523 n=23	7.95-8.16 7.75-8.38 x=8.054 n=32	9.44-9.64 9.24-9.84 x=9.552 n=115	11.91-12.32 11.54-12.68 x=12.12 n=56	14.45-14.85 14.06-15.18 x=14.63 n=33
12: UP1	51% 95% x n	NA	NA	NA n=2	6.50-6.83 6.33-7.00 x=6.664 n=6	8.00-8.29 7.67-8.57 x=8.137 n=21	9.17-9.50 8.85-9.75 x=9.341 n=48	10.80-11.22 10.41-11.61 x=11.03 n=51	14.12-14.72 13.66-15.16 x=14.44 n=32
13: UP2	51% 95% x n	NA	NA	6.25-6.75 5.63-7.25 x=6.478 n=8	7.84-8.16 7.56-8.44 x=7.994 n=25	8.69-9.08 8.36-9.31 x=8.882 n=36	9.90-10.17 9.61-10.46 x=10.04 n=59	11.90-12.26 11.56-12.60 x=12.09 n=50	14.94-15.35 14.55-15.74 x=15.17 n=31
14: UM1	51% 95% x n	NA	NA	NA	NA	NA n=2	7.00-7.67 6.50-8.17 x=7.331 n=6	8.27-8.59 7.91-8.91 x=8.451 n=56	12.31-12.62* 12.03-12.90* x=12.46 n=103
15: UM2	51% 95% x n	NA	5.71-6.29 5.14-6.71 x=5.978 n=7	7.34-7.72 6.84-8.06 x=7.487 n=32	8.48-8.72 8.28-8.93 x=8.59 n=54	8.90-9.15 8.64-9.44 x=9.023 n=39	10.23-10.65 9.89-11.08 x=10.46 n=26	11.87-12.21 11.59-12.49 x=12.03 n=68	15.37-15.88 14.88-16.35 x=15.62 n=17

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	9.00-9.34 8.63-9.63 x=9.161 n=32	10.18-10.54 9.92-10.86 x=10.38 n=50	11.93-12.34 11.51-12.71 x=12.12 n=41	13.09-13.59 12.68-14.14 x=13.37 n=22	14.60-15.13 14.20-15.60 x=14.87 n=15	14.38-14.88 13.63-15.50 x=14.64 n=8	15.86-17.00 15.00-17.86 x=16.43 n=7	18.50-18.50 18.00-19.00 x=18.51 n=2
17: LM3	51% 95% x n	8.98-9.30 8.59-9.55 x=9.133 n=53	10.84-11.17 10.52-11.49 x=11.04 n=63	12.28-12.72 11.83-13.14 x=12.49 n=29	13.33-14.17 12.67-15.17 x=13.81 n=12	14.25-14.75 13.75-15.25 x=14.52 n=16	14.71-15.29 14.14-15.86 x=14.97 n=7	16.64-17.55 15.91-18.36 x=17.09 n=11	NA
18: LM2	51% 95% x n	NA	5.56-5.78 5.22-6.11 x=5.653 n=9	7.65-8.06 7.24-8.35 x=7.857 n=34	8.43-8.77 8.07-9.07 x=8.58 n=30	8.80-9.03 8.57-9.25 x=8.921 n=61	10.38-10.63 10.15-10.87 x=10.50 n=52	12.63-12.96 12.33-13.28 x=12.80 n=75	15.48-16.04 15.00-16.56 x=15.77 n=25
19: LM1	51% 95% x n	NA	NA	NA	NA	5.00-5.50 5.00-6.00 x=5.498 n=2	6.50-7.00 6.08-7.42 x=6.754 n=12	8.50-8.70 8.32-8.90 x=8.607 n=115	12.02-12.30* 11.76-12.52* x=12.16 n=151
20: LP2	51% 95% x n	NA	NA n=2	6.46-6.92 6.00-7.39 x=6.689 n=13	7.61-7.87 7.37-8.08 x=7.736 n=38	8.80-9.08 8.48-9.32 x=8.953 n=50	10.03-10.26 9.83-10.46 x=10.14 n=94	11.95-12.37 11.55-12.74 x=12.15 n=38	14.82-15.26 14.48-15.72 x=15.04 n=50
21: LP1	51% 95% x n	NA	NA	5.29-5.57 4.86-5.86 x=5.418 n=7	7.41-7.74 7.11-8.00 x=7.593 n=27	8.09-8.49 7.71-8.77 x=8.252 n=35	9.35-9.57 9.13-9.74 x=9.464 n=97	11.12-11.36 10.90-11.56 x=11.24 n=50	14.08-14.45* 13.77-14.77* x=14.27 n=62
22: LC	51% 95% x n	NA	NA	NA n=1	6.33-6.73 5.80-7.20 x=6.528 n=15	7.48-7.78 7.22-8.00 x=7.629 n=27	9.25-9.42 9.09-9.64 x=9.341 n=118	11.35-11.77 11.02-12.16 x=11.58 n=62	14.18-14.65 13.68-15.13 x=14.42 n=40
23: LI2	51% 95% x n	NA	NA	NA	NA n=2	5.67-6.33 5.00-7.00 x=5.998 n=3	7.40-7.69 7.14-7.94 x=7.537 n=35	9.00-9.42 8.54-9.73 x=9.173 n=41	11.30-11.60* 11.01-11.88* x=11.45 n=115

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	NA n=2	6.67-7.11 6.33-7.56 x=6.886 n=9	7.65-7.92 7.38-8.17 x=7.789 n=42	11.04-11.34* 10.78-11.63* x=11.18 n=114

Table A3.17: Confidence intervals from Native American female subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA	NA	NA	NA	10.00-11.00 9.00-11.00 x=10.03 n=2	13.60-15.20* 12.20-16.60* x=14.45 n=5
10: UI2	51% 95% x n	NA	NA	NA	NA	NA	NA	10.25-10.75 9.83-11.08 x=10.50 n=12	12.83-14.00* 11.67-15.00* x=13.49 n=6
11: UC	51% 95% x n	NA	NA	NA	NA	NA	9.90-10.50 9.40-10.90 x=10.19 n=10	11.90-12.60 11.10-13.10 x=12.20 n=10	15.54-16.00 15.17-16.50 x=15.82 n=6
12: UP1	51% 95% x n	NA	NA	NA	NA	NA	9.75-10.00 9.38-10.38 x=9.865 n=8	11.57-12.57 10.43-13.14 x=12.00 n=7	15.40-16.20 14.40-17.00 x=15.78 n=5
13: UP2	51% 95% x n	NA	NA	NA	NA n=1	9.67-10.33 9.00-11.00 x=9.999 n=3	10.50-11.12 9.88-11.50 x=10.77 n=8	12.62-13.50 11.75-14.12 x=13.00 n=8	14.57-15.29 13.86-16.00 x=14.99 n=7
14: UM1	51% 95% x n	NA	NA	NA	NA	NA	NA	NA n=1	12.56-13.56* 11.67-14.56* x=13.13 n=9
15: UM2	51% 95% x n	NA	NA	NA	9.33-10.00 9.33-10.33 x=9.657 n=3	9.60-10.00 9.20-10.40 x=9.788 n=5	11.00-12.00 10.50-12.00 x=11.50 n=4	13.44-14.67 12.22-15.77 x=13.97 n=9	15.00-15.80 14.20-16.60 x=15.40 n=5

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	9.00-10.00 9.00-10.00 x=9.508 n=2	10.71-11.43 10.00-12.00 x=10.99 n=7	12.00-12.86 11.29-13.29 x=12.46 n=7	15.17-15.83 14.67-16.33 x=15.50 n=6	NA	NA n=1	14.67-16.33 12.67-17.67 x=15.36 n=3	NA n=1
17: LM3	51% 95% x n	10.00-10.67 9.67-10.67 x=10.34 n=3	11.18-11.82 10.46-12.45 x=11.56 n=11	14.50-15.17 14.00-15.83 x=14.81 n=6	13.67-16.67 11.67-17.67 x=15.36 n=3	16.00-17.00 15.50-17.50 x=16.49 n=4	NA	16.00-16.00 15.00-17.00 x=16.00 n=2	NA
18: LM2	51% 95% x n	NA	NA	NA	9.50-10.00 9.00-10.00 x==9.505 n=2	9.83-10.17 9.33-10.67 x=9.985 n=6	10.86-11.43 10.43-11.86 x=11.16 n=7	14.50-15.21 13.79-15.93 x=14.84 n=14	15.00-15.67 14.33-16.33 x=15.36 n=6
19: LM1	51% 95% x n	NA	NA	NA	NA	NA	NA	NA n=6	13.00-13.65* 12.46-14.31* x=13.35 n=26
20: LP2	51% 95% x n	NA	NA	NA	NA n=1	10.00-10.40 9.60-10.80 x=10.21 n=5	10.57-11.14 10.00-11.57 x=10.88 n=7	13.00-13.87 12.38-14.62 x=13.47 n=13	15.33-16.00 14.50-16.67 x=15.65 n=6
21: LP1	51% 95% x n	NA	NA	NA	NA	NA	10.09-10.73 9.64-11.18 x=10.45 n=11	12.00-12.89 11.11-13.67 x=12.41 n=9	15.33-16.00* 14.89-16.56* x=15.67 n=9
22: LC	51% 95% x n	NA	NA	NA	NA	NA	9.78-10.22 9.44-10.56 x=9.981 n=9	12.62-13.75 11.75-14.75 x=13.25 n=8	14.00-15.29 13.14-16.43 x=14.70 n=7
23: LI2	51% 95% x n	NA	NA	NA	NA	NA	NA	9.40-9.80 8.80-10.20 x=9.592 n=5	12.60-13.60* 11.60-14.60* x=13.11 n=10

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	NA	NA	9.516-10.48 9.00-11.00 x=10.01 n=3	11.80-13.00* 10.80-14.00* x=12.45 n=5

Table A3.18: Confidence intervals from Native American male subset of training sample for the dispersion of age around each Demirjian et al. (1973) score, at 51% and 95% confidence level.

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
9: UI1	51% 95% x n	NA	NA	NA	NA	NA	8.00-9.33 7.33-9.33 x=8.659 n=3	NA n=2	13.00-13.80* 12.40-14.40* x=13.39 n=5
10: UI2	51% 95% x n	NA	NA	NA	NA	NA	8.67-9.33 8.00-10.00 x=8.974 n=3	9.00-14.00 9.00-14.00 x=11.38 n=2	13.29-14.14* 12.71-14.71* x=13.74 n=7
11: UC	51% 95% x n	NA	NA	NA	NA	NA n=2	8.20-9.60 9.00-9.80 x=9.405 n=5	12.00-13.33 11.33-13.33 x=12.66 n=3	15.33-16.50 14.00-17.17 x=15.88 n=6
12: UP1	51% 95% x n	NA	NA	NA	NA n=1	NA	9.00-9.67 8.67-9.67 x=9.335 n=3	10.67-12.58 9.33-14.33 x=11.66 n=3	14.00-15.00 13.40-16.00 x=14.62 n=5
13: UP2	51% 95% x n	NA	NA	NA	NA n=1	9.00-9.40 8.60-9.80 x=9.205 n=5	NA n=1	13.00-14.33 12.67-15.33 x=13.64 n=3	15.75-17.50 14.75-18.25 x=16.76 n=4
14: UM1	51% 95% x n	NA	NA	NA	NA	NA	NA	9.00-10.00 8.00-10.00 x=9.005 n=2	12.44-13.33* 11.67-14.22* x=12.91 n=9
15: UM2	51% 95% x n	NA	NA	NA	8.00-8.67 7.67-8.67 x=8.335 n=3	NA n=1	10.08-11.33 9.33-12.33 x=10.68 n=3	12.71-13.29 12.29-13.71 x=13.00 n=7	15.00-18.33 13.33-18.33 x=16.68 n=3

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
16: UM3	51% 95% x n	9.00-9.67 8.67-9.67 x=9.337 n=3	11.25-12.00 10.50-12.50 x=11.52 n=4	12.50-13.50 12.00-14.00 x=12.97 n=4	12.00-13.50 12.00-15.00 x=13.51 n=2	15.67-17.67 14.33-18.33 x=16.66 n=3	15.33-16.33 14.33-17.33 x=15.65 n=3	NA n=1	NA
17: LM3	51% 95% x n	NA n=2	11.43-12.00 10.71-12.71 x=11.73 n=7	12.00-14.00 12.00-14.00 x=12.97 n=2	12.00-15.00 12.00-15.00 x=13.50 n=2	16.25-17.50 15.00-18.00 x=16.72 n=4	NA n=1	17.33-19.33 16.67-20.67 x=18.28 n=3	NA
18: LM2	51% 95% x n	NA	NA	8.00-8.50 8.00-9.00 x=8.517 n=2	8.00-9.00 8.00-10.00 x=8.988 n=2	9.00-9.67 8.67-9.67 x=9.332 n=3	11.00-13.00 11.00-13.00 x=12.00 n=2	13.38-14.62 12.00-15.75 x=14.01 n=8	16.00-17.00 14.86-17.85 x=16.46 n=7
19: LM1	51% 95% x n	NA	NA	NA	NA	NA	NA	9.00-9.57 8.43-10.00 x=9.264 n=7	13.29-14.00* 12.64-14.79* x=13.65 n=14
20: LP2	51% 95% x n	NA	NA	NA	NA n=1	8.50-8.50 8.00-9.00 x=8.492 n=2	9.80-10.40 9.00-10.80 x=9.991 n=5	13.43-14.71 12.00-15.75 x=14.01 n=7	16.20-17.40 15.00-18.00 x=16.77 n=5
21: LP1	51% 95% x n	NA	NA	NA	NA n=1	8.00-9.00 8.00-9.00 x=8.50 n=2	9.75-11.25 8.75-11.75 x=10.47 n=4	11.67-13.00 10.67-13.67 x=12.34 n=3	14.33-15.17* 13.67-16.17* x=14.84 n=6
22: LC	51% 95% x n	NA	NA	NA	NA n=1	NA n=1	9.00-9.40 8.60-10.00 x=9.199 n=5	13.71-15.00 12.29-16.00 x=14.29 n=7	14.75-16.12 13.38-17.12 x=15.46 n=8
23: LI2	51% 95% x n	NA	NA	NA	NA	NA	NA n=2	9.25-9.75 9.00-10.00 x=9.498 n=4	12.50-13.38* 11.75-14.38* x=13.05 n=8

Tooth		Demirjian et al. (1973) Scores							
		A	B	C	D	E	F	G	H
24: LI1	51% 95% x n	NA	NA	NA	NA	NA	NA	NA n=2	11.86-13.00* 10.71-14.14* x=12.40 n=7

Appendix 4: Accuracy Tests for 95% Confidence Intervals

Comparisons are made between the general set of CI's created using the total training sample and sex-, ancestry-, and sex-and-ancestry-specific CI's created from subdivisions of the training sample. These values are applied to each subset of the test sample (e.g., the general and female-specific CI's are tested on the female portion of the test set). The proportion of individuals in each subset of the test sample whose chronological age falls within the 95% CI are recorded, and these proportions are compared using z-scores for proportions of two populations.

General Correct Test evaluates the likelihood that the CI based on all individuals is correct more often than the CI based on a subset of the training sample, while Specific Correct Test evaluates the converse. Because the numerator of the z-score is calculated by subtracting one value from the other, the two-tailed p-value is the same for both tests; therefore, this value is reported once in each table. p-values in *italics** are significant at $\alpha = 0.05$, while p-values in ***bold italics***** are significant at Bonferroni corrected $\alpha = 0.000173$.

N/A's in test columns indicates instances in which a comparison could not be performed. To calculate the z-score for proportions, the sample size for each group is part of the denominator. If there are cases in which the sample includes one or zero individuals, the denominator becomes zero. Therefore, the formulae cannot be calculated in these cases.

Abbreviations for Appendix 4: % corr = proportion of individuals whose age is within 95% CI (correct); n corr = number of individuals correct; n scor = number of individuals scored at each tooth.

Table A4.1: Comparison of general CI values to female-specific CI values.

Tooth	General Values			Female Values			General Correct Test		Female Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	58.62	17	29	58.62	17	29	0.0000	0.5000	0.0000	0.5000	1.0000
10: UI2	38.71	12	31	45.16	14	31	-0.5147	0.6966	0.5147	0.3034	0.6067
11: UC	47.62	20	42	50.00	21	42	-0.2183	0.5864	0.2183	0.4136	0.8272
12: UP1	17.39	4	23	26.09	6	23	-0.7149	0.7627	0.7149	0.2373	0.4747
13: UP2	42.86	12	28	39.29	11	28	0.2716	0.3930	-0.2716	0.6070	0.7859
14: UM1	62.50	15	24	62.50	15	24	0.0000	0.5000	0.0000	0.5000	1.0000
15: UM2	55.26	21	38	55.26	21	38	0.0000	0.5000	0.0000	0.5000	1.0000
16: UM3	41.18	14	34	41.18	14	34	0.0000	0.5000	0.0000	0.5000	1.0000
17: LM3	37.14	13	35	48.57	17	35	-0.9661	0.8330	0.9661	0.1670	0.3340
18: LM2	35.42	17	48	35.42	17	48	0.0000	0.5000	0.0000	0.5000	1.0000
19: LM1	54.17	26	48	54.17	26	48	0.0000	0.5000	0.0000	0.5000	1.0000
20: LP2	54.17	26	48	45.83	22	48	0.8165	0.2071	-0.8165	0.7929	0.4142
21: LP1	40.43	19	47	40.43	19	47	0.0000	0.5000	0.0000	0.5000	1.0000
22: LC	44.19	19	43	39.53	17	43	0.4372	0.3310	-0.4372	0.6690	0.6620
23: LI2	57.14	16	28	60.71	17	28	-0.2716	0.6070	0.2716	0.3930	0.7859
24: LI1	70.83	17	24	66.67	16	24	0.3114	0.3777	-0.3114	0.6222	0.7555
All Teeth	47.10	268	569	47.45	270	569	-0.1888	0.5473	0.1188	0.4527	0.9055

Table A4.2: Comparison of general CI values to male-specific CI values.

Tooth	General Values			Male Values			General Correct Test		Male Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	64.00	16	25	64.00	16	25	0.0000	0.5000	0.0000	0.5000	1.0000
10: UI2	77.78	21	27	62.96	17	27	1.1921	0.1166	-1.1921	0.8833	0.2332
11: UC	37.21	16	43	30.23	13	43	0.6843	0.2469	-0.6843	0.7531	0.4938
12: UP1	43.48	10	23	47.83	11	23	-0.2960	0.6164	0.2960	0.3836	0.7672
13: UP2	48.57	17	35	51.43	18	35	-0.2390	0.5945	0.2390	0.4055	0.8111
14: UM1	75.86	22	29	75.86	22	29	0.0000	0.5000	0.0000	0.5000	1.0000
15: UM2	46.67	21	45	48.89	22	45	-0.2110	0.5836	0.2110	0.4164	0.8329
16: UM3	45.16	14	31	45.16	14	31	0.0000	0.5000	0.0000	0.5000	1.0000
17: LM3	41.67	15	36	52.78	19	36	-0.9443	0.8275	0.9443	0.1725	0.3450
18: LM2	34.69	17	49	40.82	20	49	-0.6251	0.7341	0.6251	0.2659	0.5319
19: LM1	58.00	29	50	58.00	29	50	0.0000	0.5000	0.0000	0.5000	1.0000
20: LP2	52.00	26	50	54.00	27	50	-0.2004	0.5794	0.2004	0.4206	0.8412
21: LP1	36.96	17	46	45.65	21	46	-0.8470	0.8015	0.8470	0.1985	0.3970
22: LC	43.18	19	44	31.82	14	44	1.1010	0.1355	-1.1010	0.8645	0.2709
23: LI2	45.45	15	33	42.42	14	33	0.2480	0.4021	-0.2480	0.5979	0.8041
24: LI1	71.43	20	28	71.43	20	28	0.0000	0.5000	0.0000	0.5000	1.0000
All Teeth	49.66	295	594	50.00	297	594	-0.1161	0.5462	0.1161	0.4538	0.9076

Table A4.3: Comparison of general CI values to African-American-specific CI values.

Tooth	General Values			African American Values			General Correct Test		African American Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
10: UI2	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
11: UC	100.00	2	2	100.00	2	2	N/A	N/A	N/A	N/A	N/A
12: UP1	50.00	1	2	100.00	2	2	-1.1547	0.8759	1.1547	0.1241	0.2482
13: UP2	50.00	1	2	50.00	1	2	0.0000	0.5000	0.0000	0.5000	1.0000
14: UM1	33.33	1	3	33.33	1	3	0.0000	0.5000	0.0000	0.5000	1.0000
15: UM2	66.67	2	3	66.67	2	3	0.0000	0.5000	0.0000	0.5000	1.0000
16: UM3	100.00	3	3	100.00	3	3	N/A	N/A	N/A	N/A	N/A
17: LM3	66.67	2	3	100.00	3	3	-1.0954	0.8633	1.0954	0.1367	0.2733
18: LM2	33.33	1	3	33.33	1	3	0.0000	0.5000	0.0000	0.5000	1.0000
19: LM1	66.67	2	3	66.67	2	3	0.0000	0.5000	0.0000	0.5000	1.0000
20: LP2	33.33	1	3	33.33	1	3	0.0000	0.5000	0.0000	0.5000	1.0000
21: LP1	50.00	1	2	100.00	3	2	-1.1547	0.8759	1.1547	0.1241	0.2482
22: LC	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
23: LI2	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
24: LI1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
All Teeth	60.61	20	33	69.70	23	33	-0.7750	0.7808	0.7750	0.2192	0.4383

Table A4.4: Comparison of general CI values to Asian-American-specific CI values.

Tooth	General Values			Asian American Values			General Correct Test		Asian American Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	0.00	0	1	100.00	1	1	-1.4142	0.9214	1.4142	0.0786	0.1573
10: UI2	100.00	2	2	50.00	1	2	1.1547	0.1241	-1.1547	0.8759	0.2482
11: UC	100.00	3	3	66.67	2	3	1.0954	0.1367	-1.0954	0.8633	0.2733
12: UP1	100.00	2	2	50.00	1	2	1.1547	0.1241	-1.1547	0.8759	0.2482
13: UP2	75.00	3	4	50.00	2	4	0.7303	0.2326	-0.7303	0.7674	0.4652
14: UM1	100.00	2	2	100.00	2	2	N/A	N/A	N/A	N/A	N/A
15: UM2	33.33	1	3	66.67	2	3	-0.8165	0.7929	0.8165	0.2071	0.4142
16: UM3	0.00	0	1	100.00	1	1	-1.4142	0.9214	1.4142	0.0786	0.1573
17: LM3	50.00	1	2	50.00	1	2	0.0000	0.5000	0.0000	0.5000	1.0000
18: LM2	50.00	2	4	75.00	3	4	-0.7303	0.7674	0.7303	0.2326	0.4652
19: LM1	75.00	3	4	50.00	2	4	0.7303	0.2326	-0.7303	0.7674	0.4652
20: LP2	25.00	1	4	50.00	2	4	-0.7303	0.7674	0.7303	0.2326	0.4652
21: LP1	75.00	3	4	50.00	2	4	0.7303	0.2326	-0.7303	0.7674	0.4652
22: LC	100.00	2	2	100.00	2	2	N/A	N/A	N/A	N/A	N/A
23: LI2	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
24: LI1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
All Teeth	67.50	27	40	66.67	26	39	0.0788	0.4686	-0.0788	0.5314	0.9372

Table A4.5: Comparison of general CI values to European-American-specific CI values.

Tooth	General Values			European American Values			General Correct Test		European American Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	60.87	14	23	56.52	13	23	0.2994	0.3823	-0.2994	0.6177	0.7646
10: UI2	52.00	13	25	44.00	11	25	0.5661	0.2856	-0.5661	0.7144	0.5713
11: UC	38.46	15	39	38.46	15	39	0.0000	0.5000	0.0000	0.5000	1.0000
12: UP1	15.79	3	19	36.84	7	19	-1.4736	0.9297	1.4736	0.0703	0.1406
13: UP2	33.33	9	27	25.93	7	27	0.5960	0.2756	-0.5960	0.7244	0.5511
14: UM1	65.00	13	20	65.00	13	20	0.0000	0.5000	0.0000	0.5000	1.0000
15: UM2	43.24	16	37	43.24	16	37	0.0000	0.5000	0.0000	0.5000	1.0000
16: UM3	33.33	10	30	40.00	12	30	-0.5358	0.7040	0.5358	0.2960	0.5921
17: LM3	42.42	14	33	42.42	14	33	0.0000	0.5000	0.0000	0.5000	1.0000
18: LM2	26.67	12	45	26.67	12	45	0.0000	0.5000	0.0000	0.5000	1.0000
19: LM1	48.89	22	45	48.89	22	45	0.0000	0.5000	0.0000	0.5000	1.0000
20: LP2	46.67	21	45	46.67	21	45	0.0000	0.5000	0.0000	0.5000	1.0000
21: LP1	37.21	16	43	51.16	22	43	-1.3028	0.9037	1.3028	0.0963	0.1926
22: LC	47.62	20	42	38.10	16	42	0.8819	0.1889	-0.8819	0.8111	0.3778
23: LI2	48.28	14	29	41.38	12	29	0.5281	0.2987	-0.5281	0.7013	0.5975
24: LI1	72.00	18	25	72.00	18	25	0.0000	0.5000	0.0000	0.5000	1.0000
All Teeth	43.64	230	527	43.83	231	527	-0.0621	0.5248	0.0621	0.4752	0.9505

Table A4.6: Comparison of general CI values to Hispanic-specific CI values.

Tooth	General Values			Hispanic Values			General Correct Test		Hispanic Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	54.17	13	24	58.33	14	24	-0.2910	0.6145	0.2910	0.3855	0.7711
10: UI2	52.17	12	23	69.57	16	23	-1.2084	0.8866	1.2084	0.1134	0.2269
11: UC	32.36	11	34	26.47	9	34	0.5323	0.2973	-0.5323	0.7027	0.5945
12: UP1	26.32	5	19	57.89	11	19	-1.9714	0.9757	1.9714	*0.0243**	*0.0487**
13: UP2	50.00	13	26	30.77	8	26	1.4131	0.0788	-1.4131	0.9212	0.1576
14: UM1	69.57	16	23	69.57	16	23	0.0000	0.5000	0.0000	0.5000	1.0000
15: UM2	51.52	17	33	39.39	13	33	0.9888	0.1614	-0.9888	0.8386	0.3227
16: UM3	47.83	11	23	52.17	12	23	-0.2949	0.6160	0.2949	0.3840	0.7681
17: LM3	32.00	8	25	48.00	12	25	-1.1547	0.8759	1.1547	0.1241	0.2482
18: LM2	36.84	14	38	52.63	20	38	-1.3842	0.9168	1.3842	0.0832	0.1663
19: LM1	56.41	22	39	58.97	23	39	-0.2292	0.5906	0.2292	0.4094	0.8187
20: LP2	60.53	23	38	39.47	15	38	1.8353	*0.0332**	-1.8353	0.9668	0.0665
21: LP1	29.73	11	37	37.84	14	37	-0.7373	0.7695	0.7373	0.2305	0.4609
22: LC	28.57	10	35	31.43	11	35	-0.2608	0.6029	0.2608	0.3971	0.7942
23: LI2	41.67	10	24	45.83	11	24	-0.2910	0.6145	0.2910	0.3855	0.7711
24: LI1	60.00	12	20	60.00	12	20	0.0000	0.5000	0.0000	0.5000	1.0000
All Teeth	45.12	208	461	47.07	217	461	-0.5946	0.7239	0.5946	0.2761	0.5521

Table A4.7: Comparison of general CI values to Native American-specific CI values.

Tooth	General Values			Native American Values			General Correct Test		Native American Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
10: UI2	66.67	2	3	66.67	2	3	0.0000	0.5000	0.0000	0.5000	1.0000
11: UC	50.00	2	4	75.00	3	4	-0.7303	0.7674	0.7303	0.2326	0.4652
12: UP1	50.00	1	2	100.00	2	2	-1.1547	0.8759	1.1547	0.1241	0.2482
13: UP2	66.67	2	3	66.67	2	3	0.0000	0.5000	0.0000	0.5000	1.0000
14: UM1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
15: UM2	75.00	3	4	100.00	4	4	-1.0690	0.8575	1.0690	0.1425	0.2850
16: UM3	50.00	2	4	75.00	3	4	-0.7303	0.7674	0.7303	0.2326	0.4652
17: LM3	25.00	1	4	50.00	2	4	0.7303	0.7674	-0.7303	0.2326	0.4652
18: LM2	50.00	2	4	75.00	3	4	-0.7303	0.7674	0.7303	0.2326	0.4652
19: LM1	75.00	3	4	100.00	4	4	-1.0690	0.8575	1.0690	0.1425	0.2850
20: LP2	50.00	2	4	50.00	2	4	0.0000	0.5000	0.0000	0.5000	1.0000
21: LP1	33.33	1	3	66.67	2	3	-0.8165	0.7929	0.8165	0.2071	0.4142
22: LC	66.67	2	3	66.67	2	3	0.0000	0.5000	0.0000	0.5000	1.0000
23: LI2	50.00	1	2	50.00	1	2	0.0000	0.5000	0.0000	0.5000	1.0000
24: LI1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
All Teeth	57.45	27	47	74.47	35	47	-1.7413	0.9592	1.7413	*0.0408**	0.0816

Table A4.8: Comparison of general CI values to African-American-female-specific CI values.

Tooth	General Values			African American Female Values			General Correct Test		African American Female Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
10: UI2	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
11: UC	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
12: UP1	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
13: UP2	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
14: UM1	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
15: UM2	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
16: UM3	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
17: LM3	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
18: LM2	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
19: LM1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
20: LP2	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
21: LP1	0.00	0	1	100.00	1	1	-1.4142	0.9214	1.4142	0.0786	0.1573
22: LC	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
23: LI2	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
24: LI1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
All Teeth	53.33	8	16	60.00	9	16	-0.3542	0.6384	0.3542	0.3616	0.7232

Table A4.9: Comparison of general CI values to African-American-male-specific CI values.

Tooth	General Values			African American Male Values			General Correct Test		African American Male Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
11: UC	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
12: UP1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
13: UP2	100.00	1	1	0.00	0	1	1.4142	0.0786	-1.4142	0.9214	0.1573
14: UM1	50.00	1	2	50.00	1	2	0.0000	0.5000	0.0000	0.5000	1.0000
15: UM2	50.00	1	2	50.00	1	2	0.0000	0.5000	0.0000	0.5000	1.0000
16: UM3	100.00	2	2	100.00	2	2	N/A	N/A	N/A	N/A	N/A
17: LM3	50.00	1	2	50.00	1	2	0.0000	0.5000	0.0000	0.5000	1.0000
18: LM2	50.00	1	2	50.00	1	2	0.0000	0.5000	0.0000	0.5000	1.0000
19: LM1	50.00	1	2	50.00	1	2	0.0000	0.5000	0.0000	0.5000	1.0000
20: LP2	50.00	1	2	50.00	1	2	0.0000	0.5000	0.0000	0.5000	1.0000
21: LP1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
22: LC	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
23: LI2	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
All Teeth	66.67	12	18	61.11	11	18	0.3470	0.3643	-0.3470	0.6357	0.7286

Table A4.10: Comparison of general CI values to Asian-American-male-specific CI values.

Tooth	General Values			Asian American Male Values			General Correct Test		Asian American Male Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	0.00	0	1	100.00	1	1	-1.4142	0.9214	1.4142	0.0786	0.1573
10: UI2	100.00	2	2	50.00	1	2	1.1547	0.1241	-1.1547	0.8759	0.2482
11: UC	100.00	3	3	66.67	2	3	1.0954	0.1367	-1.0954	0.8633	0.2733
12: UP1	100.00	2	2	50.00	1	2	1.1547	0.1241	-1.1547	0.8759	0.2482
13: UP2	75.00	3	4	25.00	1	4	1.4142	0.0786	-1.4142	0.9214	0.1573
14: UM1	100.00	2	2	100.00	2	2	N/A	N/A	N/A	N/A	N/A
15: UM2	33.33	1	3	33.33	1	3	0.0000	0.5000	0.0000	0.5000	1.0000
16: UM3	0.00	0	1	100.00	1	1	-1.4142	0.9214	1.4142	0.0786	0.1573
17: LM3	50.00	1	2	0.00	0	2	1.1547	0.1241	-1.1547	0.8759	0.2482
18: LM2	50.00	2	4	100.00	4	4	-1.6330	0.9488	1.6330	0.0512	0.1025
19: LM1	75.00	3	4	50.00	2	4	0.7303	0.2326	-0.7303	0.7674	0.4652
20: LP2	25.00	1	4	75.00	3	4	-1.4142	0.9214	1.4142	0.0786	0.1573
21: LP1	75.00	3	4	75.00	3	4	0.0000	0.5000	0.0000	0.5000	1.0000
22: LC	100.00	2	2	50.00	1	2	1.1547	0.1241	-1.1547	0.8759	0.2482
23: LI2	100.00	1	1	0.00	0	1	1.4142	0.0786	-1.4142	0.9214	0.1573
24: LI1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
All Teeth	67.50	27	40	60.00	24	40	0.6977	0.2427	-0.6977	0.7573	0.4853

Table A4.11: Comparison of general CI values to European-American-female-specific CI values.

Tooth	General Values			European American Female Values			General Correct Test		European American Female Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	54.55	6	11	63.63	7	11	-0.4336	0.6677	0.4336	0.3323	0.6646
10: UI2	38.46	5	13	46.15	6	13	-0.3970	0.6543	0.3970	0.3457	0.6914
11: UC	52.63	10	19	57.89	11	19	-0.3263	0.6279	0.3263	0.3721	0.7442
12: UP1	10.00	1	10	40.00	4	10	-1.5492	0.9393	1.5492	0.0607	0.1213
13: UP2	41.67	5	12	41.67	5	12	0.0000	0.5000	0.0000	0.5000	1.0000
14: UM1	55.56	5	9	55.56	5	9	0.0000	0.5000	0.0000	0.5000	1.0000
15: UM2	55.56	10	18	55.56	10	18	0.0000	0.5000	0.0000	0.5000	1.0000
16: UM3	27.78	5	18	44.44	8	18	-1.0410	0.8511	1.0410	0.1489	0.2979
17: LM3	33.33	6	18	50.00	9	18	-1.0142	0.8448	1.0142	0.1552	0.3105
18: LM2	30.43	7	23	26.09	6	23	0.3275	0.3717	-0.3275	0.6283	0.7433
19: LM1	52.17	12	23	52.17	12	23	0.0000	0.5000	0.0000	0.5000	1.0000
20: LP2	43.48	10	23	43.48	10	23	0.0000	0.5000	0.0000	0.5000	1.0000
21: LP1	45.45	10	22	54.55	12	22	-0.6030	0.7268	0.6030	0.2732	0.5465
22: LC	47.62	10	21	42.86	9	21	0.3100	0.3783	-0.3100	0.6217	0.7565
23: LI2	58.33	7	12	58.33	7	12	0.0000	0.5000	0.0000	0.5000	1.0000
24: LI1	75.00	9	12	75.00	9	12	0.0000	0.5000	0.0000	0.5000	1.0000
All Teeth	44.70	118	264	49.24	130	264	-1.0464	0.8523	1.0464	0.1477	0.2954

Table A4.12: Comparison of general CI values to European-American-male-specific CI values.

Tooth	General Values			European American Male Values			General Correct Test		European American Male Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	66.67	8	12	41.67	5	12	1.2290	0.1095	-1.2290	0.8905	0.2191
10: UI2	66.67	8	12	58.33	7	12	0.4216	0.3366	-0.4216	0.6634	0.6733
11: UC	25.00	5	20	35.00	7	20	-0.6901	0.7549	0.6901	0.2451	0.4902
12: UP1	22.22	2	9	44.44	4	9	-1.0000	0.8413	1.0000	0.1587	0.3173
13: UP2	26.67	4	15	20.00	3	15	0.4317	0.3330	-0.4317	0.6670	0.6660
14: UM1	72.73	8	11	45.45	5	11	1.3009	0.0966	-1.3009	0.9034	0.1933
15: UM2	31.58	6	19	42.11	8	19	-0.6726	0.7494	0.6726	0.2506	0.5012
16: UM3	41.67	5	12	33.33	4	12	0.4216	0.3366	-0.4216	0.6634	0.6733
17: LM3	53.33	8	15	46.67	7	15	0.3651	0.3575	-0.3651	0.6425	0.7150
18: LM2	22.73	5	22	27.27	6	22	-0.3482	0.6361	0.3482	0.3639	0.7277
19: LM1	45.45	10	22	54.55	12	22	-0.6030	0.7268	0.6030	0.2732	0.5465
20: LP2	50.00	11	22	54.55	12	22	-0.3018	0.6186	0.3018	0.3814	0.7628
21: LP1	28.57	6	21	42.88	9	21	-0.9661	0.8330	0.9661	0.1670	0.3340
22: LC	47.62	10	21	28.57	6	21	1.2710	0.1019	-1.2710	0.8981	0.2037
23: LI2	41.18	7	17	41.18	7	17	0.0000	0.5000	0.0000	0.5000	1.0000
24: LI1	69.23	9	13	69.23	9	13	0.0000	0.5000	0.0000	0.5000	1.0000
All Teeth	42.59	112	263	42.21	111	263	0.0882	0.4648	-0.0882	0.5352	0.9297

Table A4.13: Comparison of general CI values to Hispanic-female-specific CI values.

Tooth	General Values			Hispanic Female Values			General Correct Test		Hispanic Female Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	50.00	7	14	50.00	7	14	0.0000	0.5000	0.0000	0.5000	1.0000
10: UI2	28.57	4	14	35.71	5	14	-0.4047	0.6571	0.4047	0.3429	0.6857
11: UC	27.78	5	18	27.78	5	18	0.0000	0.5000	0.0000	0.5000	1.0000
12: UP1	10.00	1	10	50.00	5	10	-1.9518	0.9745	1.9518	*0.0255**	0.0510
13: UP2	42.86	6	14	42.86	6	14	0.0000	0.5000	0.0000	0.5000	1.0000
14: UM1	63.64	7	11	63.64	7	11	0.0000	0.5000	0.0000	0.5000	1.0000
15: UM2	43.75	7	16	43.75	7	16	0.0000	0.5000	0.0000	0.5000	1.0000
16: UM3	63.64	7	11	63.64	7	11	0.0000	0.5000	0.0000	0.5000	1.0000
17: LM3	41.67	5	12	41.67	5	12	0.0000	0.5000	0.0000	0.5000	1.0000
18: LM2	35.00	7	20	55.00	11	20	-1.2713	0.8982	1.2713	0.1018	0.2036
19: LM1	45.00	9	20	55.00	11	20	-0.6325	0.7365	0.6325	0.2635	0.5271
20: LP2	65.00	13	20	45.00	9	20	1.2713	0.1018	-1.2713	0.8982	0.2036
21: LP1	30.00	6	20	40.00	8	20	-0.6630	0.7463	0.6630	0.2537	0.5073
22: LC	29.41	5	17	35.29	6	17	-0.3666	0.6430	0.3666	0.3570	0.7139
23: LI2	41.67	5	12	41.67	5	12	0.0000	0.5000	0.0000	0.5000	1.0000
24: LI1	50.00	4	8	50.00	4	8	0.0000	0.5000	0.0000	0.5000	1.0000
All Teeth	41.35	98	237	45.57	108	237	-0.9266	0.8229	0.9266	0.1771	0.3541

Table A4.14: Comparison of general CI values to Hispanic-male-specific CI values.

Tooth	General Values			Hispanic Male Values			General Correct Test		Hispanic Male Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	60.00	6	10	80.00	8	10	-0.9759	0.8354	0.9759	0.1646	0.3291
10: UI2	88.89	8	9	100.00	9	9	-1.0290	0.8483	1.0290	0.1517	0.3035
11: UC	37.50	6	16	37.50	6	16	0.0000	0.5000	0.0000	0.5000	1.0000
12: UP1	44.44	4	9	66.67	6	9	-0.9487	0.8286	0.9487	0.1714	0.3428
13: UP2	58.33	7	12	58.33	7	12	0.0000	0.5000	0.0000	0.5000	1.0000
14: UM1	75.00	9	12	75.00	9	12	0.0000	0.5000	0.0000	0.5000	1.0000
15: UM2	58.82	10	17	41.18	7	17	1.0290	0.1517	-1.0290	0.8483	0.3035
16: UM3	33.33	4	12	41.67	5	12	-0.4216	0.6634	0.4216	0.3366	0.6733
17: LM3	23.08	3	13	61.54	8	13	-1.9848	0.9764	1.9848	*0.0236**	*0.0472**
18: LM2	38.89	7	18	72.22	13	18	-2.0125	0.9779	2.0125	*0.0221**	*0.0442**
19: LM1	68.42	13	19	73.68	14	19	-0.3577	0.6397	0.3577	0.3603	0.7206
20: LP2	55.56	10	18	50.00	9	18	0.3338	0.3692	-0.3338	0.6308	0.7385
21: LP1	29.41	5	17	47.06	8	17	-1.0587	0.8551	1.0587	0.1449	0.2897
22: LC	27.78	5	18	27.78	5	18	0.0000	0.5000	0.0000	0.5000	1.0000
23: LI2	41.67	5	12	50.00	6	12	-0.4097	0.6590	0.4097	0.3410	0.6820
24: LI1	66.67	8	12	83.33	10	12	-0.9428	0.8271	0.9428	0.1729	0.3458
All Teeth	49.11	110	224	58.04	130	224	-1.8947	0.9709	1.8947	*0.0291**	0.0581

Table A4.15: Comparison of general CI values to Native-American-female-specific CI values.

Tooth	General Values			Native American Female Values			General Correct Test		Native American Female Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
10: UI2	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
11: UC	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
12: UP1	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
13: UP2	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
14: UM1	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
15: UM2	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
16: UM3	0.00	0	1	100.00	1	1	-1.4142	0.9214	1.4142	0.0786	0.1573
17: LM3	0.00	0	1	100.00	1	1	-1.4142	0.9214	1.4142	0.0786	0.1573
18: LM2	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
19: LM1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
20: LP2	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
21: LP1	0.00	0	1	0.00	0	1	N/A	N/A	N/A	N/A	N/A
22: LC	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
23: LI2	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
24: LI1	N/A	0	0	N/A	0	0	N/A	N/A	N/A	N/A	N/A
All Teeth	44.44	4	9	66.67	6	9	-0.9487	0.8286	0.9487	0.1714	0.3428

Table A4.16: Comparison of general CI values to Native-American-male-specific CI values.

Tooth	General Values			Native American Male Values			General Correct Test		Native American Male Correct Test		Both Tests
	% corr	n corr	n scor	% corr	n corr	n scor	z-score	one-tail p	z-score	one-tail p	two-tail p
9: UI1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
10: UI2	66.67	2	3	100.00	3	3	-1.0954	0.8633	1.0954	0.1367	0.2733
11: UC	33.33	1	3	33.33	1	3	0.0000	0.5000	0.0000	0.5000	1.0000
12: UP1	50.00	1	2	100.00	2	2	-1.1547	0.8759	1.1547	0.1241	0.2482
13: UP2	66.67	2	3	33.33	1	3	0.8165	0.2071	-0.8165	0.7929	0.4142
14: UM1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
15: UM2	66.67	2	3	100.00	3	3	-1.0954	0.8633	1.0954	0.1367	0.2733
16: UM3	66.67	2	3	66.67	2	3	0.0000	0.5000	0.0000	0.5000	1.0000
17: LM3	33.33	1	3	33.33	1	3	0.0000	0.5000	0.0000	0.5000	1.0000
18: LM2	66.67	2	3	66.67	2	3	0.0000	0.5000	0.0000	0.5000	1.0000
19: LM1	66.67	2	3	100.00	3	3	-1.0954	0.8633	1.0954	0.1367	0.2733
20: LP2	66.67	2	3	66.67	2	3	0.0000	0.5000	0.0000	0.5000	1.0000
21: LP1	50.00	1	2	100.00	2	2	-1.1547	0.8759	1.1547	0.1241	0.2482
22: LC	50.00	1	2	50.00	1	2	0.0000	0.5000	0.0000	0.5000	1.0000
23: LI2	50.00	1	2	50.00	1	2	0.0000	0.5000	0.0000	0.5000	1.0000
24: LI1	100.00	1	1	100.00	1	1	N/A	N/A	N/A	N/A	N/A
All Teeth	60.53	23	38	71.05	27	38	-0.9672	0.8333	0.9672	0.1667	0.3335

Appendix 5: Linear Models for Age Estimation

The results presented in this appendix include linear models based on the entire training sample created in the statistical software R (R Core Team 2017), combining multiple teeth for age estimation. Additionally, a sex- and ancestry-specific version of each linear model is included. Results of accuracy and precision tests are presented when each model is applied to the test sample.

The use of the orthogonal polynomial contrasts tables is explained in Chapter 7. Terms in linear model equations whose coefficient is N/A are not being used to inform the equation and can be ignored in calculations. However, the order of these terms should still be taken into consideration when selecting the appropriate orthogonal polynomial contrasts table and deciding from which row to select values for data transformation.

Definitions for Appendix 5:

Under-aged means estimates are below chronological age; Correct means point estimate matches or PI contains chronological age; Over-aged means estimates are above chronological age. Total n = number of individuals from the test sample to which the linear model could be applied; Total N/A = number of individuals to which linear model could not be applied (i.e., missing information at one or more teeth).

AfA = African American; AsA = Asian American; EA = European American; His = Hispanic; Haw = Hawaiian; Nat = Native American; Fem = Female.

A5.1: Maxillary Polar Model Based on All Individuals

R code: lm(formula = AGE ~ (#9 + #11 + #12 + #14), data = dataset)

Age = 9.0870 + 2.5938(#9.L) – 1.1079(#9.Q) + 0.1417(#9.C) + 0.0384(#9^4) – 0.1863(#9^5) + 3.0854(#11.L) + 1.8167(#11.Q) + 0.1862(#11.C) + 0.4584(#11^4) – 0.1943(#11^5) + 2.6588(#12.L) + 1.2536(#12.Q) + 0.6419(#12.C) + 0.0798(#12^4) – 0.1350(#12^5) + 0.0139(#14.L) + 0.9456(#14.Q) + 0.2732(#14.C) – 0.2710(#14^4)

Residual standard error = 1.871, df = 291

Multiple R^2 = 0.7925, Adjusted R^2 = 0.779

F-statistic = 58.51, F-stat p-value < 0.0000, F-stat df = 19 and 291

Figure A5.1: Plot of chronological age by ages predicted from maxillary polar teeth (#9, 11, 12, and 14).

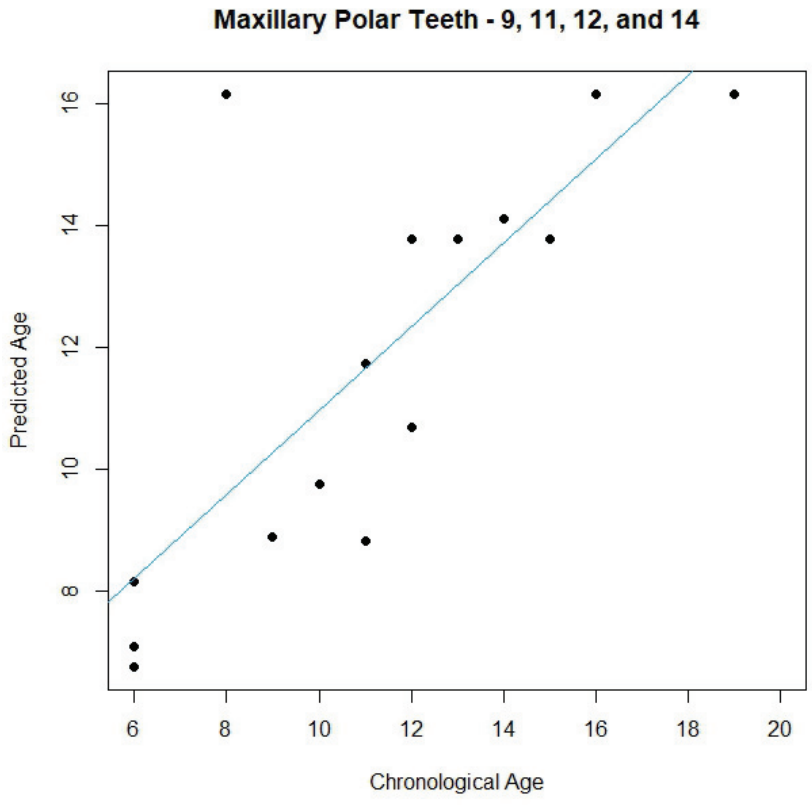


Table A5.1.1: Results of accuracy test with maxillary polar teeth linear model (#9, 11, 12, and 14). Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	0	0.00	4	57.14	3	42.86	0	0.00	6	85.71	1	14.29	0	0.00	6	85.71	1	14.29	7	41
Male	6	66.67	2	22.22	1	11.11	2	22.22	7	77.78	0	0.00	0	0.00	9	100.00	0	0.00	9	42
AfA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2
AsA	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
EA	3	75.00	1	25.00	0	0.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	42
Haw	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
His	2	25.00	3	37.50	3	37.50	0	0.00	7	87.50	1	12.50	0	0.00	7	87.50	1	12.50	8	31
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
AfA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AfA Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
EA Fem	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	23
EA Male	3	100.00	0	0.00	0	0.00	1	33.33	2	66.67	0	0.00	0	0.00	3	100.00	0	0.00	3	19
Haw Fem	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	0	0.00	1	25.00	3	75.00	0	0.00	3	75.00	1	25.00	0	0.00	3	75.00	1	25.00	4	16
His Male	2	50.00	2	50.00	0	0.00	0	0.00	4	100.00	0	0.00	0	0.00	4	100.00	0	0.00	4	15
Nat Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
Nat Male	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Total	6	37.50	6	37.50	4	25.00	2	12.50	13	81.25	1	6.25	0	0.00	15	93.75	1	6.25	16	83

Table A5.1.2: Results of accuracy test with maxillary polar teeth linear model (#9, 11, 12, and 14). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	0	0.00	1	33.33	2	66.67	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	0
Childhood Fem	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0
Childhood Male	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Juvenile	3	60.00	1	20.00	1	20.00	1	20.00	3	60.00	1	20.00	0	0.00	4	80.00	1	20.00	5	44
Juvenile Fem	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	1	23
Juvenile Male	3	75.00	1	25.00	0	0.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	21
Adolescence	3	37.50	4	50.00	1	12.50	1	12.50	7	87.50	0	0.00	0	0.00	8	100.00	0	0.00	8	39
Adolescent Fem	0	0.00	3	75.00	1	25.00	0	0.00	4	100.00	0	0.00	0	0.00	4	100.00	0	0.00	4	18
Adolescent Male	3	75.00	1	25.00	0	0.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	21
Total	6	37.50	6	37.50	4	25.00	2	12.50	13	81.25	1	6.25	0	0.00	15	93.75	1	6.25	16	83

Table A5.1.3: Results of precision test with maxillary polar teeth linear model (#9, 11, 12, and 14). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	2.779 – 3.658	7.914 – 10.415
Juvenile	2.599 – 2.664	7.400 – 7.585
Adolescence	2.599 – 2.652	7.400 – 7.551

Table A5.1.4: Accuracy of specific versions of maxillary polar teeth linear model (#9, 11, 12, and 14), applied to the appropriate subsample of the test set, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.1.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	1	14.29	2	28.57	4	57.14	0	0.00	5	71.43	2	28.57	0	0.00	6	85.71	1	14.29	7	41
Male	4	44.44	3	33.33	2	22.22	2	22.22	7	77.78	0	0.00	0	0.00	9	100.00	0	0.00	9	42
AfA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2
AsA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
EA	3	75.00	1	25.00	0	0.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	42
His	2	25.00	3	37.50	3	37.50	0	0.00	7	87.50	1	12.50	0	0.00	7	87.50	1	12.50	8	15
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0

Table A5.1.5: Results of precision tests for specific versions of maxillary polar teeth linear model (#9, 11, 12, and 14), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.544 – 2.963	–	7.266 – 8.462	–
Male	2.712 – 4.714	–	7.750 – 13.474	–
AfA	–	–	–	–
AsA	–	–	–	–
EA	2.678 – 2.954	–	7.654 – 8.445	–
His	2.606 – 3.538	–	7.459 – 10.126	–
Nat	2.207	–	8.954	–

Appendix A5.1.1: Specific Versions of Maxillary Polar Model

A5.1.1.1: Female-Specific Maxillary Polar Model

Age = 8.9147 + 1.1203(#9.L) – 0.8232(#9.Q) + 0.5633(#9.C) + 0.3799(#9^4) – 0.0619(#9^5) + 2.6670(#11.L) + 1.2173(#11.Q) + 0.2336(#11.C) + 0.5809(#11^4) + 0.1487(#11^5) + 3.3493(#12.L) + 1.4595(#12.Q) + 1.2214(#12.C) – 0.1262(#12^4) + 0.4531(#14.L) + 1.3689(#14.Q) + 0.3550(#14.C) – 0.4755(#14^4)

Residual standard error = 1.822, df = 144

Multiple R^2 = 0.8231, Adjusted R^2 = 0.7997

F-statistic = 35.25, F-stat p-value < 0.0000, F-stat df = 19 and 144

A5.1.1.2: Male-Specific Maxillary Polar Model

Age = 9.5537 + 2.4190(#9.L) – 0.9468(#9.Q) – 0.0524(#9.C) – 0.5564(#9^4) + 4.7729(#11.L) + 1.9151(#11.Q) + 0.0731(#11.C) + 0.5372(#11^4) – 0.5350(#11^5) + 0.6089(#12.L) + 1.4987(#12.Q) – 0.1083(#12.C) + 0.0302(#12^4) – 0.1670(#12^5) + 0.3820(#14.L) + 0.4975(#14.Q) + 0.0832(#14.C)

Residual standard error = 1.94, df = 129

Multiple R^2 = 0.7777, Adjusted R^2 = 0.7484

F-statistic = 26.55, F-stat p-value < 0.0000, F-stat df = 17 and 129

A5.1.1.3: African-American-Specific Maxillary Polar Model

Age = 11.4464 – 3.6895(#9.L) – 1.7500(#9.Q) + 2.1243(#9.C) – 7.2731(#11.L) + 0.6999(#11.Q) + 18.9737(#12.L) + N/A(#12.Q) + N/A(#12.C) + N/A(#12^4) + 0.0000(#14.L) + N/A(#14.Q)

Residual standard error = 2.505, df = 7

Multiple R^2 = 0.8414, Adjusted R^2 = 0.6827

F-statistic = 5.304, F-stat p-value = 0.0213, F-stat df = 7 and 7

A5.1.1.4: Asian-American-Specific Maxillary Polar Model

Age = 7.0919 + 10.3418(#9.L) + 2.0515(#9.Q) – 6.0341(#9.C) + 5.8967(#11.L) – 0.5502(#11.Q) + 1.5997(#11.C) + N/A(#11^4) – 6.7663(#12.L) + 6.9606(#12.Q) + N/A(#12.C) + N/A(#12^4) + N/A(#14.L)

Residual standard error = 2.226, df = 10

Multiple R^2 = 0.8473, Adjusted R^2 = 0.7252

F-statistic = 6.938, F-stat p-value = 0.0031, F-stat df = 8 and 10

A5.1.1.5: European-American-Specific Maxillary Polar Model

Age = 9.2600 + 2.0809(#9.L) – 1.6111(#9.Q) + 0.1173(#9.C) + 0.3387(#9^4) – 0.4349(#9^5) + 3.7881(#11.L) + 1.8140(#11.Q) – 0.2420(#11.C) + 0.4884(#11^4) – 0.0943(#11^5) + 2.8280(#12.L) + 2.0644(#12.Q) + 0.5578(#12.C) + 0.0371(#12^4) + 0.1222(#12^5) + 0.3622(#14.L) + 1.0552(#14.Q) – 0.1393(#14.C) – 0.3296(#14^4)

Residual standard error = 1.86, df = 125

Multiple R^2 = 0.8337, Adjusted R^2 = 0.8084

F-statistic = 32.98, F-stat p-value < 0.0000, F-stat df = 19 and 125

A5.1.1.6: Hispanic-Specific Maxillary Polar Model

Age = 9.1666 + 5.2805(#9.L) – 3.2146(#9.Q) + 2.2459(#9.C) – 0.8712(#9^4) – 0.1570(#9^5) – 0.1795(#11.L) + 4.0285(#11.Q) – 1.0038(#11.C) + 0.5249(#11^4) + N/A(#11^5) + 3.3397(#12.L) + 0.1746(#12.Q) + 0.6346(#12.C) + 0.0965(#12^4) – 0.2307(#12^5) – 0.8358(#14.L) + 1.1504(#14.Q)

Residual standard error = 1.853, df = 106

Multiple R^2 = 0.7563, Adjusted R^2 = 0.7196

F-statistic = 20.57, F-stat p-value < 0.0000, F-stat df = 16 and 106

A5.1.1.7: Native-American-Specific Maxillary Polar Model

Age = 10.7500 – 1.5026(#9.L) + 0.7655(#9.Q) + 4.7516(#11.L) + 1.1250(#11.Q) + N/A(#11.C) + 2.2361(#12.L) + N/A(#12.Q) + N/A(#12.C) + N/A(#14.L)

Residual standard error = 1.258, df = 3

Multiple R^2 = 0.9375, Adjusted R^2 = 0.8333

F-statistic = 9.00, F-stat p-value = 0.0501, F-stat df = 5 and 3

A5.2: Mandibular Polar Model Based on All Individuals

R code: lm(formula = AGE ~ (#19 + #21 + #22 + #23), data = dataset)

Age = 8.9709 + 1.3078(#23.L) – 0.0209(#23.Q) – 0.4313(#23.C) – 0.0450(#23^4) + 1.8999(#22.L) + 0.9732(#22.Q) + 0.4556(#22.C) + 0.0720(#22^4) – 0.0929(#22^5) + 3.8942(#21.L) + 1.3899(#21.Q) + 0.9591(#21.C) + 0.2311(#21^4) + 0.2608(#21^5) + 0.4145(#19.L) + 0.8227(#19.Q) – 0.2033(#19.C) + 0.1122(#19^4)

Residual standard error = 1.746, df = 964

Multiple R^2 = 0.7741, Adjusted R^2 = 0.7699

F-statistic = 183.5, F-stat p-value < 0.0000, F-stat df = 18 and 964

Figure A5.2: Plot of chronological age by ages predicted from mandibular polar teeth (#19, 21, 22, and 23).

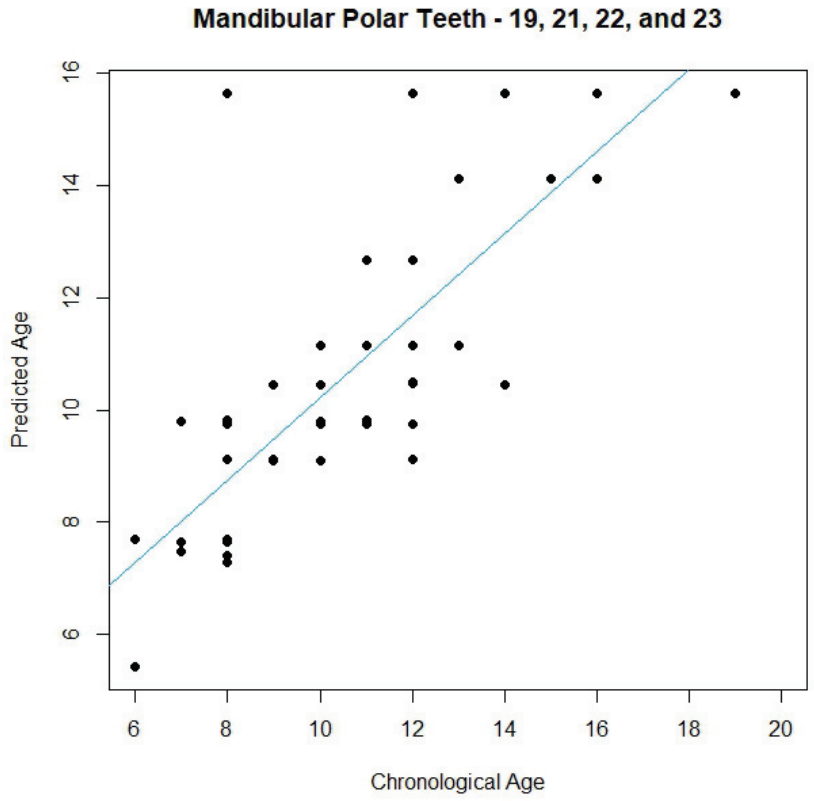


Table A5.2.1: Results of accuracy test with mandibular polar teeth linear model (#19, 21, 22, and 23).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	12	50.00	4	16.67	8	33.33	4	16.67	18	75.00	2	8.33	0	0.00	23	95.83	1	4.17	24	25
Male	17	60.71	5	17.86	6	21.43	8	28.57	18	64.29	2	7.14	1	3.57	27	96.43	0	0.00	28	23
AfA	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
AsA	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
EA	13	54.17	3	12.50	8	33.33	7	29.17	16	66.67	1	4.17	0	0.00	24	100.00	0	0.00	24	22
Haw	3	100.00	0	0.00	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	1
His	11	50.00	5	22.73	6	27.27	4	18.18	15	68.18	3	13.64	1	4.55	20	90.91	1	4.55	22	17
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
AfA Fem	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
AfA Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
AsA Male	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
EA Fem	4	44.44	1	11.11	4	44.44	2	22.22	7	77.78	0	0.00	0	0.00	9	100.00	0	0.00	9	15
EA Male	9	60.00	2	13.33	4	26.67	5	33.33	9	60.00	1	6.67	0	0.00	15	100.00	0	0.00	15	7
Haw Fem	3	100.00	0	0.00	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	0
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	5	45.45	2	18.18	4	36.36	2	18.18	7	63.64	2	18.18	0	0.00	10	90.91	1	9.09	11	9
His Male	6	54.55	3	27.27	2	18.18	2	18.18	8	72.73	1	9.09	1	9.09	10	90.91	0	0.00	11	8
Nat Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
Nat Male	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Total	29	55.77	9	17.31	14	26.92	12	23.08	36	69.23	4	7.69	1	1.92	50	96.15	1	1.92	52	48

Table A5.2.2: Results of accuracy test with mandibular polar teeth linear model (#19, 21, 22, and 23). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	1	50.00	0	0.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
Childhood Fem	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
Childhood Male	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Juvenile	12	42.86	8	28.57	8	28.57	1	3.57	25	89.29	2	7.14	0	0.00	27	96.43	1	3.57	28	21
Juvenile Fem	5	38.46	3	23.08	5	38.46	0	0.00	12	92.31	1	7.69	0	0.00	12	92.31	1	7.69	13	11
Juvenile Male	7	46.67	5	33.33	3	20.00	1	6.67	13	86.67	1	6.67	0	0.00	15	100.00	0	0.00	15	10
Adolescence	16	72.73	1	4.55	5	22.73	11	50.00	9	40.91	2	9.09	1	4.55	21	95.45	0	0.00	22	26
Adolescent Fem	7	70.00	1	10.00	2	20.00	4	40.00	5	50.00	1	10.00	0	0.00	10	100.00	0	0.00	10	13
Adolescent Male	9	75.00	0	0.00	3	25.00	7	58.33	4	33.33	1	8.33	1	8.33	11	91.67	0	0.00	12	13
Total	29	55.77	9	17.31	14	26.92	12	23.08	36	69.23	4	7.69	1	1.92	50	96.15	1	1.92	52	48

Table A5.2.3: Results of precision test with mandibular polar teeth linear model (#19, 21, 22, and 23). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	2.435 – 2.579	6.919 – 7.329
Juvenile	2.416 – 2.470	6.867 – 7.019
Adolescence	2.416 – 2.445	6.867 – 6.949

Table A5.2.4: Accuracy of specific versions of mandibular polar teeth linear model (#19, 21, 22, and 23), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.2.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	13	54.17	4	16.67	7	29.17	5	20.83	17	70.83	2	8.33	0	0.00	23	95.83	1	4.17	24	25
Male	15	53.57	7	25.00	6	21.43	7	25.00	19	67.86	2	7.14	1	3.57	27	96.43	0	0.00	28	23
AfA	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
AsA	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
EA	13	54.17	3	12.50	8	33.33	6	25.00	16	66.67	2	8.33	0	0.00	24	100.00	0	0.00	24	22
His	15	68.18	3	13.64	4	18.18	4	18.18	15	68.18	3	13.64	1	4.55	20	90.91	1	4.55	22	17
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1

Table A5.2.5: Results of precision tests for specific versions of mandibular polar teeth linear model (#19, 21, 22, and 23), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.526 – 2.675	–	7.185 – 7.609	–
Male	2.301 – 2.591	–	6.545 – 7.371	–
AfA	3.474	–	10.133	–
AsA	4.733	–	13.805	–
EA	2.399 – 2.500	–	6.825 – 7.111	–
His	2.254 – 2.320	–	6.414 – 6.602	–
Nat	2.800	–	8.400	–

Appendix A5.2.1: Specific Versions of Mandibular Polar Model

A5.2.1.1: Female-Specific Mandibular Polar Model

Age = 8.8315 + 1.2498(#23.L) + 0.2256(#23.Q) – 0.3634(#23.C) – 0.0437(#23^4) + 1.6616(#22.L) + 1.1051(#22.Q) + 0.3563(#22.C) + 0.0845(#22^4) – 0.0867(#22^5) + 3.9875(#21.L) + 1.4656(#21.Q) + 1.0625(#21.C) + 0.2083(#21^4) + 0.3259(#21^5) + 0.3114(#19.L) + 0.7727(#19.Q) – 0.2256(#19.C) + 0.0636(#19^4)

Residual standard error = 1.823, df = 492

Multiple R^2 = 0.7762, Adjusted R^2 = 0.7680

F-statistic = 94.77, F-stat p-value < 0.0000, F-stat df = 18 and 492

A5.2.1.2: Male-Specific Mandibular Polar Model

Age = 8.9581 + 1.1148(#23.L) – 0.0829(#23.Q) – 0.5124(#23.C) – 0.1123(#23^4) + 2.7111(#22.L) + 0.8064(#22.Q) + 0.5003(#22.C) – 0.0011(#22^4) + 0.0229(#22^5) + 3.5231(#21.L) + 1.2937(#21.Q) + 0.9792(#21.C) + 0.1055(#21^4) + 0.2259(#21^5) + 1.2172(#19.L) + 0.0699(#19.Q) + 0.1149(#19.C)

Residual standard error = 1.658, df = 454

Multiple R^2 = 0.7815, Adjusted R^2 = 0.7733

F-statistic = 95.50, F-stat p-value < 0.0000, F-stat df = 17 and 454

A5.2.1.3: African-American-Specific Mandibular Polar Model

Age = 10.2178 – 0.4482(#23.L) + 0.2078(#23.Q) + 2.4687(#22.L) + 1.0982(#22.Q) – 0.3259(#22.C) + 4.3939(#21.L) + 0.7225(#21.Q) – 0.2244(#21.C) + 0.5686(#21^4) + 0.2735(#21^5) + 0.2112(#19.L)

Residual standard error = 2.199, df = 32

Multiple R^2 = 0.7339, Adjusted R^2 = 0.6424

F-statistic = 8.022, F-stat p-value < 0.0000, F-stat df = 11 and 32

A5.2.1.4: Asian-American-Specific Mandibular Polar Model

Age = 9.6910 + 3.2626(#23.L) – 0.8012(#23.Q) – 0.4966(#23.C) + 5.2379(#22.L) + 2.2456(#22.Q) + 0.8749(#22.C) – 0.7589(#22^4) + 0.8619(#21.L) + 0.7983(#21.Q) – 0.1010(#21.C) – 0.1830(#21^4) + N/A(#21^5) – 0.9124(#19.L) + N/A(#19.Q) + N/A(#19.C)

Residual standard error = 1.783, df = 32

Multiple R^2 = 0.8723, Adjusted R^2 = 0.8245

F-statistic = 18.22, F-stat p-value < 0.0000, F-stat df = 12 and 32

A5.2.1.5: European-American-Specific Mandibular Polar Model

Age = 9.0978 + 1.3728(#23.L) – 0.0539(#23.Q) – 0.5601(#23.C) – 0.0469(#23^4) + 1.9134(#22.L) + 0.9544(#22.Q) + 0.4884(#22.C) – 0.0645(#22^4) – 0.1570(#22^5) + 3.9514(#21.L) + 1.5776(#21.Q) + 1.0387(#21.C) + 0.5158(#21^4) + 0.2636(#21^5) + 0.7793(#19.L) + 0.8118(#19.Q) – 0.1399(#19.C) – 0.0186(#19^4)

Residual standard error = 1.73, df = 449

Multiple R^2 = 0.8123, Adjusted R^2 = 0.8048

F-statistic = 108.00, F-stat p-value < 0.0000, F-stat df = 18 and 449

A5.2.1.6: Hispanic-Specific Mandibular Polar Model

Age = 8.7545 + 1.7203(#23.L) – 0.3811(#23.Q) – 0.0214(#23.C) – 0.0023(#23^4) + 1.0712(#22.L) + 1.1811(#22.Q) + 0.0591(#22.C) + 0.3134(#22^4) + 0.0691(#22^5) + 3.9286(#21.L) + 1.0485(#21.Q) + 0.8996(#21.C) – 0.0378(#21^4) + 0.2208(#21^5) + 0.0491(#19.L) + 0.6384(#19.Q) – 0.0656(#19.C)

Residual standard error = 1.621, df = 382

Multiple R^2 = 0.7308, Adjusted R^2 = 0.7188

F-statistic = 60.99, F-stat p-value < 0.0000, F-stat df = 17 and 382

A5.2.1.7: Native-American-Specific Mandibular Polar Model

Age = 11.3649 + 0.8510(#23.L) – 0.5954(#23.Q) + 3.4961(#22.L) + 0.3233(#22.Q) – 1.7383(#22.C) – 1.4956(#22^4) + 2.2133(#21.L) + 1.3993(#21.Q) + N/A(#21.C) + N/A(#21^4) + 0.2841(#19.L)

Residual standard error = 1.859, df = 16

Multiple R^2 = 0.8092, Adjusted R^2 = 0.7019

F-statistic = 7.54, F-stat p-value = 0.0003, F-stat df = 9 and 16

Appendix A5.3: Maxillary Forensic Model Based on All Individuals

R code: lm(formula = AGE ~ (#12 + #13 + #14 + #15), data = dataset)

Age = 9.6722 + 2.7364(#12.L) + 0.3199(#12.Q) + 0.3496(#12.C) + 0.1429(#12^4) – 0.0867(#12^5) + 1.6048(#13.L) – 0.1312(#13.Q) + 0.7657(#13.C) + 0.0988(#13^4) – 0.3797(#13^5) + 0.0349(#13^6) + 0.1831(#14.L) + 0.3025(#14.Q) + 0.2645(#14.C) + 4.0119(#15.L) + 2.4256(#15.Q) + 0.7236(#15.C) + 0.7244(#15^4) + 0.1866(#15^5) + 0.1301(#15^6) – 0.0014(#15^7)

Residual standard error = 1.615, df = 379

Multiple R^2 = 0.8228, Adjusted R^2 = 0.8130

F-statistic = 83.82, F-stat p-value < 0.0000, F-stat df = 21 and 379

Figure A5.3: Plot of chronological age by ages predicted from maxillary forensic teeth (#12, 13, 14, and 15).

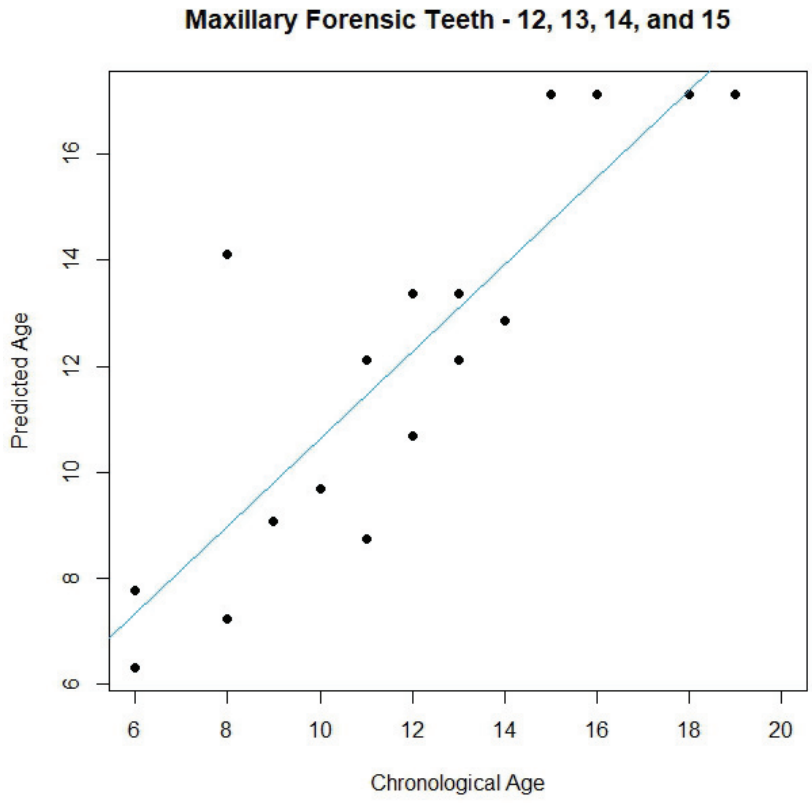


Table A5.3.1: Results of accuracy test with maxillary forensic teeth linear model (#12, 13, 14, and 15).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	2	33.33	0	0.00	4	66.67	0	0.00	5	83.33	1	16.67	0	0.00	5	83.33	1	16.67	6	42
Male	6	54.55	3	27.27	2	18.18	3	27.27	7	63.64	1	9.09	0	0.00	11	100.00	0	0.00	11	40
AfA	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
AsA	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
EA	4	80.00	0	0.00	1	20.00	2	40.00	2	40.00	1	20.00	0	0.00	5	100.00	0	0.00	5	41
Haw	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
His	2	25.00	2	25.00	4	50.00	0	0.00	7	87.50	1	12.50	0	0.00	7	87.50	1	12.50	8	31
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
AfA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AfA Male	1	100.00	0	0.00	0	0.00	0	0.00	3	300.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
EA Fem	2	100.00	0	0.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	22
EA Male	2	66.67	0	0.00	1	33.33	2	66.67	0	0.00	1	33.33	0	0.00	3	100.00	0	0.00	3	19
Haw Fem	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	0	0.00	0	0.00	3	100.00	0	0.00	2	66.67	1	33.33	0	0.00	2	66.67	1	33.33	3	17
His Male	2	40.00	2	40.00	1	20.00	0	0.00	5	100.00	0	0.00	0	0.00	5	100.00	0	0.00	5	14
Nat Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
Nat Male	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Total	8	47.06	3	17.65	6	35.29	3	17.65	12	70.59	2	11.76	0	0.00	16	94.12	1	5.88	17	82

Table A5.3.2: Results of accuracy test with maxillary forensic teeth linear model (#12, 13, 14, and 15). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
Childhood Fem	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
Childhood Male	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Juvenile	3	50.00	1	16.67	2	33.33	1	16.67	4	66.67	1	16.67	0	0.00	5	83.33	1	16.67	6	43
Juvenile Fem	1	50.00	0	0.00	1	50.00	0	0.00	1	50.00	1	50.00	0	0.00	1	50.00	1	50.00	2	22
Juvenile Male	2	50.00	1	25.00	1	25.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	21
Adolescence	5	55.56	1	11.11	3	33.33	2	22.22	6	66.67	1	11.11	0	0.00	9	100.00	0	0.00	9	39
Adolescent Fem	1	33.33	0	0.00	2	66.67	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	20
Adolescent Male	4	66.67	1	16.67	1	16.67	2	33.33	3	50.00	1	16.67	0	0.00	6	100.00	0	0.00	6	19
Total	8	47.06	3	17.65	6	35.29	3	17.65	12	70.59	2	11.76	0	0.00	16	94.12	1	5.88	17	83

Table A5.3.3: Results of precision test with maxillary forensic teeth linear model (#12, 13, 14, and 15). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	2.322 – 2.549	6.608 – 7.252
Juvenile	2.251 – 2.638	6.405 – 7.506
Adolescence	2.245 – 2.305	6.388 – 6.560

Table A5.3.4: Accuracy of specific versions of maxillary forensic teeth linear model (#12, 13, 14, and 15), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.3.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	2	33.33	1	16.67	3	50.00	1	16.67	4	66.67	1	16.67	0	0.00	5	83.33	1	16.67	6	42
Male	6	54.55	3	27.27	2	18.18	2	18.18	8	72.73	1	9.09	0	0.00	11	100.00	0	0.00	11	40
AfA	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
AsA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
EA	4	80.00	0	0.00	1	20.00	3	60.00	1	20.00	1	20.00	0	0.00	5	100.00	0	0.00	5	41
His	5	62.50	2	25.00	1	12.50	1	12.50	6	75.00	1	12.50	0	0.00	7	87.50	1	12.50	8	15
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0

Table A5.3.5: Results of precision tests for specific versions of maxillary forensic teeth linear model (#12, 13, 14, and 15), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.267 – 2.871	–	6.465 – 8.188	–
Male	2.293 – 3.002	–	6.542 – 8.564	–
AfA	1.476	–	4.792	–
AsA	–	–	–	–
EA	2.150 – 2.741	–	6.138 – 7.824	–
His	2.183 – 2.635	–	6.234 – 7.524	–
Nat	2.922	–	9.068	–

Appendix A5.3.1: Specific Versions of Maxillary Forensic Model

A5.3.1.1: Female-Specific Maxillary Forensic Model

Age = 9.3941 + 2.8131(#12.L) + 0.8835(#12.Q) + 0.4473(#12.C) + 0.0617(#12^4) + 0.2898(#12^5) + 0.5130(#13.L) – 0.0302(#13.Q) + 0.6075(#13.C) – 0.0358(#13^4) – 0.2412(#13^5) + 0.1404(#13^6) + 0.6200(#14.L) + 0.2383(#14.Q) + 0.2152(#14.C) + 4.2149(#15.L) + 2.5988(#15.Q) + 0.2832(#15.C) + 1.2157(#15^4) – 0.2589(#15^5) + 0.3157(#15^6) – 0.0577(#15^7)

Residual standard error = 1.62, df = 186

Multiple R^2 = 0.8335, Adjusted R^2 = 0.8147

F-statistic = 44.34, F-stat p-value < 0.0000, F-stat df = 21 and 186

A5.3.1.2: Male-Specific Maxillary Forensic Model

Age = 10.0773 + 2.555(#12.L) – 0.1428(#12.Q) + 0.0557(#12.C) + 0.0709(#12^4) – 0.3775(#12^5) + 2.2917(#13.L) + 0.0667(#13.Q) + 0.9579(#13.C) – 0.4013(#13^4) – 0.2260(#13^5) + 0.7843(#14.L) + 0.0140(#14.Q) + 0.4297(#14.C) + 2.8342(#15.L) + 2.6951(#15.Q) + 0.4652(#15.C) + 0.9023(#15^4) + 0.1529(#15^5) + 0.0935(#15^6)

Residual standard error = 1.636, df = 173

Multiple R^2 = 0.8245, Adjusted R^2 = 0.8052

F-statistic = 42.77, F-stat p-value < 0.0000, F-stat df = 19 and 173

A5.3.1.3: African-American-Specific Maxillary Forensic Model

Age = 10.1167 + 12.4515(#12.L) – 6.9822(#12.Q) + 1.3835(#12.C) – 0.2540(#12^4) + 5.0200(#13.L) – 4.3644(#13.Q) + 4.5280(#13.C) – 4.4883(#13^4) + N/A(#13^5) + 6.7175(#14.L) + N/A(#14.Q) – 19.8707(#15.L) + 16.0390(#15.Q) + N/A(#15.C) + N/A(#15^4) + N/A(#15^5)

Residual standard error = 0.9063, df = 8

Multiple R^2 = 0.9805, Adjusted R^2 = 0.9498

F-statistic = 31.98, F-stat p-value < 0.0000, F-stat df = 11 and 7

A5.3.1.4: Asian-American-Specific Maxillary Forensic Model

Age = 10.3333 + 6.9570(#12.L) + 0.8018(#12.Q) + 3.4785(#12.C) – 11.9523(#12^4) + 13.5978(#13.L) + 1.8708(#13.Q) – 1.8974(#13.C) + N/A(#13^4) + N/A(#14.L) + N/A(#14.Q) – 15.8965(#15.L) + 3.0551(#15.Q) + 5.3666(#15.C) + N/A(#15^4) + N/A(#15^5)

Residual standard error = 1.953, df = 8

Multiple R^2 = 0.9095, Adjusted R^2 = 0.7965

F-statistic = 8.043, F-stat p-value = 0.0035, F-stat df = 10 and 8

A5.3.1.5: European-American-Specific Maxillary Forensic Model

Age = 9.9475 + 2.8430(#12.L) + 0.8398(#12.Q) + 0.5929(#12.C) – 0.3570(#12^4) + 0.2496(#12^5) + 0.7895(#13.L) – 1.5104(#13.Q) + 0.4407(#13.C) + 0.5301(#13^4) – 0.2228(#13^5) – 0.1220(#13^6) + 0.0297(#14.L) + 0.1707(#14.Q) – 0.0347(#14.C) + 5.7344(#15.L) + 3.0699(#15.Q) + 1.3958(#15.C) + 0.0708(#15^4) + 0.4198(#15^5) – 0.748(#15^6) – 0.0051(#15^7)

Residual standard error = 1.539, df = 159

Multiple R^2 = 0.8746, Adjusted R^2 = 0.8580

F-statistic = 52.79, F-stat p-value < 0.0000, F-stat df = 21 and 159

A5.3.1.6: Hispanic-Specific Maxillary Forensic Model

Age = 9.2872 + 4.2581(#12.L) – 0.6113(#12.Q) – 0.1403(#12.C) + 0.8371(#12^4) – 0.3599(#12^5) + 0.0318(#13.L) + 1.3491(#13.Q) + 0.284(#13.C) – 0.3020(#13^4) + 0.1587(#13^5) + 0.0888(#14.L) + 0.5178(#14.Q) + 3.8072(#15.L) + 1.0756(#15.Q) + 0.8384(#15.C) – 0.1784(#15^4) + 0.8109(#15^5) – 0.1094(#15^6)

Residual standard error = 1.551, df = 150

Multiple R^2 = 0.7624, Adjusted R^2 = 0.7339

F-statistic = 26.74, F-stat p-value < 0.0000, F-stat df = 18 and 150

A5.3.1.7: Native-American-Specific Maxillary Forensic Model

Age = 11.4167 + 3.4659(#12.L) + 1.2500(#12.Q) + 0.7826(#12.C) + 1.9007(#13.L) – 0.4167(#13.Q) + 0.2609(#13.C) + N/A(#14.L) + 0(#15.L) + N/A(#15.Q) + N/A(#15.C)

Residual standard error = 1.528, df = 5

Multiple R^2 = 0.8759, Adjusted R^2 = 0.7021

F-statistic = 5.041, F-stat p-value = 0.0468, F-stat df = 7 and 5

Appendix A5.4: Mandibular Forensic Model Based on All Individuals

R code: lm(formula = AGE ~ (#18 + #19 + #20 + #21), data = dataset)

Age = 9.3688 + 2.5429(#21.L) + 0.4202(#21.Q) + 0.4561(#21.C) + 0.0436(#21^4) + 0.1681(#21^5) + 0.7733(#20.L) + 1.1052(#20.Q) + 0.2532(#20.C) + 0.3342(#20^4) – 0.0751(#20^5) – 0.0045(#20^6) – 0.0018(#20^7) + 1.0480(#19.L) + 0.4992(#19.Q) – 0.2615(#19.C) + N/A(#19^4) + 4.1286(#18.L) + 1.9800(#18.Q) + 0.3524(#18.C) + 0.5917(#18^4) – 0.1202(#18^5) + 0.1701(#18^6) – 0.1114(#18^7)

Residual standard error = 1.515, df = 1492

Multiple R^2 = 0.8184, Adjusted R^2 = 0.8157

F-statistic = 305.60, F-stat p-value < 0.0000, F-stat df = 22 and 1492

Figure A5.4: Plot of chronological age by ages predicted from mandibular forensic teeth (#18, 19, 20, and 21).

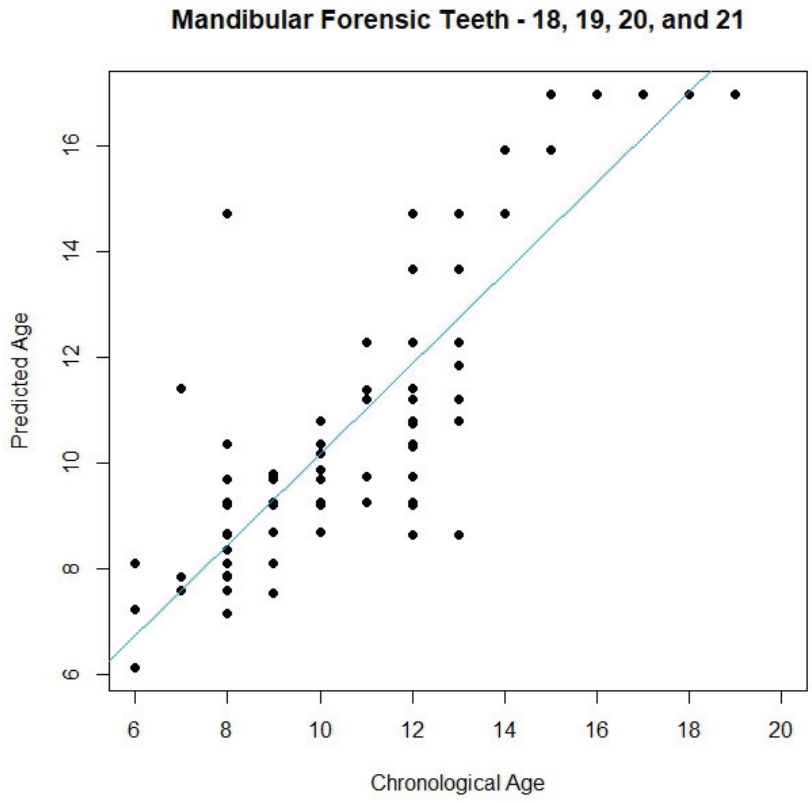


Table A5.4.1: Results of accuracy test with mandibular forensic teeth linear model (#18, 19, 20, and 21).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	18	40.91	16	36.36	10	22.73	8	18.18	32	72.73	4	9.09	2	4.55	41	93.18	1	2.27	44	5
Male	23	52.27	15	34.09	6	13.64	13	29.55	30	68.18	1	2.27	0	0.00	43	97.73	1	2.27	44	7
AfA	2	100.00	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
AsA	1	25.00	2	50.00	1	25.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	0
EA	22	55.00	13	32.50	5	12.50	13	32.50	26	65.00	1	2.50	1	2.50	38	95.00	1	2.50	40	6
Haw	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	1
His	14	38.89	13	36.11	9	25.00	4	11.11	29	80.56	3	8.33	1	2.78	34	94.44	1	2.78	36	3
Nat	2	66.67	0	0.00	1	33.33	2	66.67	0	0.00	1	33.33	0	0.00	3	100.00	0	0.00	3	1
AfA Fem	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
AfA Male	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	1	25.00	2	50.00	1	25.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	0
EA Fem	10	52.63	7	36.84	2	10.53	5	26.32	14	73.68	0	0.00	1	5.26	18	94.74	0	0.00	19	5
EA Male	12	57.14	6	28.57	3	14.29	8	38.10	12	57.14	1	4.76	0	0.00	20	95.24	1	4.76	21	1
Haw Fem	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	0
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	7	35.00	6	30.00	7	35.00	2	10.00	15	75.00	3	15.00	1	5.00	18	90.00	1	5.00	20	0
His Male	7	43.75	7	43.75	2	12.50	2	12.50	14	87.50	0	0.00	0	0.00	16	100.00	0	0.00	16	3
Nat Fem	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	1	0
Nat Male	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
Total	41	46.59	31	35.23	16	18.18	21	23.86	62	70.45	5	5.68	2	2.27	84	95.45	2	2.27	88	12

Table A5.4.2: Results of accuracy test with mandibular forensic teeth linear model (#18, 19, 20, and 21). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	0	0.00	1	33.33	2	66.67	0	0.00	2	66.67	1	33.33	0	0.00	3	100.00	0	0.00	3	0
Childhood Fem	0	0.00	0	0.00	2	100.00	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	2	0
Childhood Male	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Juvenile	17	37.78	21	46.67	7	15.56	5	11.11	37	82.22	3	6.67	0	0.00	43	95.56	2	4.44	45	4
Juvenile Fem	9	39.13	10	43.48	4	17.39	2	8.70	19	82.61	2	8.70	0	0.00	22	95.65	1	4.35	23	1
Juvenile Male	8	36.36	11	50.00	3	13.64	3	13.64	18	81.82	1	4.55	0	0.00	21	95.45	1	4.55	22	3
Adolescence	24	60.00	9	22.50	7	17.50	16	40.00	23	57.50	1	2.50	2	5.00	38	95.00	0	0.00	40	8
Adolescent Fem	9	47.37	6	31.58	4	21.05	6	31.58	12	63.16	1	5.26	2	10.53	17	89.47	0	0.00	19	4
Adolescent Male	15	71.43	3	14.29	3	14.29	10	47.62	11	52.38	0	0.00	0	0.00	21	100.00	0	0.00	21	4
Total	41	46.59	31	35.23	16	18.18	21	23.86	62	70.45	5	5.68	2	2.27	84	95.45	2	2.27	88	12

Table A5.4.3: Results of precision test with mandibular forensic teeth linear model (#18, 19, 20, and 21). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	2.102 – 2.169	5.972 – 6.161
Juvenile	2.099 – 2.135	5.964 – 6.064
Adolescence	2.097 – 2.129	5.958 – 6.048

Table A5.4.4: Accuracy of specific versions of mandibular forensic teeth linear model (#18, 19, 20, and 21), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.4.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	17	38.64	13	29.55	14	31.82	9	20.45	33	75.00	2	4.55	2	4.55	41	93.18	1	2.27	44	5
Male	24	54.55	12	27.27	8	18.18	13	29.55	30	68.18	1	2.27	0	0.00	43	97.73	1	2.27	44	7
AfA	2	100.00	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
AsA	2	50.00	1	25.00	1	25.00	0	0.00	3	75.00	1	25.00	0	0.00	4	100.00	0	0.00	4	0
EA	21	52.50	11	27.50	8	20.00	11	27.50	27	67.50	2	5.00	1	2.50	38	95.00	1	2.50	40	6
His	19	52.78	12	33.33	5	13.89	9	25.00	25	69.44	2	5.56	1	2.78	34	94.44	1	2.78	36	3
Nat	2	66.67	0	0.00	1	33.33	2	66.67	0	0.00	1	33.33	0	0.00	2	66.67	1	33.33	3	0

Table A5.4.5: Results of precision tests for specific versions of mandibular forensic teeth linear model (#18, 19, 20, and 21), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.116 – 2.202	–	6.014 – 6.259	–
Male	2.079 – 2.192	–	5.909 – 6.231	–
AfA	2.706 – 3.111	–	7.817 – 8.989	–
AsA	2.178 – 3.416	25.403	6.329 – 9.927	73.819
EA	1.950 – 2.026	–	5.544 – 5.759	–
His	2.070 – 2.166	–	5.886 – 5.966	–
Nat	2.068 – 3.248	–	6.055 – 9.510	–

Appendix A5.4.1: Specific Versions of Mandibular Forensic Model

A5.4.1.1: Female-Specific Mandibular Forensic Model

Age = 9.3322 + 2.7438(#21.L) + 0.5356(#21.Q) + 0.2411(#21.C) – 0.0449(#21^4) + 0.2810(#21^5) + 0.4056(#20.L) + 1.1721(#20.Q) + 0.5074(#20.C) + 0.2987(#20^4) – 0.2068(#20^5) + 0.0565(#20^6) + 0.0285(#20^7) + 0.8696(#19.L) + 0.4723(#19.Q) – 0.3198(#19.C) + N/A(#19^4) + 4.4106(#18.L) + 2.1705(#18.Q) + 0.2367(#18.C) + 0.7783(#18^4) – 0.1513(#18^5) + 0.0952(#18^6) – 0.1109(#18^7)

Residual standard error = 1.525, df = 779

Multiple R^2 = 0.8269, Adjusted R^2 = 0.8220

F-statistic = 169.10, F-stat p-value < 0.0000, F-stat df = 22 and 779

A5.4.1.2: Male-Specific Mandibular Forensic Model

Age = 9.7069 + 2.6388(#21.L) + 0.3163(#21.Q) + 0.6643(#21.C) + 0.0795(#21^4) + 0.0995(#21^5) + 1.1956(#20.L) + 0.5786(#20.Q) + 0.3081(#20.C) + 0.1414(#20^4) + 0.0056(#20^5) – 0.0120(#20^6) + 1.0966(#19.L) + 0.3607(#19.Q) – 0.1829(#19.C) + 3.6914(#18.L) + 1.3147(#18.Q) + 0.6331(#18.C) + 0.1139(#18^4) + 0.1222(#18^5) – 0.0463(#18^6)

Residual standard error = 1.497, df = 692

Multiple R^2 = 0.8152, Adjusted R^2 = 0.8098

F-statistic = 152.6, F-stat p-value < 0.0000, F-stat df = 20 and 692

A5.4.1.3: African-American-Specific Mandibular Forensic Model

Age = 9.7165 + 1.9125(#21.L) – 0.0268(#21.Q) + 0.2500(#21.C) – 0.3900(#21^4) – 0.2445(#21^5) + 3.8154(#20.L) + 1.7053(#20.Q) – 0.0318(#20.C) – 0.2824(#20^4) – 0.6702(#20^5) + 0.8412(#19.L) – 0.3308(#19.Q) + 2.5845(#18.L) – 0.7079(#18.Q) + 0.5818(#18.C) + 0.7795(#18^4) + 0.5196(#18^5) + 0.0217(#18^6)

Residual standard error = 1.892, df = 49

Multiple $R^2 = 0.7966$, Adjusted $R^2 = 0.7218$

F-statistic = 10.66, F-stat p-value < 0.0000, F-stat df = 18 and 49

A5.4.1.4: Asian-American-Specific Mandibular Forensic Model

Age = 9.3233 + 1.6110(#21.L) + 1.3639(#21.Q) + 0.6130(#21.C) + 0.1028(#21^4) + 0.0984(#21^5) + 1.0471(#20.L) + 1.0199(#20.Q) + 1.2096(#20.C) + 0.4674(#20^4) + 0.3626(#20^5) + 2.0837(#19.L) + 1.7064(#19.Q) – 2.4053(#19.C) + 3.3635(#18.L) + 2.8562(#18.Q) – 1.1343(#18.C) + 1.5307(#18^4) – 0.1244(#18^5) + N/A(#18^6)

Residual standard error = 1.489, df = 37

Multiple $R^2 = 0.9205$, Adjusted $R^2 = 0.8818$

F-statistic = 23.79, F-stat p-value < 0.0000, F-stat df = 18 and 37

A5.4.1.5: European-American-Specific Mandibular Forensic Model

Age = 9.7533 + 2.9375(#21.L) + 0.2941(#21.Q) + 0.3981(#21.C) + 0.0569(#21^4) + 0.1868(#21^5) + 0.9299(#20.L) + 0.5825(#20.Q) + 0.4066(#20.C) – 0.0000(#20^4) – 0.0836(#20^5) – 0.0800(#20^6) + 0.1233(#20^7) + 0.8032(#19.L) + 0.8449(#19.Q) – 0.5427(#19.C) + N/A(#19^4) + 4.3923(#18.L) + 1.9164(#18.Q) + 0.8815(#18.C) + 0.2461(#18^4) + 0.1426(#18^5) – 0.1788(#18^6)

Residual standard error = 1.406, df = 722

Multiple $R^2 = 0.8635$, Adjusted $R^2 = 0.8596$

F-statistic = 217.60, F-stat p-value < 0.0000, F-stat df = 21 and 722

A5.4.1.6: Hispanic-Specific Mandibular Forensic Model

Age = 9.1885 + 2.4063(#21.L) + 0.4554(#21.Q) + 0.4550(#21.C) + 0.0312(#21^4) + 0.1380(#21^5) + 1.7519(#20.L) + 0.3762(#20.Q) + 0.8113(#20.C) + 0.2705(#20^4) + 0.1563(#20^5) – 0.0289(#20^6) + 0.3617(#19.L) + 0.3429(#19.Q) – 0.0821(#19.C) + 3.5724(#18.L) + 1.4109(#18.Q) + 0.0077(#18.C) + 0.3219(#18^4) – 0.2400(#18^5) + 0.2222(#18^6) + 0.0416(#18^7)

Residual standard error = 1.487, df = 582

Multiple R^2 = 0.7693, Adjusted R^2 = 0.7610

F-statistic = 92.43, F-stat p-value < 0.0000, F-stat df = 21 and 582

A5.4.1.7: Native-American-Specific Mandibular Forensic Model

Age = 11.0906 + 3.7476(#21.L) + 0.9119(#21.Q) – 0.0255(#21.C) + 1.0253(#21^4) + 2.1792(#20.L) + 0.3099(#20.Q) + 0.4051(#20.C) – 0.5991(#20^4) + 0.9307(#19.L) + 0.0588(#18.L) + 0.8454(#18.Q) – 1.3160(#18.C) – 1.0349(#18^4) – 0.1742(#18^5)

Residual standard error = 1.389, df = 28

Multiple R^2 = 0.8707, Adjusted R^2 = 0.8061

F-statistic = 13.47, F-stat p-value < 0.0000, F-stat df = 14 and 28

Appendix A5.5: Maxillary and Mandibular Polar Forensic Model Based on All Individuals

R code: lm(formula = AGE ~ (#12 + #14 + #19 + #21), data = dataset)

Age = 9.1109 + 2.6491(#12.L) + 0.0840(#12.Q) + 0.2629(#12.C) + 0.1965(#12^4) – 0.1042(#12^5) – 1.6907(#14.L) + 1.6532(#14.Q) – 0.0102(#14.C) – 0.0840(#14^4) + 2.8516(#19.L) – 0.1254(#19.Q) + 0.0763(#19.C) + N/A(#19^4) + 3.2289(#21.L) + 1.5973(#21.Q) + 1.5831(#21.C) + 0.4424(#21^4) + 0.0977(#21^5)

Residual standard error = 1.795, df = 466

Multiple R^2 = 0.7863, Adjusted R^2 = 0.7786

F-statistic = 100.90, F-stat p-value < 0.0000, F-stat df = 17 and 466

Figure A5.5: Plot of chronological age by ages predicted from maxillary and mandibular polar forensic teeth (#12, 14, 19, and 21).

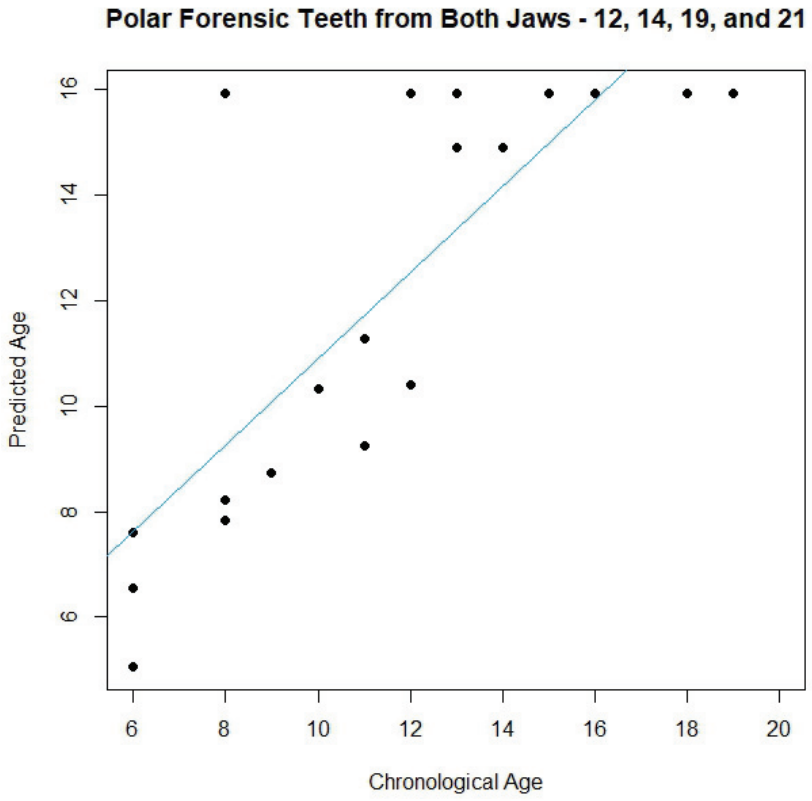


Table A5.5.1: Results of accuracy test with maxillary and mandibular polar forensic teeth linear model (#12, 14, 19, and 21).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	3	37.50	2	25.00	3	37.50	0	0.00	6	75.00	2	25.00	0	0.00	7	87.50	1	12.50	8	40
Male	6	46.15	5	38.46	2	15.38	4	30.77	8	61.54	1	7.69	0	0.00	13	100.00	0	0.00	13	38
AfA	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
AsA	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
EA	3	60.00	2	40.00	0	0.00	2	40.00	3	60.00	0	0.00	0	0.00	5	100.00	0	0.00	5	41
Haw	2	100.00	0	0.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
His	1	10.00	4	40.00	5	50.00	0	0.00	7	70.00	3	30.00	0	0.00	9	90.00	1	10.00	10	29
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
AfA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AfA Male	1	100.00	0	0.00	0	0.00	1	100.00	3	300.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
EA Fem	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	22
EA Male	2	66.67	1	33.33	0	0.00	2	66.67	1	33.33	0	0.00	0	0.00	3	100.00	0	0.00	3	19
Haw Fem	2	100.00	0	0.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	0	0.00	1	25.00	3	75.00	0	0.00	2	50.00	2	50.00	0	0.00	3	75.00	1	25.00	4	16
His Male	1	16.67	3	50.00	2	33.33	0	0.00	5	83.33	1	16.67	0	0.00	6	100.00	0	0.00	6	13
Nat Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
Nat Male	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Total	9	42.86	7	33.33	5	23.81	4	19.05	14	66.67	3	14.29	0	0.00	20	95.24	1	4.76	21	78

Table A5.5.2: Results of accuracy test with maxillary and mandibular polar forensic teeth linear model (#12, 14, 19, and 21). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	1	33.33	1	33.33	1	33.33	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	0
Childhood Fem	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	3	150.00	0	0.00	2	0
Childhood Male	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Juvenile	3	42.86	3	42.86	1	14.29	1	14.29	5	71.43	1	14.29	0	0.00	6	85.71	1	14.29	7	42
Juvenile Fem	1	50.00	0	0.00	1	50.00	0	0.00	1	50.00	1	50.00	0	0.00	1	50.00	1	50.00	2	22
Juvenile Male	2	40.00	3	60.00	0	0.00	1	20.00	4	80.00	0	0.00	0	0.00	5	100.00	0	0.00	5	20
Adolescence	5	45.45	3	27.27	3	27.27	3	27.27	6	54.55	2	18.18	0	0.00	11	100.00	0	0.00	11	37
Adolescent Fem	2	50.00	1	25.00	1	25.00	0	0.00	3	75.00	1	25.00	0	0.00	4	100.00	0	0.00	4	19
Adolescent Male	3	42.86	2	28.57	2	28.57	3	42.86	3	42.86	1	14.29	0	0.00	7	100.00	0	0.00	7	18
Total	9	42.86	7	33.33	5	23.81	4	19.05	14	66.67	3	14.29	0	0.00	20	95.24	1	4.76	21	79

Table A5.5.3: Results of precision test with maxillary and mandibular polar forensic teeth linear model (#12, 14, 19, and 21). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	2.589 – 2.859	7.364 – 8.131
Juvenile	2.488 – 3.029	7.077 – 8.615
Adolescence	2.488 – 2.544	7.077 – 7.237

Table A5.5.4: Accuracy of specific versions of maxillary and mandibular polar forensic teeth linear model (#12, 14, 19, and 21), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.5.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	3	37.50	1	12.50	4	50.00	0	0.00	6	75.00	2	25.00	0	0.00	7	87.50	1	12.50	8	40
Male	6	46.15	5	38.46	2	15.38	3	23.08	9	69.23	1	7.69	0	0.00	13	100.00	0	0.00	13	38
AfA	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
AsA	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
EA	3	60.00	1	20.00	1	20.00	0	0.00	5	100.00	0	0.00	0	0.00	5	100.00	0	0.00	5	41
His	1	10.00	4	40.00	5	50.00	0	0.00	7	70.00	3	30.00	0	0.00	9	90.00	1	10.00	10	13
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	0

Table A5.5.5: Results of precision tests for specific versions of maxillary and mandibular polar forensic teeth linear model (#12, 14, 19, and 21), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.508 – 3.424	–	7.146 – 9.755	–
Male	2.517 – 3.113	–	7.175 – 8.873	–
AfA	3.085	–	9.507	–
AsA	3.373	–	10.205	–
EA	2.534 – 3.292	–	7.227 – 9.387	–
His	2.364 – 2.740	–	6.742 – 7.815	–
Nat	2.007	–	6.309	–

Appendix A5.5.1: Specific Versions of Maxillary and Mandibular Polar Forensic Model

A5.5.1.1: Female-Specific Maxillary and Mandibular Polar Forensic Model

Age = 8.8868 + 2.6321(#12.L) + 0.2061(#12.Q) + 0.5693(#12.C) – 0.0220(#12^4) + 0.0432(#12^5) – 3.0884(#14.L) + 3.3547(#14.Q) – 0.8871(#14.C) – 0.0464(#14^4) + 4.2513(#19.L) – 1.7486(#19.Q) + 0.8538(#19.C) + N/A(#19^4) + 3.2378(#21.L) + 1.9364(#21.Q) + 1.3689(#21.C) + 0.4586(#21^4) + 0.5269(#21^5)

Residual standard error = 1.803, df = 236

Multiple R^2 = 0.8016, Adjusted R^2 = 0.7873

F-statistic = 56.10, F-stat p-value < 0.0000, F-stat df = 17 and 236

A5.5.1.2: Male-Specific Maxillary and Mandibular Polar Forensic Model

Age = 9.3837 + 2.2596(#12.L) + 0.2342(#12.Q) – 0.2198(#12.C) + 0.3390(#12^4) – 0.1148(#12^5) – 0.3625(#14.L) + 0.7643(#14.Q) + 0.0335(#14.C) + 1.7906(#19.L) + 0.5173(#19.Q) – 0.3169(#19.C) + 3.5215(#21.L) + 1.1882(#21.Q) + 1.7887(#21.C) + 0.2583(#21^4) – 0.2159(#21^5)

Residual standard error = 1.809, df = 213

Multiple R^2 = 0.7793, Adjusted R^2 = 0.7627

F-statistic = 47.00, F-stat p-value < 0.0000, F-stat df = 16 and 213

A5.5.1.3: African-American-Specific Maxillary and Mandibular Polar Forensic Model

Age = 9.9600 + 3.9212(#12.L) – 0.4989(#12.Q) + 0.6957(#12.C) + 0.0558(#12^4) + 1.4142(#14.L) + 0.0000(#14.Q) + N/A(#19.L) + 2.0028(#21.L) + 2.3697(#21.Q) + N/A(#21.C) + N/A(#21^4)

Residual standard error = 2.009, df = 11

Multiple R^2 = 0.8473, Adjusted R^2 = 0.7363

F-statistic = 7.631, F-stat p-value = 0.0015, F-stat df = 8 and 11

A5.5.1.4: Asian-American-Specific Maxillary and Mandibular Polar Forensic Model

Age = 10.7231 + 2.9190(#12.L) + 0.5962(#12.Q) + 3.0407(#12.C) – 1.9583(#12^4) – 0.7071(#14.L) + N/A(#14.Q) + 0.7071(#19.L) + N/A(#19.Q) + 3.6366(#21.L) + 0.9354(#21.Q) + 0.6325(#21.C) + N/A(#21^4)

Residual standard error = 2.292, df = 14

Multiple R^2 = 0.8297, Adjusted R^2 = 0.7202

F-statistic = 7.577, F-stat p-value = 0.0005, F-stat df = 9 and 14

A5.5.1.5: European-American-Specific Maxillary and Mandibular Polar Forensic Model

Age = 9.3302 + 2.9605(#12.L) + 0.9990(#12.Q) + 0.6375(#12.C) + 0.2116(#12^4) + 0.0429(#12^5) – 1.0256(#14.L) + 1.035(#14.Q) – 0.0133(#14.C) – 0.2878(#14^4) + 2.3322(#19.L) + 0.1575(#19.Q) – 0.3088(#19.C) + N/A(#19^4) + 3.5706(#21.L) + 1.3125(#21.Q) + 1.0159(#21.C) + 0.1919(#21^4) + 0.3824(#21^5)

Residual standard error = 1.821, df = 197

Multiple R^2 = 0.8223, Adjusted R^2 = 0.8070

F-statistic = 53.62, F-stat p-value < 0.0000, F-stat df = 17 and 197

A5.5.1.6: Hispanic-Specific Maxillary and Mandibular Polar Forensic Model

Age = 8.9010 + 2.4124(#12.L) – 0.921(#12.Q) – 0.1529(#12.C) + 0.0300(#12^4) – 0.1627(#12^5) + 0.0835(#14.L) + 0.8647(#14.Q) + 1.9580(#19.L) – 0.0971(#19.Q) + 0.0305(#19.C) + 2.7752(#21.L) + 2.1672(#21.Q) + 1.6517(#21.C) + 0.6996(#21^4) – 0.0738(#21^5)

Residual standard error = 1.695, df = 194

Multiple R^2 = 0.7562, Adjusted R^2 = 0.7373

F-statistic = 40.10, F-stat p-value < 0.0000, F-stat df = 15 and 194

A5.5.1.7: Native-American-Specific Maxillary and Mandibular Polar Forensic Model

Age = 10.875 + 7.7144(#12.L) + 0.9167(#12.Q) + 0.7081(#12.C) + 0.7071(#14.L) + N/A(#19.L) – 3.7268(#21.L) + N/A(#21.Q) + N/A(#21.C)

Residual standard error = 1.291, df = 9

Multiple R^2 = 0.8377, Adjusted R^2 = 0.7475

F-statistic = 9.288, F-stat p-value = 0.0023, F-stat df = 5 and 9

Appendix A5.6: Maxillary and Mandibular Molars (no Third) Model Based on All Individuals

R code: lm(formula = AGE ~ (#14 + #15 + #18 + #19), data = dataset)

Age = 9.1815 + 1.6265(#14.L) – 1.2378(#14.Q) + 0.8867(#14.C) – 0.2507(#14^4) + 2.9579(#15.L) + 2.2890(#15.Q) + 0.0740(#15.C) + 0.8420(#15^4) – 0.0870(#15^5) + 0.1167(#15^6) – 0.1316(#15^7) + 5.3739(#18.L) + 0.7877(#18.Q) + 1.6540(#18.C) – 0.1303(#18^4) – 0.0772(#18^5) – 0.1782(#18^6) – 0.1193(#18^7) – 0.3758(#19.L) + 2.0313(#19.Q) – 1.1436(#19.C) + 0.3651(#19^4)

Residual standard error = 1.614, df = 833

Multiple R^2 = 0.8362, Adjusted R^2 = 0.8319

F-statistic = 193.30, F-stat p-value < 0.0000, F-stat df = 22 and 833

Figure A5.6: Plot of chronological age by ages predicted from two molars in both the maxilla and mandible (#14, 15, 18, and 19).

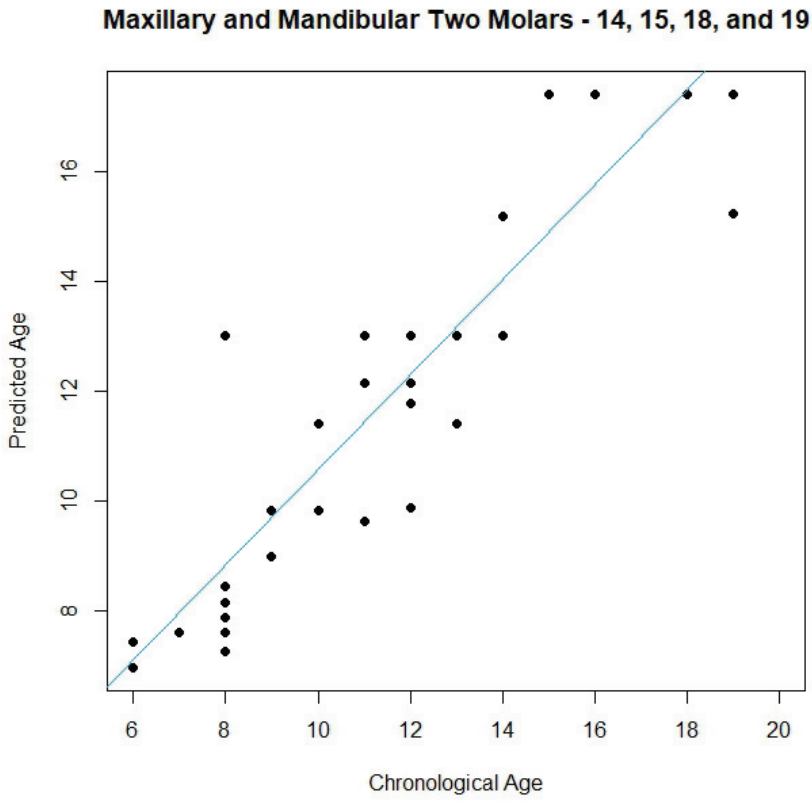


Table A5.6.1: Results of accuracy test with maxillary and mandibular molars, excluding third, linear model (#14, 15, 18, and 19).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	5	29.41	4	23.53	8	47.06	1	5.88	15	88.24	1	5.88	1	5.88	15	88.24	1	5.88	17	31
Male	11	44.00	8	32.00	6	24.00	4	16.00	20	80.00	1	4.00	0	0.00	25	100.00	0	0.00	25	26
AfA	1	50.00	0	0.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0
AsA	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
EA	9	52.94	2	11.76	6	35.29	3	17.65	13	76.47	1	5.88	1	5.88	16	94.12	0	0.00	17	29
Haw	0	0.00	0	0.00	2	100.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
His	5	26.32	9	47.37	5	26.32	1	5.26	17	89.47	1	5.26	0	0.00	18	94.74	1	5.26	19	20
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
AfA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AfA Male	1	50.00	0	0.00	1	50.00	0	0.00	3	150.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
EA Fem	4	57.14	1	14.29	2	28.57	1	14.29	6	85.71	0	0.00	1	14.29	6	85.71	0	0.00	7	17
EA Male	5	50.00	1	10.00	4	40.00	2	20.00	7	70.00	1	10.00	0	0.00	10	100.00	0	0.00	10	12
Haw Fem	0	0.00	0	0.00	2	100.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	1	12.50	3	37.50	4	50.00	0	0.00	7	87.50	1	12.50	0	0.00	7	87.50	1	12.50	8	12
His Male	4	36.36	6	54.55	1	9.09	1	9.09	10	90.91	0	0.00	0	0.00	11	100.00	0	0.00	11	8
Nat Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
Nat Male	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Total	16	38.10	12	28.57	14	33.33	5	11.90	35	83.33	2	4.76	1	2.38	40	95.24	1	2.38	42	57

Table A5.6.2: Results of accuracy test with maxillary and mandibular molars, excluding third, linear model (#14, 15, 18, and 19). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
Childhood Fem	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	2	200.00	0	0.00	1	1
Childhood Male	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Juvenile	7	36.84	5	26.32	7	36.84	1	5.26	17	89.47	1	5.26	0	0.00	18	94.74	1	5.26	19	30
Juvenile Fem	2	25.00	3	37.50	3	37.50	0	0.00	7	87.50	1	12.50	0	0.00	7	87.50	1	12.50	8	16
Juvenile Male	5	45.45	2	18.18	4	36.36	1	9.09	10	90.91	0	0.00	0	0.00	11	100.00	0	0.00	11	14
Adolescence	9	42.86	6	28.57	6	28.57	4	19.05	16	76.19	1	4.76	1	4.76	20	95.24	0	0.00	21	27
Adolescent Fem	3	37.50	1	12.50	4	50.00	1	12.50	7	87.50	0	0.00	1	12.50	7	87.50	0	0.00	8	15
Adolescent Male	6	46.15	5	38.46	2	15.38	3	23.08	9	69.23	1	7.69	0	0.00	13	100.00	0	0.00	13	12
Total	16	38.10	12	28.57	14	33.33	5	11.90	35	83.33	2	4.76	1	2.38	40	95.24	1	2.38	42	58

Table A5.6.3: Results of precision test with maxillary and mandibular molars, excluding third, linear model (#14, 15, 18, and 19). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	2.280 – 2.295	6.479 – 6.524
Juvenile	2.235 – 2.465	6.352 – 7.005
Adolescence	2.235 – 2.302	6.352 – 6.543

Table A5.6.4: Accuracy of specific versions of maxillary and mandibular molars, excluding third, linear model (#14, 15, 18, and 19), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.6.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	5	29.41	4	23.53	8	47.06	2	11.76	14	82.35	1	5.88	1	5.88	15	88.24	1	5.88	17	31
Male	9	36.00	10	40.00	6	24.00	3	12.00	21	84.00	1	4.00	0	0.00	25	100.00	0	0.00	25	26
AfA	1	50.00	0	0.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0
AsA	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
EA	8	47.06	2	11.76	7	41.18	4	23.53	10	58.82	3	17.65	1	5.88	16	94.12	0	0.00	17	29
His	11	57.89	4	21.05	4	21.05	1	5.26	17	89.47	1	5.26	0	0.00	18	94.74	1	5.26	19	20
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0

Table A5.6.5: Results of precision tests for specific versions of maxillary and mandibular molars, excluding third, linear model (#14, 15, 18, and 19), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.293 – 2.721	–	6.522 – 7.742	–
Male	2.193 – 2.393	–	6.240 – 6.810	–
AfA	2.301 – 2.313	–	6.746 – 6.780	–
AsA	6.167	–	18.218	–
EA	2.059 – 2.416	–	5.858 – 6.873	–
His	2.292 – 2.457	–	6.525 – 6.997	–
Nat	3.589	–	10.980	–

Appendix A5.6.1: Specific Versions of Maxillary and Mandibular Molars (no Third) Model

A5.6.1.1: Female-Specific Maxillary and Mandibular Molars (no Third) Model

Age = 9.1054 + 2.2992(#14.L) – 1.3722(#14.Q) + 0.8943(#14.C) – 0.1427(#14^4) + 2.6422(#15.L) + 2.3152(#15.Q) – 0.2617(#15.C) + 1.0566(#15^4) – 0.4000(#15^5) + 0.1424(#15^6) – 0.3994(#15^7) + 5.8112(#18.L) + 0.9288(#18.Q) + 2.0771(#18.C) – 0.2621(#18^4) + 0.1194(#18^5) – 0.3400(#18^6) + 0.0531(#18^7) – 1.2186(#19.L) + 2.2927(#19.Q) – 1.0667(#19.C) + 0.2956(#19^4)

Residual standard error = 1.651, df = 423

Multiple R^2 = 0.8389, Adjusted R^2 = 0.8305

F-statistic = 100.10, F-stat p-value < 0.0000, F-stat df = 22 and 423

A5.6.1.2: Male-Specific Maxillary and Mandibular Molars (no Third) Model

Age = 9.8266 – 0.2522(#14.L) + 0.2234(#14.Q) – 0.1248(#14.C) + 3.6472(#15.L) + 1.4147(#15.Q) + 0.6428(#15.C) + 0.3917(#15^4) + 0.3450(#15^5) + 0.1362(#15^6) + 3.7997(#18.L) + 1.2377(#18.Q) + 0.8639(#18.C) – 0.1955(#18^4) – 0.2181(#18^5) – 0.2342(#18^6) + 1.8573(#19.L) – 0.0531(#19.Q) + 0.0136(#19.C)

Residual standard error = 1.579, df = 391

Multiple R^2 = 0.8395, Adjusted R^2 = 0.8321

F-statistic = 113.60, F-stat p-value < 0.0000, F-stat df = 18 and 391

A5.6.1.3: African-American-Specific Maxillary and Mandibular Molars (no Third) Model

Age = 11.4007 – 3.6668(#14.L) + 4.6013(#14.Q) + 6.7617(#15.L) – 2.6897(#15.Q) + 4.7618(#15.C) – 0.3160(#15^4) + N/A(#15^5) + N/A(#15^6) + 3.8484(#18.L) + 0.4469(#18.Q) + 0.9256(#18.C) – 0.9717(#18^4) + N/A(#18^5) + N/A(#18^6) + N/A(#19.L)

Residual standard error = 1.567, df = 27

Multiple R^2 = 0.8867, Adjusted R^2 = 0.8448

F-statistic = 21.14, F-stat p-value < 0.0000, F-stat df = 10 and 27

A5.6.1.4: Asian-American-Specific Maxillary and Mandibular Molars (no Third) Model

Age = 8.9783 + 5.3080(#14.L) – 6.2897(#14.Q) + 2.1420(#14.C) + 1.7909(#15.L) + 6.3538(#15.Q) – 5.2061(#15.C) + 3.2515(#15^4) – 0.1479(#15^5) + N/A(#15^6) + 3.4520(#18.L) + 2.1032(#18.Q) + 0.6143(#18.C) – 0.3939(#18^4) – 0.2779(#18^5) – 1.4227(#18^6) + 2.2361(#19.L) + N/A(#19.Q) + N/A(#19.C)

Residual standard error = 1.873, df = 22

Multiple R^2 = 0.9007, Adjusted R^2 = 0.8330

F-statistic = 13.30, F-stat p-value < 0.0000, F-stat df = 15 and 22

A5.6.1.5: European-American-Specific Maxillary and Mandibular Molars (no Third) Model

Age = 9.2996 + 1.4033(#14.L) – 1.0201(#14.Q) + 0.6673(#14.C) + 0.0323(#14^4) + 2.5592(#15.L) + 1.8753(#15.Q) + 0.3500(#15.C) + 0.5600(#15^4) – 0.3271(#15^5) – 0.0182(#15^6) – 0.5617(#15^7) + 5.9219(#18.L) + 1.4973(#18.Q) + 1.2553(#18.C) – 0.0912(#18^4) + 0.244(#18^5) – 0.2279(#18^6) + 0.0983(#18^7) + 0.2233(#19.L) + 1.7200(#19.Q) – 1.0936(#19.C) + N/A(#19^4)

Residual standard error = 1.483, df = 413

Multiple R^2 = 0.8817, Adjusted R^2 = 0.8757

F-statistic = 146.60, F-stat p-value < 0.0000, F-stat df = 21 and 413

A5.6.1.6: Hispanic-Specific Maxillary and Mandibular Molars (no Third) Model

Age = 9.4 + 0.2768(#14.L) + 0.2660(#14.Q) – 0.0729(#14.C) + 4.7990(#15.L) + 1.7732(#15.Q) + 0.3575(#15.C) + 0.2411(#15^4) + 0.252(#15^5) + 0.4006(#15^6) + 2.1073(#18.L) + 0.4747(#18.Q) + 1.3363(#18.C) – 0.0559(#18^4) – 0.3377(#18^5) – 0.4614(#18^6) + 1.0926(#19.L) – 0.0180(#19.Q) + 0.2371(#19.C)

Residual standard error = 1.649, df = 306

Multiple $R^2 = 0.7627$, Adjusted $R^2 = 0.7487$

F-statistic = 54.63, F-stat p-value < 0.0000, F-stat df = 18 and 306

A5.6.1.7: Native-American-Specific Maxillary and Mandibular Molars (no Third) Model

Age = 11.0417 + 0.6625(#14.L) + 0.1100(#15.L) + 2.3508(#15.Q) + N/A(#15.C) + 6.7207(#18.L) + 0.1216(#18.Q) – 0.9622(#18.C) – 0.4415(#18^4) + N/A(#18^5) + N/A(#19.L)

Residual standard error = 2.300, df = 12

Multiple $R^2 = 0.6776$, Adjusted $R^2 = 0.4895$

F-statistic = 3.603, F-stat p-value = 0.0251, F-stat df = 7 and 12

Appendix A5.7: Maxillary Three Molar Model Based on All Individuals

R code: lm(formula = AGE ~ (#14 + #15 + #16), data = dataset)

Age = 12.4141 + 0.7237(#14.L) – 0.0878(#14.Q) + 3.3424(#15.L) + 1.1964(#15.Q) – 0.0524(#15.C) + 0.2516(#15^4) + 0.0739(#15^5) + 5.7278(#16.L) + 0.7367(#16.Q) + 0.0706(#16.C) + 0.0279(#16^4) – 0.4566(#16^5) – 0.5578(#16^6) + 0.0203(#16^7)

Residual standard error = 1.497, df = 524

Multiple R^2 = 0.8131, Adjusted R^2 = 0.8081

F-statistic = 162.90, F-stat p-value < 0.0000, F-stat df = 14 and 524

Figure A5.7: Plot of chronological age by ages predicted from all three maxillary molars (#14, 15, and 16).

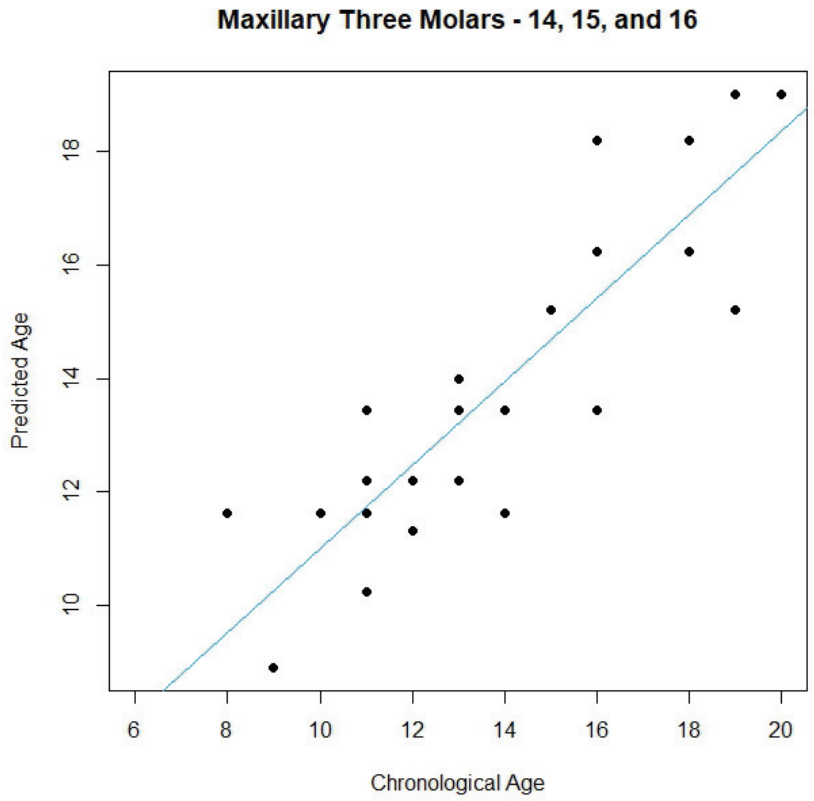


Table A5.7.1: Results of accuracy test with maxillary three molar linear model (#14, 15, and 16).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	4	33.33	5	41.67	3	25.00	3	25.00	7	58.33	2	16.67	1	8.33	11	91.67	0	0.00	12	35
Male	8	47.06	6	35.29	3	17.65	1	5.88	15	88.24	1	5.88	0	0.00	17	100.00	0	0.00	17	34
AfA	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0
AsA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	4
EA	7	63.64	3	27.27	1	9.09	4	36.36	7	63.64	0	0.00	1	9.09	10	90.91	0	0.00	11	34
Haw	1	33.33	1	33.33	1	33.33	0	0.00	2	66.67	1	33.33	0	0.00	3	100.00	0	0.00	3	1
His	4	33.33	5	41.67	3	25.00	0	0.00	10	83.33	2	16.67	0	0.00	12	100.00	0	0.00	12	27
Nat	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
AfA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AfA Male	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	4
EA Fem	4	66.67	2	33.33	0	0.00	3	50.00	3	50.00	0	0.00	1	16.67	5	83.33	0	0.00	6	17
EA Male	3	60.00	1	20.00	1	20.00	1	20.00	4	80.00	0	0.00	0	0.00	5	100.00	0	0.00	5	17
Haw Fem	0	0.00	1	50.00	1	50.00	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	2	1
Haw Male	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
His Fem	0	0.00	2	50.00	2	50.00	0	0.00	3	75.00	1	25.00	0	0.00	4	100.00	0	0.00	4	16
His Male	4	50.00	3	37.50	1	12.50	0	0.00	7	87.50	1	12.50	0	0.00	8	100.00	0	0.00	8	11
Nat Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
Nat Male	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Total	12	41.38	1	37.93	6	20.69	4	13.79	22	75.86	3	10.34	1	3.45	28	96.55	0	0.00	29	69

Table A5.7.2: Results of accuracy test with maxillary three molar linear model (#14, 15, and 16). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	3
Childhood Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2
Childhood Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
Juvenile	2	25.00	1	12.50	5	62.50	0	0.00	6	75.00	2	25.00	0	0.00	8	100.00	0	0.00	8	40
Juvenile Fem	0	0.00	1	33.33	2	66.67	0	0.00	2	66.67	1	33.33	0	0.00	3	100.00	0	0.00	3	20
Juvenile Male	2	40.00	0	0.00	3	60.00	0	0.00	4	80.00	1	20.00	0	0.00	5	100.00	0	0.00	5	20
Adolescence	10	47.62	10	47.62	1	4.76	4	19.05	16	76.19	1	4.76	1	4.76	20	95.24	0	0.00	21	27
Adolescent Fem	4	44.44	4	44.44	1	11.11	3	33.33	5	55.56	1	11.11	1	11.11	8	88.89	0	0.00	9	14
Adolescent Male	6	50.00	6	50.00	0	0.00	1	8.33	11	91.67	0	0.00	0	0.00	12	100.00	0	0.00	12	13
Total	12	41.38	11	37.93	6	20.69	4	13.79	22	75.86	3	10.34	1	3.45	28	96.55	0	0.00	29	71

Table A5.7.3: Results of precision test with maxillary three molar linear model (#14, 15, and 16). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	–	–
Juvenile	2.081 – 2.107	5.917 – 5.992
Adolescence	2.081 – 2.119	5.917 – 6.027

Table A5.7.4: Accuracy of specific versions of maxillary three molar linear model (#14, 15, and 16), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.7.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	4	33.33	5	41.67	3	25.00	3	25.00	7	58.33	2	16.67	1	8.33	11	91.67	0	0.00	12	10
Male	8	47.06	6	35.29	3	17.65	1	5.88	15	88.24	1	5.88	0	0.00	17	100.00	0	0.00	17	34
AfA	1	50.00	0	0.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0
AsA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
EA	7	63.64	2	18.18	2	18.18	4	36.36	6	54.55	1	9.09	1	9.09	10	90.91	0	0.00	11	34
His	5	41.67	4	33.33	3	25.00	2	16.67	9	75.00	1	8.33	0	0.00	12	100.00	0	0.00	12	11
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0

Table A5.7.5: Results of precision tests for specific versions of maxillary three molar linear model (#14, 15, and 16), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.267 – 2.299	–	6.459 – 6.547	–
Male	1.915 – 1.962	–	5.456 – 5.590	–
AfA	2.161 – 2.293	–	6.411 – 6.800	–
AsA	–	–	–	–
EA	2.011 – 2.060	–	5.730 – 5.869	–
His	2.221 – 2.281	–	6.334 – 6.505	–
Nat	2.815	–	9.371	–

Appendix A5.7.1: Specific Versions of Maxillary Three Molar Model

A5.7.1.1: Female-Specific Maxillary Three Molar Model

Age = 12.7052 + 0.4060(#14.L) + 2.9752(#15.L) + 1.7876(#15.Q) – 0.3783(#15.C) + 0.3557(#15^4) + 0.0425(#15^5) + 5.5489(#16.L) + 0.5111(#16.Q) – 0.3216(#16.C) – 0.1511(#16^4) – 0.3352(#16^5) – 0.6696(#16^6) – 0.4610(#16^7)

Residual standard error = 1.622, df = 258

Multiple R^2 = 0.7910, Adjusted R^2 = 0.7805

F-statistic = 75.13, F-stat p-value < 0.0000, F-stat df = 13 and 258

A5.7.1.2: Male-Specific Maxillary Three Molar Model

Age = 12.3422 + 0.6576(#14.L) – 0.2854(#14.Q) + 3.8458(#15.L) + 0.7620(#15.Q) + 0.1888(#15.C) + 0.2668(#15^4) + 0.1377(#15^5) + 5.6513(#16.L) + 0.8173(#16.Q) + 0.3680(#16.C) + 0.2172(#16^4) – 0.5337(#16^5) – 0.4927(#16^6) + 0.3321(#16^7)

Residual standard error = 1.367, df = 252

Multiple R^2 = 0.8446, Adjusted R^2 = 0.8359

F-statistic = 97.82, F-stat p-value < 0.0000, F-stat df = 14 and 252

A5.7.1.3: African-American-Specific Maxillary Three Molar Model

Age = 19.3889 – 13.5024(#14.L) + 1.4456(#15.L) + 0.7721(#15.Q) – 0.5321(#15.C) + N/A(#15^4) + 16.4505(#16.L) – 10.4433(#16.Q) + 9.3768(#16.C) – 3.4190(#16^4) + 2.3658(#16^5) + N/A(#16^6)

Residual standard error = 1.458, df = 20

Multiple R^2 = 0.8740, Adjusted R^2 = 0.8174

F-statistic = 15.42, F-stat p-value < 0.0000, F-stat df = 9 and 20

A5.7.1.4: Asian-American-Specific Maxillary Three Molar Model

Age = 12.8716 + 0.5153(#14.L) – 0.9273(#14.Q) + 6.4533(#15.L) – 0.8774(#15.Q) + 0.7967(#15.C) + N/A(#15^4) + 3.9159(#16.L) + 2.5603(#16.Q) – 0.8877(#16.C) + 0.2399(#16^4) – 0.5075(#16^5) + 0.6442(#16^6)

Residual standard error = 1.063, df = 12

Multiple R^2 = 0.9519, Adjusted R^2 = 0.9079

F-statistic = 21.61, F-stat p-value < 0.0000, F-stat df = 11 and 12

A5.7.1.5: European-American-Specific Maxillary Three Molar Model

Age = 12.5070 + 0.5283(#14.L) – 0.0954(#14.Q) + 4.177(#15.L) + 0.9267(#15.Q) + 0.1087(#15.C) – 0.1016(#15^4) – 0.0289(#15^5) + 5.2626(#16.L) + 1.0553(#16.Q) – 0.0303(#16.C) – 0.0277(#16^4) – 0.6594(#16^5) – 0.5296(#16^6) + 0.1312(#16^7)

Residual standard error = 1.431, df = 248

Multiple R^2 = 0.8420, Adjusted R^2 = 0.8330

F-statistic = 94.38, F-stat p-value < 0.0000, F-stat df = 14 and 248

A5.7.1.6: Hispanic-Specific Maxillary Three Molar Model

Age = 12.3639 + 0.3167(#14.L) + 3.0329(#15.L) + 1.4950(#15.Q) – 0.4785(#15.C) + 0.5745(#15^4) + 0.0620(#15^5) + 5.5357(#16.L) + 0.4638(#16.Q) – 0.0431(#16.C) + 0.4299(#16^4) + 0.1915(#16^5) – 0.3530(#16^6) + 0.0128(#16^7)

Residual standard error = 1.586, df = 191

Multiple R^2 = 0.7341, Adjusted R^2 = 0.7160

F-statistic = 40.55, F-stat p-value < 0.0000, F-stat df = 13 and 191

A5.7.1.7: Native-American-Specific Maxillary Three Molar Model

Age = 13.4375 + 0.7071(#14.L) + 0.0000(#15.L) + 1.0000(#15.Q) + N/A(#15.C) + 7.2908(#16.L) – 0.1929(#16.Q) – 0.5231(#16.C) – 2.6391(#16^4) – 1.2732(#16^5) – 1.4463(#16^6) – 1.2546(#16^7)

Residual standard error = 1.354, df = 6

Multiple R^2 = 0.9161, Adjusted R^2 = 0.7762

F-statistic = 6.549, F-stat p-value = 0.0160, F-stat df = 10 and 6

Appendix A5.8: Mandibular Three Molar Model Based on All Individuals

R code: lm(formula = AGE ~ (#17 + #18 + #19), data = dataset)

Age = 12.8544 + 5.5690(#17.L) + 0.4971(#17.Q) + 0.1953(#17.C) + 0.1634(#17^4) – 0.3739(#17^5) – 0.7241(#17^6) + 0.0972(#17^7) + 3.1392(#18.L) + 1.5296(#18.Q) – 0.3720(#18.C) + 0.0293(#18^4) – 0.3779(#18^5) + 0.4088(#19.L) + 0.2613(#19.Q)

Residual standard error = 1.593, df = 1087

Multiple R^2 = 0.7875, Adjusted R^2 = 0.7847

F-statistic = 287.7, F-stat p-value < 0.0000, F-stat df = 14 and 1087

Figure A5.8: Plot of chronological age by ages predicted from all three mandibular molars (#17, 18, and 19).

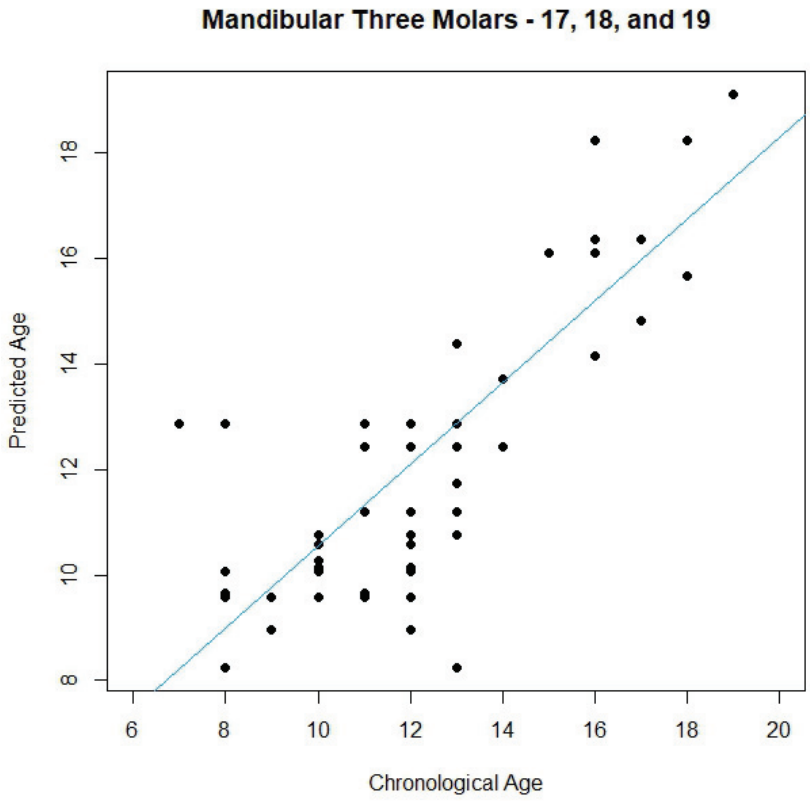


Table A5.8.1: Results of accuracy test with mandibular three molar linear model (#17, 18, and 19).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	14	42.42	12	36.36	7	21.21	9	27.27	22	66.67	2	6.06	1	3.03	31	93.94	1	3.03	33	16
Male	15	44.12	9	26.47	10	29.41	9	26.47	24	70.59	1	2.94	0	0.00	33	97.06	1	2.94	34	17
AfA	1	33.33	1	33.33	1	33.33	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	0
AsA	1	50.00	0	0.00	1	50.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
EA	15	48.39	8	25.81	8	25.81	12	38.71	18	58.06	1	3.23	1	3.23	29	93.55	1	3.23	31	15
Haw	0	0.00	2	66.67	1	33.33	0	0.00	2	66.67	1	33.33	0	0.00	3	100.00	0	0.00	3	1
His	11	45.83	7	29.17	6	25.00	4	16.67	19	79.17	1	4.17	0	0.00	23	95.83	1	4.17	24	15
Nat	1	25.00	3	75.00	0	0.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	0
AfA Fem	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
AfA Male	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	1	50.00	0	0.00	1	50.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
EA Fem	8	50.00	4	25.00	4	25.00	7	43.75	9	56.25	0	0.00	1	6.25	15	93.75	0	0.00	16	8
EA Male	7	46.67	4	26.67	4	26.67	5	33.33	9	60.00	1	6.67	0	0.00	14	93.33	1	6.67	15	7
Haw Fem	0	0.00	2	66.67	1	33.33	0	0.00	2	66.67	1	33.33	0	0.00	3	100.00	0	0.00	3	0
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	5	41.67	5	41.67	2	16.67	2	16.67	9	75.00	1	8.33	0	0.00	11	91.67	1	8.33	12	8
His Male	6	50.00	2	16.67	4	33.33	2	16.67	10	83.33	0	0.00	0	0.00	12	100.00	0	0.00	12	7
Nat Fem	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Nat Male	1	33.33	2	66.67	0	0.00	1	33.33	2	66.67	0	0.00	0	0.00	3	100.00	0	0.00	3	0
Total	29	43.28	21	31.34	17	25.37	18	26.87	46	68.66	3	4.48	1	1.49	64	95.52	2	2.99	67	33

Table A5.8.2: Results of accuracy test with mandibular three molar linear model (#17, 18, and 19). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	3
Childhood Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2
Childhood Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
Juvenile	5	19.23	10	38.46	11	42.31	2	7.69	22	84.62	2	7.69	0	0.00	24	92.31	2	7.69	26	23
Juvenile Fem	1	7.69	6	46.15	6	46.15	1	7.69	11	84.62	1	7.69	0	0.00	12	92.31	1	7.69	13	11
Juvenile Male	4	30.77	4	30.77	5	38.46	1	7.69	11	84.62	1	7.69	0	0.00	12	92.31	1	7.69	13	12
Adolescence	24	58.54	11	26.83	6	14.63	16	39.02	24	58.54	1	2.44	1	2.44	40	97.56	0	0.00	41	7
Adolescent Fem	13	65.00	6	30.00	1	5.00	8	40.00	11	55.00	1	5.00	1	5.00	19	95.00	0	0.00	20	3
Adolescent Male	11	52.38	5	23.81	5	23.81	8	38.10	13	61.90	0	0.00	0	0.00	21	100.00	0	0.00	21	4
Total	29	43.28	21	31.34	17	25.37	18	26.87	46	68.66	3	4.48	1	1.49	64	95.52	2	2.99	67	33

Table A5.8.3: Results of precision test with mandibular three molar linear model (#17, 18, and 19). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	–	–
Juvenile	2.207 – 2.227	6.271 – 6.328
Adolescence	2.207 – 2.261	6.271 – 6.424

Table A5.8.4: Accuracy of specific versions of mandibular three molar linear model (#17, 18, and 19), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.8.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	17	51.52	9	27.27	7	21.21	9	27.27	22	66.67	2	6.06	1	3.03	31	93.94	1	3.03	33	7
Male	12	35.29	14	41.18	8	23.53	7	20.59	26	76.47	1	2.94	0	0.00	33	97.06	1	2.94	34	17
AfA	2	66.67	0	0.00	1	33.33	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	0
AsA	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
EA	12	38.71	11	35.48	8	25.81	12	38.71	18	58.06	1	3.23	1	3.23	29	93.55	1	3.23	31	15
His	13	54.17	8	33.33	3	12.50	4	16.67	19	79.17	1	4.17	1	4.17	22	91.67	1	4.17	24	14
Nat	1	33.33	0	0.00	2	66.67	0	0.00	2	66.67	1	33.33	0	0.00	3	100.00	0	0.00	3	0

Table A5.8.5: Results of precision tests for specific versions of mandibular three molar linear model (#17, 18, and 19), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.222 – 2.254	–	6.319 – 6.410	–
Male	2.191 – 2.284	–	6.231 – 6.496	–
AfA	2.210 – 2.367	–	6.379 – 6.831	–
AsA	2.479 – 3.435	–	7.219 – 10.003	–
EA	2.057 – 2.095	–	5.850 – 5.958	–
His	2.249 – 2.303	–	6.399 – 6.552	–
Nat	2.271 – 2.868	–	6.596 – 8.329	–

Appendix A5.8.1: Specific Versions of Mandibular Three Molar Model

A5.8.1.1: Female-Specific Mandibular Three Molar Model

Age = 13.1012 + 5.8793(#17.L) + 0.4248(#17.Q) + 0.0912(#17.C) + 0.4289(#17^4) – 0.4456(#17^5) – 1.0565(#17^6) + 0.1021(#17^7) + 3.4859(#18.L) + 0.4847(#18.Q) – 0.0617(#18.C) – 0.3970(#18^4) + 0.4485(#19.L)

Residual standard error = 1.600, df = 560

Multiple R^2 = 0.7950, Adjusted R^2 = 0.7906

F-statistic = 181.00, F-stat p-value < 0.0000, F-stat df = 12 and 560

A5.8.1.2: Male-Specific Mandibular Three Molar Model

Age = 12.7946 + 5.2562(#17.L) + 0.6287(#17.Q) + 0.3108(#17.C) – 0.1570(#17^4) – 0.2914(#17^5) – 0.3347(#17^6) + 0.1355(#17^7) + 3.0537(#18.L) + 1.4798(#18.Q) – 0.1736(#18.C) – 0.0394(#18^4) – 0.3194(#18^5) + 0.5101(#19.L) + 0.2422(#19.Q)

Residual standard error = 1.576, df = 514

Multiple R^2 = 0.7869, Adjusted R^2 = 0.7811

F-statistic = 135.50, F-stat p-value < 0.0000, F-stat df = 14 and 514

A5.8.1.3: African-American-Specific Mandibular Three Molar Model

Age = 13.1354 + 7.1395(#17.L) + 1.3380(#17.Q) + 0.8624(#17.C) + 0.2515(#17^4) + 0.0209(#17^5) – 1.1064(#17^6) – 0.7035(#17^7) + 1.5914(#18.L) + 0.0318(#18.Q) – 0.0091(#18.C) – 0.3579(#18^4) + 0.6264(#19.L)

Residual standard error = 1.514, df = 52

Multiple R^2 = 0.8535, Adjusted R^2 = 0.8197

F-statistic = 25.25, F-stat p-value < 0.0000, F-stat df = 12 and 52

A5.8.1.4: Asian-American-Specific Mandibular Three Molar Model

Age = 12.2229 + 2.7664(#17.L) + 3.1452(#17.Q) + 0.2824(#17.C) – 0.1964(#17^4) – 0.7300(#17^5) – 0.4880(#17^6) + 0.0106(#17^7) + 6.4942(#18.L) + 1.2420(#18.Q) – 1.4745(#18.C) + N/A(#18^4) + 0.4985(#19.L)

Residual standard error = 1.538, df = 34

Multiple R^2 = 0.8680, Adjusted R^2 = 0.8252

F-statistic = 20.32, F-stat p-value < 0.0000, F-stat df = 11 and 34

A5.8.1.5: European-American-Specific Mandibular Three Molar Model

Age = 12.7017 + 5.1111(#17.L) + 0.0676(#17.Q) + 0.0935(#17.C) + 0.0607(#17^4) – 0.6299(#17^5) – 0.7999(#17^6) + 0.2667(#17^7) + 4.2150(#18.L) + 0.8361(#18.Q) + 0.5035(#18.C) – 0.1937(#18^4) – 0.2306(#18^5) + 0.5800(#19.L) + 0.1503(#19.Q)

Residual standard error = 1.479, df = 495

Multiple R^2 = 0.8323, Adjusted R^2 = 0.8275

F-statistic = 175.40, F-stat p-value < 0.0000, F-stat df = 14 and 495

A5.8.1.6: Hispanic-Specific Mandibular Three Molar Model

Age = 13.0984 + 5.6026(#17.L) + 0.9524(#17.Q) + 0.1978(#17.C) + 0.3697(#17^4) – 0.2109(#17^5) – 0.5981(#17^6) + 0.0482(#17^7) + 1.1373(#18.L) + 3.5078(#18.Q) – 2.0474(#18.C) + 0.8262(#18^4) – 0.5972(#18^5) + 0.4112(#19.L)

Residual standard error = 1.617, df = 417

Multiple R^2 = 0.7313, Adjusted R^2 = 0.7229

F-statistic = 87.28, F-stat p-value < 0.0000, F-stat df = 13 and 417

A5.8.1.7: Native-American-Specific Mandibular Three Molar Model

Age = 13.5031 + 4.6287(#17.L) + 0.4122(#17.Q) – 0.1247(#17.C) + 1.4595(#17^4) + 0.9486(#17^5) + 0.9059(#17^6) + 2.2295(#18.L) – 0.4642(#18.Q) – 1.6775(#18.C) – 0.0237(#18^4) – 0.0226(#19.L)

Residual standard error = 1.541, df = 38

Multiple R^2 = 0.7858, Adjusted R^2 = 0.7238

F-statistic = 12.67, F-stat p-value < 0.0000, F-stat df = 11 and 38

Appendix A5.9: Model based on Four Teeth with Narrowest Average CIs from Both Jaws (#21, 11, 22, and 19) Based on All Individuals

R code: lm(formula = AGE ~ (#21 + #11 + #22 + #19), data = dataset)

Age = 9.1692 + 3.0586(#21.L) + 0.9736(#21.Q) + 0.7831(#21.C) + 0.0130(#21^4) + 0.2284(#21^5) + 2.6274(#11.L) + 0.5626(#11.Q) + 0.2055(#11.C) + 0.3092(#11^4) + 0.0862(#11^5) + 1.3247(#22.L) + 0.7323(#22.Q) + 0.1834(#22.C) + 0.0095(#22^4) – 0.1443(#22^5) + 0.8168(#19.L) + 0.7684(#19.Q) – 0.2541(#19.C) + 0.0939(#19^4)

Residual standard error = 1.558, df = 1254

Multiple R^2 = 0.7878, Adjusted R^2 = 0.7846

F-statistic = 245.10, F-stat p-value < 0.0000, F-stat df = 19 and 1254

Figure A5.9: Plot of chronological age by ages predicted from the four teeth with the narrowest average CIs from both jaws (#21, 11, 22, and 19).

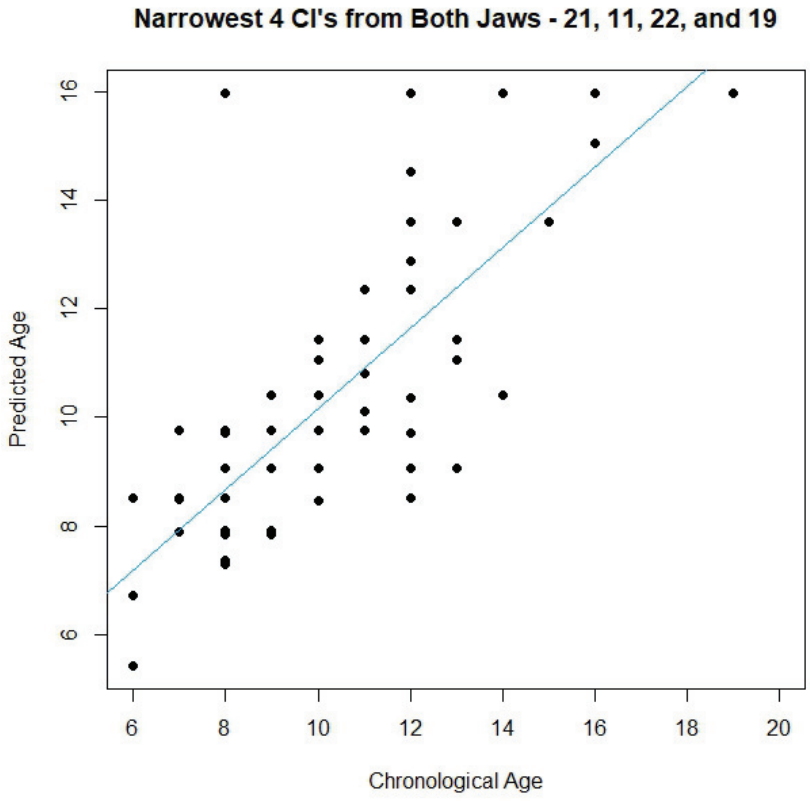


Table A5.9.1: Results of accuracy test with linear model based on four narrowest CIs from both jaws (#21, 11, 22, and 19).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	17	45.95	6	16.22	14	37.84	6	16.22	28	75.68	3	8.11	2	5.41	34	91.89	1	2.70	37	12
Male	22	59.46	9	24.32	6	16.22	13	35.14	22	59.46	2	5.41	1	2.70	36	97.30	0	0.00	37	14
AfA	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
AsA	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
EA	20	58.82	5	14.71	9	26.47	12	35.29	21	61.76	1	2.94	1	2.94	33	97.06	0	0.00	34	12
Haw	3	100.00	0	0.00	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	1
His	14	43.75	8	25.00	10	31.25	6	18.75	22	68.75	4	12.50	2	6.25	29	90.63	1	3.13	32	7
Nat	1	50.00	0	0.00	1	50.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
AfA Fem	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
AfA Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
EA Fem	9	56.25	2	12.50	5	31.25	4	25.00	12	75.00	0	0.00	1	6.25	15	93.75	0	0.00	16	8
EA Male	11	61.11	3	16.67	4	22.22	8	44.44	9	50.00	1	5.56	0	0.00	18	100.00	0	0.00	18	4
Haw Fem	3	100.00	0	0.00	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	0
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	5	31.25	3	18.75	8	50.00	2	12.50	11	68.75	3	18.75	1	6.25	14	87.50	1	6.25	16	4
His Male	9	56.25	5	31.25	2	12.50	4	25.00	11	68.75	1	6.25	1	6.25	15	93.75	0	0.00	16	3
Nat Fem	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Nat Male	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Total	39	52.70	15	20.27	20	27.03	19	25.68	50	67.57	5	6.76	3	4.05	70	94.59	1	1.35	74	26

Table A5.9.2: Results of accuracy test with linear model based on four teeth with narrowest CIs from both jaws (#21, 11, 22, and 19). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	1	33.33	1	33.33	1	33.33	0	0.00	2	66.67	1	33.33	0	0.00	3	100.00	0	0.00	3	0
Childhood Fem	0	0.00	1	50.00	1	50.00	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	2	0
Childhood Male	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Juvenile	20	46.51	9	20.93	14	32.56	5	11.63	36	83.72	2	4.65	0	0.00	42	97.67	1	2.33	43	6
Juvenile Fem	9	42.86	2	9.52	10	47.62	2	9.52	18	85.71	1	4.76	0	0.00	20	95.24	1	4.76	21	3
Juvenile Male	11	50.00	7	31.82	4	18.18	3	13.64	18	81.82	1	4.55	0	0.00	22	100.00	0	0.00	22	3
Adolescence	18	64.29	5	17.86	5	17.86	14	50.00	12	42.86	2	7.14	3	10.71	25	89.29	0	0.00	28	20
Adolescent Fem	8	57.14	3	21.43	3	21.43	4	28.57	9	64.29	1	7.14	2	14.29	12	85.71	0	0.00	14	9
Adolescent Male	10	71.43	2	14.29	2	14.29	10	71.43	3	21.43	1	7.14	1	7.14	13	92.86	0	0.00	14	11
Total	39	52.70	15	20.27	20	27.03	19	25.68	50	67.57	5	6.76	3	4.05	70	94.59	1	1.35	74	26

Table A5.9.3: Results of precision test with linear model based on four teeth with narrowest CIs from both jaws (#21, 11, 22, and 19). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	2.161 – 2.366	6.139 – 6.721
Juvenile	2.156 – 2.193	6.126 – 6.230
Adolescence	2.156 – 2.176	6.126 – 6.183

Table A5.9.4: Accuracy of specific versions of linear model based on four teeth with narrowest CIs from both jaws (#21, 11, 22, and 19), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.9.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	19	51.35	7	18.92	11	29.73	8	21.62	26	70.27	3	8.11	2	5.41	34	91.89	1	2.70	37	12
Male	15	40.54	15	40.54	7	18.92	11	29.73	23	62.16	3	8.11	2	5.41	34	91.89	1	2.70	37	14
AfA	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
AsA	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
EA	18	52.94	6	17.65	10	29.41	9	26.47	21	61.76	4	11.76	1	2.94	33	97.06	0	0.00	34	12
His	17	53.13	7	21.88	8	25.00	8	25.00	21	65.63	3	9.38	2	6.25	29	90.63	1	3.13	32	7
Nat	2	100.00	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1

Table A5.9.5: Results of precision tests for specific versions of linear model based on four teeth with narrowest CIs from both jaws (#21, 11, 22, and 19), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.216 – 2.312	–	6.300 – 6.574	–
Male	2.043 – 2.357	–	5.810 – 6.703	–
AfA	3.039	–	8.842	–
AsA	2.688 – 4.807	–	7.810 – 13.969	–
EA	2.119 – 2.177	–	6.023 – 6.190	–
His	2.070 – 2.168	–	5.888 – 6.167	–
Nat	2.375 – 3.459	–	7.045 – 10.260	–

Appendix A5.9.1: Specific Versions of Model based on Four Teeth with Narrowest Average CIs from Both Jaws (#21, 11, 22, and 19)

A5.9.1.1: Female-Specific Model based on Four Teeth with Narrowest Average CIs from Both Jaws

Age = 9.0298 + 3.3524(#21.L) + 1.3101(#21.Q) + 0.9441(#21.C) + 0.0577(#21^4) + 0.3375(#21^5) + 2.7025(#11.L) + 0.8322(#11.Q) + 0.2680(#11.C) + 0.3602(#11^4) + 0.1260(#11^5) + 1.1112(#22.L) + 0.5424(#22.Q) – 0.0575(#22.C) – 0.1972(#22^4) – 0.1753(#22^5) + 0.6273(#19.L) + 0.7698(#19.Q) – 0.3522(#19.C) + 0.0878(#19^4)

Residual standard error = 1.598, df = 639

Multiple R^2 = 0.7933, Adjusted R^2 = 0.7871

F-statistic = 129.10, F-stat p-value < 0.0000, F-stat df = 19 and 639

A5.9.1.2: Male-Specific Model based on Four Teeth with Narrowest Average CIs from Both Jaws

Age = 9.3944 + 2.524(#21.L) + 0.6765(#21.Q) + 0.8093(#21.C) – 0.0948(#21^4) + 0.1819(#21^5) + 2.6223(#11.L) + 0.3109(#11.Q) – 0.0273(#11.C) + 0.2141(#11^4) + 0.0474(#11^5) + 1.7864(#22.L) + 1.0056(#22.Q) + 0.2842(#22.C) + 0.1561(#22^4) – 0.0515(#22^5) + 1.0611(#19.L) + 0.4019(#19.Q) – 0.0751(#19.C)

Residual standard error = 1.472, df = 596

Multiple R^2 = 0.7993, Adjusted R^2 = 0.7932

F-statistic = 131.80, F-stat p-value < 0.0000, F-stat df = 18 and 596

A5.9.1.3: African-American-Specific Model based on Four Teeth with Narrowest Average CIs from Both Jaws

Age = 10.1717 + 5.1267(#21.L) + 0.7604(#21.Q) + 0.2184(#21.C) + 0.0000(#21^4) + 0.9827(#21^5) + 0.9633(#11.L) – 1.2750(#11.Q) + 1.3446(#11.C) – 0.6652(#11^4) + 1.3263(#22.L) + 1.6995(#22.Q) + 1.7261(#22.C) – 1.6834(#22^4) – 0.2284(#22^5) + 0.0926(#19.L) + N/A(#19.Q)

Residual standard error = 1.801, df = 35

Multiple $R^2 = 0.8378$, Adjusted $R^2 = 0.7682$

F-statistic = 12.05, F-stat p-value < 0.0000, F-stat df = 15 and 35

A5.9.1.4: Asian-American-Specific Model based on Four Teeth with Narrowest Average CIs from Both Jaws

Age = 9.1805 + 5.6456(#21.L) – 4.3722(#21.Q) + 4.3397(#21.C) – 2.2647(#21^4) + 0.4548(#21^5) – 2.6707(#11.L) + 5.6899(#11.Q) – 3.4544(#11.C) + 1.7440(#11^4) + N/A(#11^5) + 5.0720(#22.L) + 0.6594(#22.Q) + 0.7339(#22.C) + N/A(#22^4) + 1.2649(#19.L) + 0.1314(#19.Q) + N/A(#19.C)

Residual standard error = 1.763, df = 37

Multiple $R^2 = 0.8710$, Adjusted $R^2 = 0.8222$

F-statistic = 17.85, F-stat p-value < 0.0000, F-stat df = 14 and 37

A5.9.1.5: European-American-Specific Model based on Four Teeth with Narrowest Average CIs from Both Jaws

Age = 9.2983 + 3.1328(#21.L) + 1.0814(#21.Q) + 0.7101(#21.C) + 0.0252(#21^4) + 0.1937(#21^5) + 2.3017(#11.L) + 0.6462(#11.Q) + 0.2782(#11.C) + 0.3226(#11^4) + 0.2203(#11^5) + 1.8694(#22.L) + 0.7193(#22.Q) + 0.2288(#22.C) + 0.0235(#22^4) – 0.1253(#22^5) + 1.0199(#19.L) + 0.6654(#19.Q) – 0.2785(#19.C) + 0.0312(#19^4)

Residual standard error = 1.527, df = 610

Multiple $R^2 = 0.8208$, Adjusted $R^2 = 0.8152$

F-statistic = 147.10, F-stat p-value < 0.0000, F-stat df = 19 and 610

A5.9.1.6: Hispanic-Specific Mandibular Model based on Four Teeth with Narrowest Average CIs from Both Jaws

Age = 8.929 + 3.7664(#21.L) + 0.7871(#21.Q) + 0.9873(#21.C) – 0.0343(#21^4) + 0.2485(#21^5) + 3.6756(#11.L) – 0.7625(#11.Q) + 0.7280(#11.C) – 0.0942(#11^4) + 0.1795(#11^5) – 0.7919(#22.L) + 1.3862(#22.Q) – 0.5240(#22.C) + 0.2604(#22^4) – 0.245(#22^5) + 0.6207(#19.L) + 0.5487(#19.Q) – 0.0727(#19.C)

Residual standard error = 1.492, df = 491

Multiple R^2 = 0.7336, Adjusted R^2 = 0.7239

F-statistic = 75.14, F-stat p-value < 0.0000, F-stat df = 18 and 491

A5.9.1.7: Native-American-Specific Model based on Four Teeth with Narrowest Average CIs from Both Jaws

Age = 11.2781 – 6.0304(#21.L) + 2.8347(#21.Q) – 1.6373(#21.C) – 0.1830(#21^4) + 5.8295(#11.L) + 0.4284(#11.Q) + 1.3405(#11.C) + 6.1456(#22.L) – 1.6248(#22.Q) + N/A(#22.C) + N/A(#22^4) + 0.4976(#19.L)

Residual standard error = 1.573, df = 20

Multiple R^2 = 0.8171, Adjusted R^2 = 0.7256

F-statistic = 8.935, F-stat p-value < 0.0000, F-stat df = 10 and 20

Appendix A5.10: Model based on Four Posterior Teeth with Narrowest Average CIs from Both Jaws (#21, 19, 13, and 20) Based on All Individuals

R code: lm(formula = AGE ~ (#21 + #19 + #13 + #20), data = dataset)

Age = 9.3891 + 2.5730(#21.L) + 0.7666(#21.Q) + 0.5754(#21.C) – 0.0664(#21^4) + 0.1872(#21^5) + 0.9348(#19.L) + 0.4993(#19.Q) – 0.1398(#19.C) + 3.6509(#13.L) + 0.5704(#13.Q) + 0.7234(#13.C) + 0.1361(#13^4) – 0.0366(#13^5) – 0.1532(#13^6) + 1.3514(#20.L) + 0.8323(#20.Q) + 0.4701(#20.C) + 0.2558(#20^4) + 0.1418(#20^5) + 0.0536(#20^6)

Residual standard error = 1.57, df = 1034

Multiple R^2 = 0.794, Adjusted R^2 = 0.79

F-statistic = 199.30, F-stat p-value < 0.0000, F-stat df = 20 and 1034

Figure A5.10: Plot of chronological age by ages predicted from the four posterior teeth with the narrowest average CIs from both jaws (#21, 19, 13, and 20).

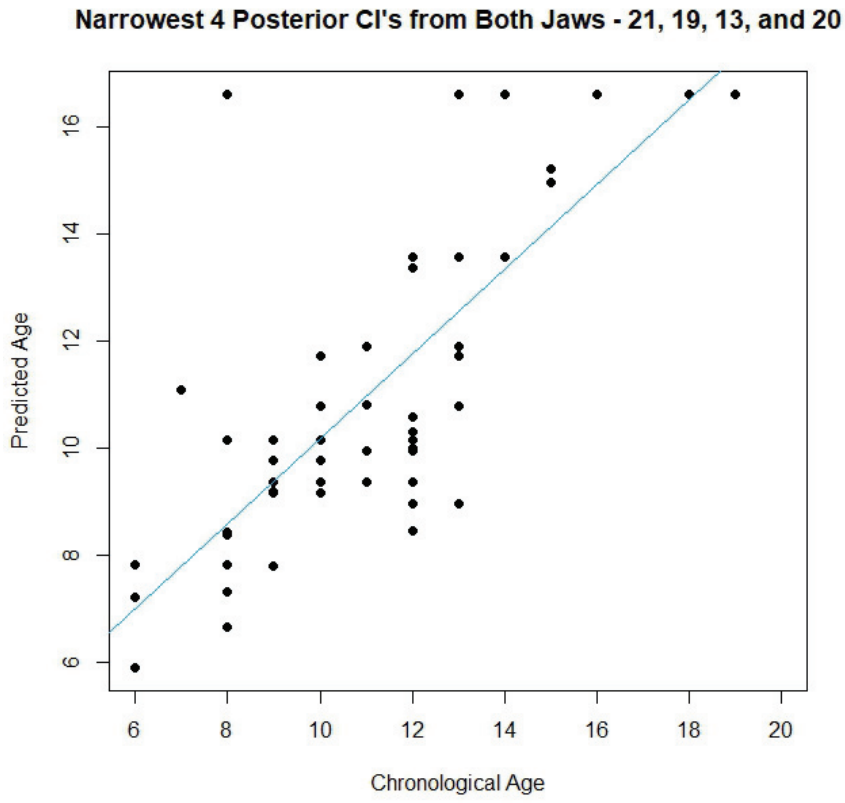


Table A5.10.1: Results of accuracy test with linear model based on four narrowest CIs from posterior teeth in both jaws (#21, 19, 13, and 20).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	13	48.15	5	18.52	9	33.33	8	29.63	15	55.56	4	14.81	2	7.41	24	88.89	1	3.70	27	22
Male	21	61.76	10	29.41	3	8.82	12	35.29	21	61.76	1	2.94	0	0.00	34	100.00	0	0.00	34	17
AfA	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
AsA	3	75.00	0	0.00	1	25.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	0
EA	17	65.38	5	19.23	4	15.38	10	38.46	14	53.85	2	7.69	1	3.85	25	96.15	0	0.00	26	20
Haw	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
His	10	38.46	9	34.62	7	26.92	5	19.23	18	69.23	3	11.54	1	3.85	24	92.31	1	3.85	26	13
Nat	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
AfA Fem	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
AfA Male	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	3	75.00	0	0.00	1	25.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	0
EA Fem	7	63.64	2	18.18	2	18.18	4	36.36	6	54.55	1	9.09	1	9.09	10	90.91	0	0.00	11	13
EA Male	10	66.67	3	20.00	2	13.33	6	40.00	8	53.33	1	6.67	0	0.00	15	100.00	0	0.00	15	7
Haw Fem	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	5	35.71	2	14.29	7	50.00	3	21.43	8	57.14	3	21.43	1	7.14	12	85.71	1	7.14	14	6
His Male	5	41.67	7	58.33	0	0.00	2	16.67	10	83.33	0	0.00	0	0.00	12	100.00	0	0.00	12	7
Nat Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
Nat Male	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
Total	34	55.74	15	24.59	12	19.67	20	32.79	36	59.02	5	8.20	2	3.28	58	95.08	1	1.64	61	39

Table A5.10.2: Results of accuracy test with linear model based on four narrowest CIs from posterior teeth in both jaws (#21, 19, 13, and 20). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	1	33.33	0	0.00	2	66.67	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	0
Childhood Fem	0	0.00	0	0.00	2	100.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0
Childhood Male	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Juvenile	12	44.44	10	37.04	5	18.52	3	11.11	21	77.78	3	11.11	0	0.00	26	96.30	1	3.70	27	22
Juvenile Fem	6	54.55	3	27.27	2	18.18	2	18.18	7	63.64	2	18.18	0	0.00	10	90.91	1	9.09	11	13
Juvenile Male	6	37.50	7	43.75	3	18.75	1	6.25	14	87.50	1	6.25	0	0.00	16	100.00	0	0.00	16	9
Adolescence	21	67.74	5	16.13	5	16.13	17	54.84	12	38.71	2	6.45	2	6.45	29	93.55	0	0.00	31	17
Adolescent Fem	7	50.00	2	14.29	5	35.71	6	42.86	6	42.86	2	14.29	2	14.29	12	85.71	0	0.00	14	9
Adolescent Male	14	82.35	3	17.65	0	0.00	11	64.71	6	35.29	0	0.00	0	0.00	17	100.00	0	0.00	17	8
Total	34	55.74	15	24.59	12	19.67	20	32.79	36	59.02	5	8.20	2	3.28	58	95.08	1	1.64	61	39

Table A5.10.3: Results of precision test with linear model based on four narrowest CIs from posterior teeth in both jaws (#21, 19, 13, and 20). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	2.182 – 2.345	6.201 – 6.664
Juvenile	2.175 – 2.246	6.179 – 6.381
Adolescence	2.175 – 2.220	6.179 – 6.309

Table A5.10.4: Accuracy of specific versions of linear model based on four narrowest CIs from posterior teeth in both jaws (#21, 19, 13, and 20), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.10.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	13	46.43	6	21.43	8	28.57	7	25.00	17	60.71	3	10.71	2	7.14	24	85.71	1	3.57	28	21
Male	18	52.94	13	38.24	3	8.82	10	29.41	23	67.65	1	2.94	0	0.00	33	97.06	1	2.94	34	17
AfA	2	100.00	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
AsA	1	33.33	2	66.67	0	0.00	1	33.33	2	66.67	0	0.00	0	0.00	3	100.00	0	0.00	3	0
EA	14	53.85	5	19.23	7	26.92	8	30.77	14	53.85	4	15.38	1	3.85	24	92.31	1	3.85	26	20
His	13	50.00	7	26.92	6	23.08	7	26.92	17	65.38	2	7.69	1	3.85	24	92.31	1	3.85	26	13
Nat	1	50.00	0	0.00	1	50.00	1	50.00	0	0.00	1	50.00	0	0.00	2	100.00	0	0.00	2	0

Table A5.10.5: Results of precision tests for specific versions of linear model based on four narrowest CIs from posterior teeth in both jaws (#21, 19, 13, and 20), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.183 – 2.350	–	6.208 – 6.683	–
Male	2.173 – 2.536	–	6.181 – 7.214	–
AfA	2.413 – 3.535	–	7.066 – 10.35	–
AsA	2.773 – 4.611	–	8.129 – 13.519	–
EA	2.093 – 2.208	–	5.953 – 6.281	–
His	2.096 – 2.272	–	5.964 – 6.463	–
Nat	2.204	8.768	6.524	25.952

Appendix A5.10.1: Specific Versions of Model based on Four Posterior Teeth with Narrowest Average CIs from Both Jaws (#21, 19, 13, and 20)

A5.10.1.1: Female-Specific Model based on Four Posterior Teeth with Narrowest Average CIs from Both Jaws

Age = 9.4194 + 2.6213(#21.L) + 0.8368(#21.Q) + 0.1310(#21.C) – 0.0347(#21^4) + 0.2480(#21^5) + 0.8373(#19.L) + 0.5950(#19.Q) – 0.2734(#19.C) + 4.0925(#13.L) + 0.3409(#13.Q) + 1.0883(#13.C) – 0.1225(#13^4) + 0.1203(#13^5) – 0.1901(#13^6) + 0.5099(#20.L) + 1.8323(#20.Q) + 0.2061(#20.C) + 0.4242(#20^4) – 0.0714(#20^5) + 0.1458(#20^6)

Residual standard error = 1.572, df = 549

Multiple R^2 = 0.8025, Adjusted R^2 = 0.7953

F-statistic = 111.50, F-stat p-value < 0.0000, F-stat df = 20 and 549

A5.10.1.2: Male-Specific Model based on Four Posterior Teeth with Narrowest Average CIs from Both Jaws

Age = 9.8972 + 2.8012(#21.L) + 0.8217(#21.Q) + 0.8994(#21.C) – 0.0492(#21^4) + 0.1060(#21^5) + 1.0661(#19.L) + 0.1557(#19.Q) + 2.6621(#13.L) + 0.6533(#13.Q) + 0.5953(#13.C) – 0.0201(#13^4) – 0.1304(#13^5) + 1.3047(#20.L) + 0.3553(#20.Q) + 0.3010(#20.C) + 0.3570(#20^4) + 0.2648(#20^5) + 0.0295(#20^6)

Residual standard error = 1.564, df = 466

Multiple R^2 = 0.7926, Adjusted R^2 = 0.7846

F-statistic = 98.95, F-stat p-value < 0.0000, F-stat df = 18 and 466

A5.10.1.3: African-American-Specific Model based on Four Posterior Teeth with Narrowest Average CIs from Both Jaws

Age = 10.1982 + 3.2837(#21.L) – 3.0859(#21.Q) + 2.0580(#21.C) – 0.7413(#21^4) + 0.1304(#21^5) + 0.2914(#19.L) + 5.3488(#13.L) + 0.4061(#13.Q) + 0.2665(#13.C) – 0.0087(#13^4) – 0.6817(#13^5) + 0.1527(#20.L) + 4.3164(#20.Q) – 1.2097(#20.C) + 0.8762(#20^4) + N/A(#20^5)

Residual standard error = 1.642, df = 28

Multiple R^2 = 0.8784, Adjusted R^2 = 0.8133

F-statistic = 13.49, F-stat p-value < 0.0000, F-stat df = 15 and 28

A5.10.1.4: Asian-American-Specific Model based on Four Posterior Teeth with Narrowest Average CIs from Both Jaws

Age = 9.5389 + 0.8547(#21.L) + 0.8428(#21.Q) + 0.9157(#21.C) – 0.2092(#21^4) + 2.2082(#19.L) – 0.0735(#19.Q) + 0.2075(#13.L) + 0.7774(#13.Q) + 0.6144(#13.C) + 0.1764(#13^4) + N/A(#13^5) + 4.5227(#20.L) + 1.9316(#20.Q) + 0.3726(#20.C) + 0.7441(#20^4) + N/A(#20^5)

Residual standard error = 1.697, df = 27

Multiple R^2 = 0.8960, Adjusted R^2 = 0.8421

F-statistic = 16.62, F-stat p-value < 0.0000, F-stat df = 14 and 27

A5.10.1.5: European-American-Specific Model based on Four Posterior Teeth with Narrowest Average CIs from Both Jaws

Age = 9.7458 + 2.7109(#21.L) + 0.7813(#21.Q) + 0.4116(#21.C) – 0.1539(#21^4) + 0.2265(#21^5) + 0.9573(#19.L) + 0.3370(#19.Q) – 0.2303(#19.C) + 4.3929(#13.L) + 0.898(#13.Q) + 0.9600(#13.C) + 0.1742(#13^4) + 0.0772(#13^5) – 0.3438(#13^6) + 0.9935(#20.L) + 0.6623(#20.Q) + 0.3564(#20.C) + 0.4027(#20^4) + 0.0163(#20^5) + 0.0947(#20^6)

Residual standard error = 1.507, df = 478

Multiple R^2 = 0.8359, Adjusted R^2 = 0.8291

F-statistic = 121.80, F-stat p-value < 0.0000, F-stat df = 20 and 478

A5.10.1.6: Hispanic-Specific Mandibular Model based on Four Posterior Teeth with Narrowest Average CIs from Both Jaws

Age = 9.194 + 2.1413(#21.L) + 1.0849(#21.Q) + 0.6032(#21.C) + 0.0866(#21^4) + 0.0893(#21^5) + 0.6825(#19.L) + 0.7902(#19.Q) – 0.2298(#19.C) + 2.0873(#13.L) +

0.3496(#13.Q) – 0.0074(#13.C) – 0.0613(#13^4) – 0.0090(#13^5) + 2.2486(#20.L) + 0.1225(#20.Q) + 0.8262(#20.C) + 0.1711(#20^4) + 0.1995(#20^5) + 0.0162(#20^6)

Residual standard error = 1.504, df = 416

Multiple R^2 = 0.7478, Adjusted R^2 = 0.7363

F-statistic = 64.92, F-stat p-value < 0.0000, F-stat df = 19 and 416

A5.10.1.7: Native-American-Specific Model based on Four Posterior Teeth with Narrowest Average CIs from Both Jaws

Age = 11.1311 + 2.4878(#21.L) + 0.8847(#21.Q) – 0.2466(#21.C) + 0.7537(#21^4) + 1.2636(#19.L) + 5.2079(#13.L) – 2.8976(#13.Q) + 2.2146(#13.C) – 1.3623(#13^4) – 2.6718(#20.L) + 3.9897(#20.Q) – 1.8282(#20.C) + N/A(#20^4)

Residual standard error = 1.458, df = 21

Multiple R^2 = 0.8400, Adjusted R^2 = 0.7486

F-statistic = 9.189, F-stat p-value < 0.0000, F-stat df = 12 and 21

Appendix A5.11: Model based on Four Teeth with Narrowest Average CIs in the Maxilla (#11, 9, 13, and 10) Based on All Individuals

R code: lm(formula = AGE ~ (#11 + #9 + #13 + #10), data = dataset)

Age = 9.5385 + 2.8827(#11.L) + 0.9051(#11.Q) + 0.1344(#11.C) – 0.1659(#11^4) – 0.2403(#11^5) + 0.9195(#9.L) – 0.2793(#9.Q) – 0.0486(#9.C) – 0.0660(#9^4) + 4.4845(#13.L) + 1.7746(#13.Q) + 1.3835(#13.C) + 0.0363(#13^4) – 0.0627(#13^5) – 0.2596(#13^6) + 0.4283(#10.L) + 0.9075(#10.Q) – 0.3713(#10.C) – 0.1488(#10^4) – 0.0989(#10^5)

Residual standard error = 1.692, df = 537

Multiple R^2 = 0.8073, Adjusted R^2 = 0.8001

F-statistic = 112.50, F-stat p-value < 0.0000, F-stat df = 20 and 537

Figure A5.11: Plot of chronological age by ages predicted from the four maxillary teeth with the narrowest average CIs (#11, 9, 13, and 10).

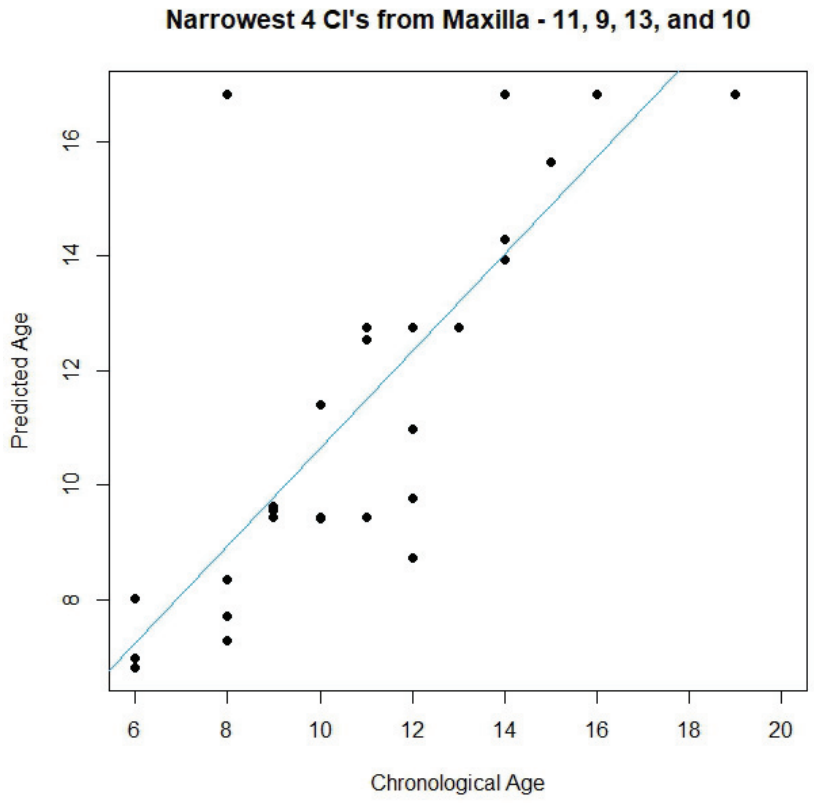


Table A5.11.1: Results of accuracy test with linear model based on four narrowest CIs from maxillary teeth (#11, 9, 13, and 10).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	5	31.25	7	43.75	4	25.00	1	6.25	13	81.25	2	12.50	0	0.00	15	93.75	1	6.25	16	33
Male	6	40.00	7	46.67	2	13.33	3	20.00	12	80.00	0	0.00	0	0.00	15	100.00	0	0.00	15	36
AfA	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
AsA	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
EA	3	27.27	5	45.45	3	27.27	2	18.18	8	72.73	1	9.09	0	0.00	11	100.00	0	0.00	11	35
Haw	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
His	6	37.5	7	43.75	3	18.75	1	6.25	14	87.50	1	6.25	0	0.00	15	93.75	1	6.25	16	23
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
AfA Fem	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
AfA Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
EA Fem	0	0.00	3	60.00	2	40.00	0	0.00	4	80.00	1	20.00	0	0.00	5	100.00	0	0.00	5	19
EA Male	3	50.00	2	33.33	1	16.67	2	33.33	4	66.67	0	0.00	0	0.00	6	100.00	0	0.00	6	16
Haw Fem	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	4	44.44	3	33.33	2	22.22	1	11.11	7	77.78	1	11.11	0	0.00	8	88.89	1	11.11	9	11
His Male	2	28.57	4	57.14	1	14.29	0	0.00	7	100.00	0	0.00	0	0.00	7	100.00	0	0.00	7	12
Nat Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
Nat Male	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Total	11	35.48	14	45.16	6	19.35	4	12.90	25	80.65	2	6.45	0	0.00	30	96.77	1	3.23	31	69

Table A5.11.2: Results of accuracy test with linear model based on four narrowest CIs from maxillary teeth (#11, 9, 13, and 10). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	0	0.00	2	66.67	1	33.33	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	0
Childhood Fem	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0
Childhood Male	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Juvenile	5	35.71	5	35.71	4	28.57	1	7.14	12	87.71	1	7.14	0	0.00	13	92.86	1	7.14	14	35
Juvenile Fem	2	40.00	1	20.00	2	40.00	0	0.00	4	80.00	1	20.00	0	0.00	4	80.00	1	20.00	5	19
Juvenile Male	3	33.33	4	44.44	2	22.22	1	11.11	8	88.89	0	0.00	0	0.00	9	100.00	0	0.00	9	16
Adolescence	6	42.86	7	50.00	1	7.14	3	21.43	10	71.43	1	7.14	0	0.00	14	100.00	0	0.00	14	34
Adolescent Fem	3	33.33	5	55.56	1	11.11	1	11.11	7	77.78	1	11.11	0	0.00	9	100.00	0	0.00	9	14
Adolescent Male	3	60.00	2	40.00	0	0.00	2	40.00	3	60.00	0	0.00	0	0.00	5	100.00	0	0.00	5	20
Total	11	35.48	14	45.16	6	19.35	4	12.90	25	80.65	2	6.45	0	0.00	30	96.77	1	3.23	31	69

Table A5.11.3: Results of precision test with linear model based on four narrowest CIs from maxillary teeth (#11, 9, 13, and 10). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	2.372 – 3.675	6.747 – 10.451
Juvenile	2.348 – 2.407	6.678 – 6.845
Adolescence	2.348 – 2.418	6.678 – 6.877

Table A5.11.4: Accuracy of specific versions of linear model based on four narrowest CIs from maxillary teeth (#11, 9, 13, and 10), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.11.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	5	31.25	6	37.50	5	31.25	1	6.25	13	81.25	2	12.50	1	6.25	14	87.50	1	6.25	16	26
Male	7	46.67	3	20.00	5	33.33	3	20.00	12	80.00	0	0.00	0	0.00	15	100.00	0	0.00	15	36
AfA	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
AsA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2
EA	3	27.27	1	9.09	7	63.64	2	18.18	8	72.73	1	9.09	0	0.00	11	100.00	0	0.00	11	35
His	8	50.00	4	25.00	4	25.00	2	12.50	13	81.25	1	6.25	1	6.25	14	87.50	1	6.25	16	18
Nat	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2

Table A5.11.5: Results of precision tests for specific versions of linear model based on four narrowest CIs from maxillary teeth (#11, 9, 13, and 10), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.330 – 2.615	–	6.635 – 7.447	–
Male	2.413 – 4.317	–	6.874 – 12.301	–
AfA	7.683	–	23.364	–
AsA	–	–	–	–
EA	2.277 – 2.408	–	6.488 – 6.861	–
His	2.298 – 2.820	–	6.551 – 8.040	–
Nat	3.474	–	12.704	–

Appendix A5.11.1: Specific Versions of Model based on Four Teeth with Narrowest Average CIs in the Maxilla (#11, 9, 13, and 10)

A5.11.1.1: Female-Specific Model based on Four Teeth with Narrowest Average CIs in the Maxilla

Age = 9.6283 + 2.4832(#11.L) + 0.5399(#11.Q) – 0.0011(#11.C) – 0.2003(#11^4) + 0.6073(#9.L) + 0.0411(#9.Q) + 0.0088(#9.C) + 0.1888(#9^4) + 4.3561(#13.L) + 1.7352(#13.Q) + 1.5549(#13.C) + 0.2014(#13^4) – 0.0427(#13^5) – 0.4084(#13^6) + 0.7937(#10.L) + 1.0038(#10.Q) – 0.0693(#10.C) – 0.1083(#10^4) – 0.0666(#10^5)

Residual standard error = 1.670, df = 278

Multiple R^2 = 0.8227, Adjusted R^2 = 0.8106

F-statistic = 67.91, F-stat p-value < 0.0000, F-stat df = 19 and 278

A5.11.1.2: Male-Specific Model based on Four Teeth with Narrowest Average CIs in the Maxilla

Age = 9.8674 + 3.0668(#11.L) + 1.2226(#11.Q) – 0.0274(#11.C) – 0.2412(#11^4) – 0.2397(#11^5) + 1.5502(#9.L) – 0.6258(#9.Q) – 0.1658(#9.C) – 0.2767(#9^4) + 3.5394(#13.L) + 2.3267(#13.Q) + 0.6074(#13.C) – 0.1541(#13^4) – 0.2052(#13^5) + 0.6468(#10.L) + 0.0105(#10.Q) – 0.4009(#10.C) – 0.1728(#10^4)

Residual standard error = 1.729, df = 241

Multiple R^2 = 0.7986, Adjusted R^2 = 0.7835

F-statistic = 53.08, F-stat p-value < 0.0000, F-stat df = 18 and 241

A5.11.1.3: African-American-Specific Model based on Four Teeth with Narrowest Average CIs in the Maxilla

Age = 8.6325 + 0.4032(#11.L) + 0.8753(#11.Q) – 2.3875(#11.C) + 0.7291(#11^4) + 3.6001(#9.L) – 0.5000(#9.Q) – 1.241(#9.C) + 2.4263(#13.L) + 4.9754(#13.Q) + 0.9727(#13.C) – 1.0677(#13^4) + N/A(#13^5) + 3.1623(#10.L) + N/A(#10.Q) + N/A(#10.C) + N/A(#10^4)

Residual standard error = 2.368, df = 13

Multiple $R^2 = 0.8652$, Adjusted $R^2 = 0.7407$

F-statistic = 6.951, F-stat p-value = 0.0007, F-stat df = 12 and 13

A5.11.1.4: Asian-American-Specific Model based on Four Teeth with Narrowest Average CIs in the Maxilla

Age = 9.92 + 5.8791(#11.L) + 1.7884(#11.Q) – 0.1497(#11.C) + 0.2202(#11^4) + 4.1737(#9.L) + 0.9921(#9.Q) + N/A(#9.C) + 1.2143(#13.L) + 2.2022(#13.Q) + 0.6672(#13.C) + N/A(#13^4) – 3.1129(#10.L) – 1.5528(#10.Q) + 0.06(#10.C)

Residual standard error = 1.872, df = 19

Multiple $R^2 = 0.8788$, Adjusted $R^2 = 0.8023$

F-statistic = 11.48, F-stat p-value < 0.0000, F-stat df = 12 and 19

A5.11.1.5: European-American-Specific Model based on Four Teeth with Narrowest Average CIs in the Maxilla

Age = 9.7327 + 2.5615(#11.L) + 0.4753(#11.Q) – 0.0983(#11.C) – 0.4849(#11^4) + 0.0536(#11^5) + 0.8209(#9.L) + 0.008(#9.Q) – 0.0064(#9.C) + 0.0788(#9^4) + 5.4546(#13.L) + 2.1299(#13.Q) + 1.7172(#13.C) + 0.3118(#13^4) + 0.1421(#13^5) – 0.4463(#13^6) + 0.8045(#10.L) – 0.0791(#10.Q) – 0.0696(#10.C) + 0.1340(#10^4)

Residual standard error = 1.634, df = 249

Multiple $R^2 = 0.8449$, Adjusted $R^2 = 0.8331$

F-statistic = 71.39, F-stat p-value < 0.0000, F-stat df = 19 and 249

A5.11.1.6: Hispanic-Specific Model based on Four Teeth with Narrowest Average CIs in the Maxilla

Age = 9.9797 + 2.4379(#11.L) + 0.9367(#11.Q) + 0.2659(#11.C) – 0.3983(#11^4) + 0.3671(#9.L) – 0.4813(#9.Q) + 0.2465(#9.C) – 0.5922(#9^4) + 3.3267(#13.L) + 1.0296(#13.Q) + 0.3527(#13.C) – 0.3291(#13^4) – 0.1218(#13^5) + 0.6674(#10.L) + 1.3435(#10.Q) – 0.3581(#10.C) – 0.2717(#10^4) – 0.4367(#10^5)

Residual standard error = 1.640, df = 202

Multiple R^2 = 0.7539, Adjusted R^2 = 0.7320

F-statistic = 34.38, F-stat p-value < 0.0000, F-stat df = 18 and 202

A5.11.1.7: Native-American-Specific Model based on Four Teeth with Narrowest Average CIs in the Maxilla

Age = 11.2708 + 6.9877(#11.L) + 1.8750(#11.Q) + 0.8385(#11.C) – 0.7071(#9.L) + 0.4082(#9.Q) + N/A(#13.L) + N/A(#13.Q) + N/A(#13.C) + N/A(#10.L) + N/A(#10.Q)

Residual standard error = 2.046, df = 4

Multiple R^2 = 0.8841, Adjusted R^2 = 0.7392

F-statistic = 6.101, F-stat p-value = 0.0521, F-stat df = 5 and 4

Appendix A5.12: Model based on Three Posterior Teeth with Narrowest Average CIs from Maxilla (#13, 12, and 16) Based on All Individuals

R code: lm(formula = AGE ~ (#13 + #12 + #16), data = dataset)

Age = 12.6239 + 1.0733(#13.L) + 0.7849(#13.Q) + 0.0233(#13.C) – 0.0293(#13^4) + 2.2674(#12.L) – 0.3736(#12.Q) + 0.0572(#12.C) – 0.0447(#12^4) + 6.4965(#16.L) + 0.7174(#16.Q) + 0.3263(#16.C) + 0.1144(#16^4) – 0.4907(#16^5) – 0.6552(#16^6) + 0.0253(#16^7)

Residual standard error = 1.411, df = 441

Multiple R^2 = 0.8099, Adjusted R^2 = 0.8034

F-statistic = 125.30, F-stat p-value < 0.0000, F-stat df = 15 and 441

Figure A5.12: Plot of chronological age by ages predicted from the three posterior teeth with the narrowest average CIs from the maxilla (#13, 12, and 16).

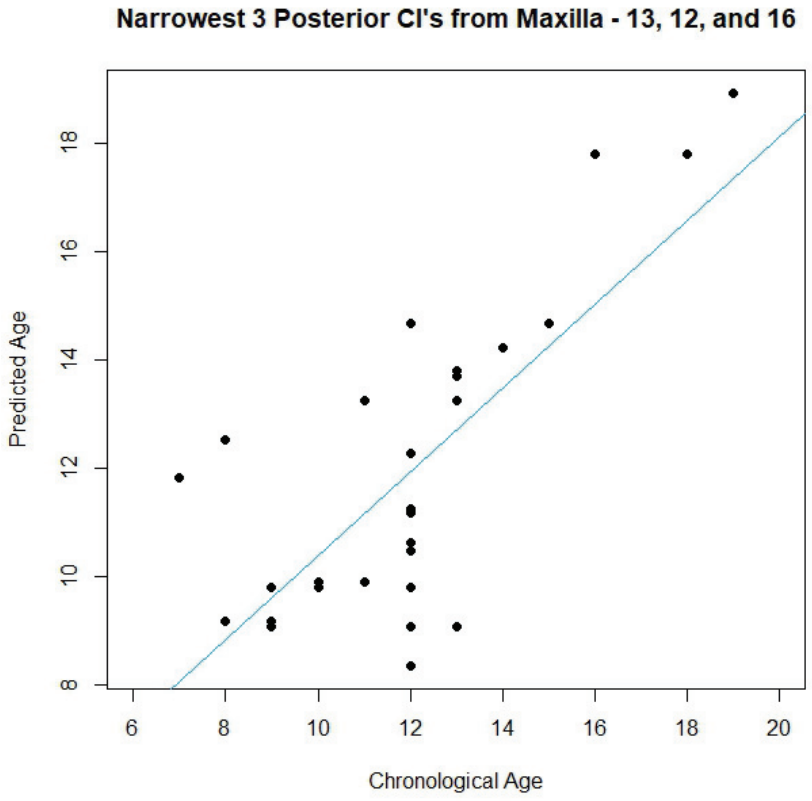


Table A5.12.1: Results of accuracy test with linear model based on three narrowest CIs from posterior teeth in maxilla (#13, 12, and 16).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	6	42.86	4	28.57	4	28.57	4	28.57	8	57.14	2	14.29	3	21.43	10	71.43	1	7.14	14	34
Male	9	60.00	4	26.67	2	13.33	4	26.67	9	60.00	2	13.33	1	6.67	13	86.67	1	6.67	15	34
AfA	2	100.00	0	0.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
AsA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	3
EA	7	63.64	2	18.18	2	18.18	4	36.36	5	45.45	2	18.18	2	18.18	8	72.73	1	9.09	11	33
Haw	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	3
His	4	30.77	6	46.15	3	23.08	3	23.08	8	61.54	2	15.38	2	15.38	10	76.92	1	7.69	13	26
Nat	2	100.00	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	2
AfA Fem	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
AfA Male	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	3
EA Fem	3	60.00	1	20.00	1	20.00	2	40.00	2	40.00	1	20.00	1	20.00	4	80.00	0	0.00	5	18
EA Male	4	66.67	1	16.67	1	16.67	2	33.33	3	50.00	1	16.67	1	16.67	4	66.67	1	16.67	6	15
Haw Fem	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	2
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	2	28.57	3	42.86	2	28.57	2	28.57	4	57.14	1	14.29	2	28.57	4	57.14	1	14.29	7	13
His Male	2	33.33	3	50.00	1	16.67	1	16.67	4	66.67	1	16.67	0	0.00	6	100.00	0	0.00	6	13
Nat Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
Nat Male	2	100.00	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
Total	15	51.72	8	27.59	6	20.69	8	27.59	17	58.62	4	13.79	4	13.79	23	79.31	2	6.90	29	68

Table A5.12.2: Results of accuracy test with linear model based on three narrowest CIs from posterior teeth in maxilla (#13, 12, and 16). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2
Childhood Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2
Childhood Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
Juvenile	3	30.00	3	30.00	4	40.00	1	10.00	6	60.00	3	30.00	0	0.00	8	80.00	2	20.00	10	37
Juvenile Fem	2	40.00	1	20.00	2	40.00	1	20.00	3	60.00	1	20.00	0	0.00	4	80.00	1	20.00	5	18
Juvenile Male	1	20.00	2	40.00	2	40.00	0	0.00	3	60.00	2	40.00	0	0.00	4	80.00	1	20.00	5	19
Adolescence	12	63.16	5	26.32	2	10.53	7	36.84	11	57.89	1	5.26	4	21.05	15	78.95	0	0.00	19	29
Adolescent Fem	4	44.44	3	33.33	2	22.22	3	33.33	5	55.56	1	11.11	3	33.33	6	66.67	0	0.00	9	14
Adolescent Male	8	80.00	2	20.00	0	0.00	4	40.00	6	60.00	0	0.00	1	10.00	9	90.00	0	0.00	10	15
Total	15	51.72	8	27.59	6	20.69	8	27.59	17	58.62	4	13.79	4	13.79	23	79.31	2	6.90	29	68

Table A5.12.3: Results of precision test with linear model based on three narrowest CIs from posterior teeth in maxilla (#13, 12, and 16). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	–	–
Juvenile	1.964 – 1.997	5.588 – 5.682
Adolescence	1.972 – 2.032	5.610 – 5.781

Table A5.12.4: Accuracy of specific versions of linear model based on three narrowest CIs from posterior teeth in maxilla (#13, 12, and 16), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.12.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	7	50.00	4	28.57	3	21.43	4	28.57	7	50.00	3	21.43	3	21.43	10	71.43	1	7.14	14	34
Male	7	46.67	5	33.33	3	20.00	3	20.00	10	66.67	2	13.33	1	6.67	13	86.67	1	6.67	15	5
AfA	2	100.00	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0
AsA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
EA	5	45.45	3	27.27	3	27.27	4	36.36	5	45.45	2	18.18	1	9.09	9	81.82	1	9.09	11	14
His	5	38.46	5	38.46	3	23.08	3	23.08	9	69.23	1	7.69	2	15.38	11	84.62	0	0.00	13	13
Nat	2	100.00	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	0

Table A5.12.5: Results of precision tests for specific versions of linear model based on three narrowest CIs from posterior teeth in maxilla (#13, 12, and 16), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	1.953 – 2.050	–	5.566 – 5.844	–
Male	2.014 – 2.127	–	5.741 – 6.064	–
AfA	1.430 – 1.921	–	4.407 – 5.920	–
AsA	–	–	–	–
EA	1.917 – 2.062	–	5.467 – 5.882	–
His	2.058 – 2.163	–	5.869 – 6.171	–
Nat	2.346 – 2.686	–	7.230 – 8.279	–

Appendix A5.12.1: Specific Versions of Model based on Three Posterior Teeth with Narrowest Average CIs from Maxilla (#13, 12, and 16)

A5.12.1.1: Female-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Maxilla

Age = 12.481 + 0.4756(#13.L) + 0.9595(#13.Q) + 0.0246(#13.C) – 0.1801(#13^4) + 2.7470(#12.L) – 0.1337(#12.Q) – 0.0654(#12.C) – 0.0733(#12^4) + 6.3578(#16.L) + 0.2886(#16.Q) + 0.1961(#16.C) – 0.1125(#16^4) – 0.6027(#16^5) – 1.0755(#16^6) – 0.1798(#16^7)

Residual standard error = 1.391, df = 218

Multiple R^2 = 0.8221, Adjusted R^2 = 0.8099

F-statistic = 67.18, F-stat p-value < 0.0000, F-stat df = 15 and 218

A5.12.1.2: Male-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Maxilla

Age = 13.1054 + 1.6455(#13.L) + 0.6569(#13.Q) + 0.0546(#13.C) + 0.1308(#13^4) + 0.8820(#12.L) – 0.2342(#12.Q) – 0.0011(#12.C) + 6.5088(#16.L) + 0.945(#16.Q) + 0.4293(#16.C) + 0.2632(#16^4) – 0.4059(#16^5) – 0.1726(#16^6) + 0.2622(#16^7)

Residual standard error = 1.429, df = 208

Multiple R^2 = 0.8107, Adjusted R^2 = 0.7979

F-statistic = 63.61, F-stat p-value < 0.0000, F-stat df = 14 and 208

A5.12.1.3: African-American-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Maxilla

Age = 12.0305 + 4.3621(#13.L) + 1.5685(#13.Q) – 0.1682(#13.C) – 0.5275(#13^4) – 0.0476(#12.L) – 0.7651(#12.Q) + N/A(#12.C) + 3.6604(#16.L) + 0.3697(#16.Q) + 0.7077(#16.C) + N/A(#16^4) + N/A(#16^5)

Residual standard error = 0.8955, df = 11

Multiple R^2 = 0.9659, Adjusted R^2 = 0.9381

F-statistic = 34.66, F-stat p-value < 0.0000, F-stat df = 9 and 11

A5.12.1.4: Asian-American-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Maxilla

Age = 11.3722 – 2.5298(#13.L) + 3.4744(#13.Q) – 0.4743(#13.C) – 0.0598(#13^4) + 8.8697(#12.L) – 0.5000(#12.Q) – 2.7578(#12.C) + 2.2311(#16.L) + 5.3100(#16.Q) – 2.4597(#16.C) + 0.6929(#16^4) + N/A(#16^5)

Residual standard error = 1.426, df = 5

Multiple R^2 = 0.9535, Adjusted R^2 = 0.8511

F-statistic = 9.313, F-stat p-value = 0.0116, F-stat df = 11 and 5

A5.12.1.5: European-American-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Maxilla

Age = 12.8704 + 1.6583(#13.L) + 0.8059(#13.Q) + 0.1897(#13.C) – 0.3300(#13^4) + 2.0003(#12.L) – 0.3576(#12.Q) – 0.1118(#12.C) – 0.0096(#12^4) + 6.1565(#16.L) + 1.0639(#16.Q) – 0.1035(#16.C) – 0.1686(#16^4) – 0.4966(#16^5) – 0.7552(#16^6) + 0.3257(#16^7)

Residual standard error = 1.363, df = 183

Multiple R^2 = 0.8520, Adjusted R^2 = 0.8399

F-statistic = 70.26, F-stat p-value < 0.0000, F-stat df = 15 and 183

A5.12.1.6: Hispanic-Specific Mandibular Model based on Three Posterior Teeth with Narrowest Average CIs from Maxilla

Age = 12.0321 + 1.2065(#13.L) + 0.2417(#13.Q) + 0.0257(#13.C) + 0.2042(#13^4) + 2.2930(#12.L) + 0.0853(#12.Q) – 0.0125(#12.C) + 0.0527(#12^4) + 6.0629(#16.L) + 0.6219(#16.Q) + 0.6463(#16.C) + 0.6834(#16^4) – 0.1129(#16^5) – 0.2638(#16^6) – 0.1904(#16^7)

Residual standard error = 1.456, df = 182

Multiple $R^2 = 0.7334$, Adjusted $R^2 = 0.7114$

F-statistic = 33.38, F-stat p-value < 0.0000, F-stat df = 15 and 182

A5.12.1.7: Native-American-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Maxilla

Age = 12.2908 + 1.3618(#13.L) + 1.2302(#13.Q) + 0.6747(#13.C) – 0.2119(#13^4) + 2.0876(#12.L) + 0.4334(#12.Q) + 1.5502(#16.L) – 0.314(#16.Q) + 1.3970(#16.C) + 0.2950(#16^4) + N/A(#16^5) + N/A(#16^6)

Residual standard error = 1.161, df = 11

Multiple $R^2 = 0.8940$, Adjusted $R^2 = 0.7977$

F-statistic = 9.28, F-stat p-value = 0.0005, F-stat df = 10 and 11

Appendix A5.13: Model based on Three Posterior Teeth with Narrowest Average CIs from Mandible (#21, 19, and 20) Based on All Individuals

R code: lm(formula = AGE ~ (#21 + #19 + #20), data = dataset)

Age = 8.9289 + 3.8201(#21.L) + 0.6719(#21.Q) + 0.5376(#21.C) – 0.0238(#21^4) + 0.0652(#21^5) + 2.6444(#19.L) – 0.2759(#19.Q) + 0.3831(#19.C) – 0.2215(#19^4) + 1.6853(#20.L) + 3.0750(#20.Q) – 0.1366(#20.C) + 1.0318(#20^4) – 0.3382(#20^5) + 0.2117(#20^6) + N/A(#20^7)

Residual standard error = 1.64, df = 1500

Multiple R^2 = 0.7859, Adjusted R^2 = 0.7838

F-statistic = 367.10, F-stat p-value < 0.0000, F-stat df = 15 and 1500

Figure A5.13: Plot of chronological age by ages predicted from the three posterior teeth with the narrowest average CIs from the maxilla (#13, 12, and 16).

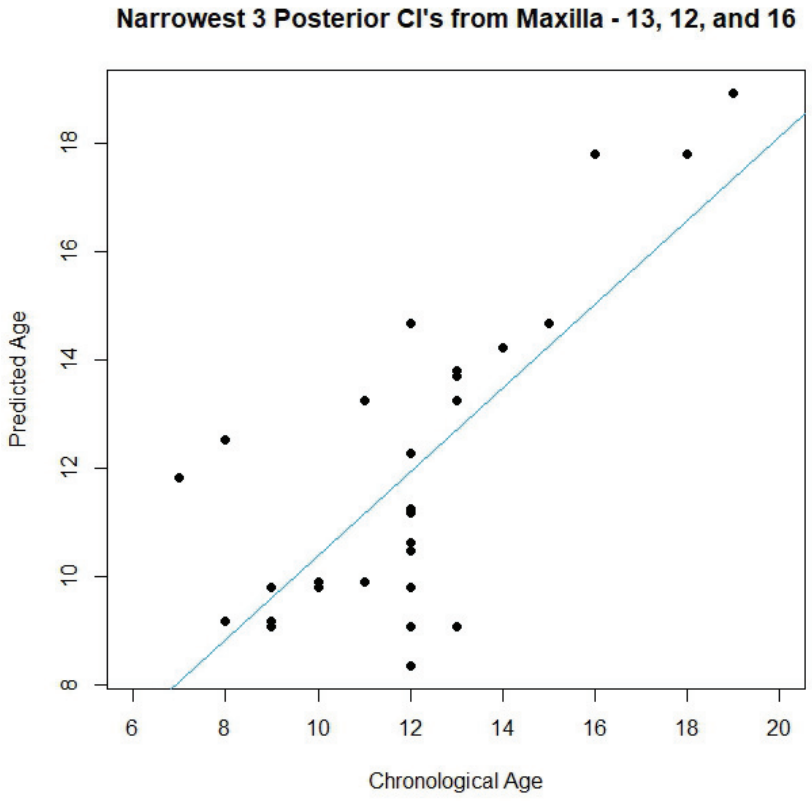


Table A5.13.1: Results of accuracy test with linear model based on three narrowest CIs from posterior teeth in mandible (#21, 19, and 20).

Linear Model	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	19	42.22	11	24.44	15	33.33	8	17.78	31	68.89	6	13.33	2	4.44	42	93.33	1	2.22	45	4
Male	26	57.78	12	26.67	7	15.56	14	31.11	30	66.67	1	2.22	0	0.00	45	100.00	0	0.00	45	6
AfA	2	100.00	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
AsA	2	50.00	0	0.00	2	50.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	0
EA	25	60.98	8	19.51	8	19.51	13	31.71	26	63.41	2	4.88	1	2.44	40	97.56	0	0.00	41	5
Haw	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	1
His	14	37.84	12	32.43	11	29.73	5	13.51	28	75.68	4	10.81	1	2.70	35	94.59	1	2.70	37	2
Nat	2	66.67	0	0.00	1	33.33	2	66.67	0	0.00	1	33.33	0	0.00	3	100.00	0	0.00	3	1
AfA Fem	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
AfA Male	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	1	1
AsA Fem	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0
AsA Male	2	50.00	0	0.00	2	50.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	0
EA Fem	11	55.00	4	20.00	5	25.00	6	30.00	13	65.00	1	5.00	1	5.00	19	95.00	0	0.00	20	4
EA Male	14	66.67	4	19.05	3	14.29	7	33.33	13	61.90	1	4.76	0	0.00	21	100.00	0	0.00	21	1
Haw Fem	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	0	0.00	3	100.00	0	0.00	3	0
Haw Male	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	1
His Fem	7	35.00	4	20.00	9	45.00	2	10.00	14	70.00	4	20.00	1	5.00	18	90.00	1	5.00	20	0
His Male	7	41.18	8	47.06	2	11.76	3	17.65	14	82.35	0	0.00	0	0.00	17	100.00	0	0.00	17	2
Nat Fem	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	100.00	0	0.00	1	0
Nat Male	2	100.00	0	0.00	0	0.00	2	100.00	0	0.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
Total	45	50.00	23	25.56	22	24.44	22	24.44	61	67.78	7	7.78	2	2.22	87	96.67	1	1.11	90	10

Table A5.13.2: Results of accuracy test with linear model based on three narrowest CIs from posterior teeth in mandible (#21, 19, and 20). Applied to biological phases as defined by Bogin (1999).

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Childhood	1	33.33	1	33.33	1	33.33	0	0.00	2	66.67	1	33.33	0	0.00	3	100.00	0	0.00	3	0
Childhood Fem	0	0.00	1	50.00	1	50.00	0	0.00	1	50.00	1	50.00	0	0.00	2	100.00	0	0.00	2	0
Childhood Male	1	100.00	0	0.00	0	0.00	0	0.00	1	100.00	0	0.00	0	0.00	1	100.00	0	0.00	1	0
Juvenile	18	40.00	14	31.11	13	28.89	4	8.89	38	84.44	3	6.67	0	0.00	44	97.78	1	2.22	45	4
Juvenile Fem	10	43.48	5	21.74	8	34.78	3	13.04	18	78.26	2	8.70	0	0.00	22	95.65	1	4.35	23	1
Juvenile Male	8	36.36	9	40.91	5	22.73	1	4.55	20	90.91	1	4.55	0	0.00	22	100.00	0	0.00	22	3
Adolescence	26	61.90	8	19.05	8	19.05	18	42.86	21	50.00	3	7.14	2	4.76	40	95.24	0	0.00	42	6
Adolescent Fem	9	45.00	5	25.00	6	30.00	5	25.00	12	60.00	3	15.00	2	10.00	18	90.00	0	0.00	20	3
Adolescent Male	17	77.27	3	13.64	2	9.09	13	59.09	9	40.91	0	0.00	0	0.00	22	100.00	0	0.00	22	3
Total	45	50.00	23	25.56	22	24.44	22	24.44	61	67.78	7	7.78	2	2.22	87	96.67	1	1.11	90	10

Table A5.13.3: Results of precision test with linear model based on three narrowest CIs from posterior teeth in mandible (#21, 19, and 20). Applied to biological phases as defined by Bogin (1999). Values represent widths of PIs in years.

Biological Phase	51% Prediction Interval	95% Prediction Interval
Childhood	2.274 – 2.330	6.460 – 6.620
Juvenile	2.269 – 2.303	6.453 – 6.544
Adolescence	2.269 – 2.297	6.446 – 6.527

Table A5.13.4: Accuracy of specific versions of linear model based on three narrowest CIs from posterior teeth in mandible (#21, 19, and 20), applied to the appropriate subsample, e.g., Female = accuracy of female-specific model on female portion of test set. Percentages calculated from number of individuals to which the model could be applied, i.e., n – N/A. Performance of general model on subsets in Table A5.13.1.

Sample	Point Estimate						51% Prediction Interval						95% Prediction Interval						Total	
	Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged		Under-aged		Correct		Over-aged			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	N/A
Female	22	48.89	11	24.44	12	26.67	9	20.00	32	71.11	4	8.89	2	4.44	42	93.33	1	2.22	45	4
Male	23	51.11	11	24.44	11	24.44	14	31.11	29	64.44	2	4.44	0	0.00	45	100.00	0	0.00	45	6
AfA	2	100.00	0	0.00	0	0.00	1	50.00	1	50.00	0	0.00	0	0.00	2	100.00	0	0.00	2	1
AsA	1	25.00	1	25.00	2	50.00	1	25.00	3	75.00	0	0.00	0	0.00	4	100.00	0	0.00	4	0
EA	23	56.10	8	19.51	10	24.39	12	29.27	27	65.85	2	4.88	1	2.44	40	97.56	0	0.00	41	5
His	19	51.35	11	29.73	7	18.92	9	24.32	26	70.27	2	5.41	1	2.70	35	94.59	1	2.70	37	2
Nat	2	66.67	0	0.00	1	33.33	1	33.33	1	33.33	1	33.33	0	0.00	2	66.67	1	33.33	3	0

Table A5.13.5: Results of precision tests for specific versions of linear model based on three narrowest CIs from posterior teeth in mandible (#21, 19, and 20), applied to the appropriate subsample of the test set. Values represent widths of PIs in years. Performance of general model on entire test sample in Table 5.19 in Chapter 5. Outside Range = PIs that are more than twice the highest value in the usual range.

Linear Model	51% Prediction Interval		95% Prediction Interval	
	Range of PI Widths	Outside Range	Range of PI Widths	Outside Range
Female	2.307 – 2.391	–	6.599 – 6.796	–
Male	2.217 – 2.305	–	6.303 – 6.552	–
AfA	2.621 – 2.928	–	7.557 – 8.445	–
AsA	2.393 – 3.283	–	6.933 – 9.513	–
EA	2.211 – 2.264	–	6.286 – 6.435	–
His	2.149 – 2.220	–	6.109 – 6.312	–
Nat	2.158 – 3.107	–	6.289 – 9.055	–

Appendix A5.13.1: Specific Versions of Model based on Three Posterior Teeth with Narrowest Average CIs from Mandible (#21, 19, and 20)

A5.13.1.1: Female-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Mandible

Age = 8.6968 + 4.0323(#21.L) + 0.8523(#21.Q) + 0.2468(#21.C) – 0.0815(#21^4) + 0.1585(#21^5) + 3.6109(#19.L) – 1.2194(#19.Q) + 0.8848(#19.C) – 0.4405(#19^4) + 0.7269(#20.L) + 4.1045(#20.Q) – 0.5874(#20.C) + 1.5341(#20^4) – 0.6853(#20^5) + 0.3398(#20^6) + N/A(#20^7)

Residual standard error = 1.666, df = 786

Multiple R^2 = 0.7917, Adjusted R^2 = 0.7877

F-statistic = 199.10, F-stat p-value < 0.0000, F-stat df = 15 and 786

A5.13.1.2: Male-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Mandible

Age = 9.4218 + 3.8632(#21.L) + 0.5514(#21.Q) + 0.7702(#21.C) + 0.0218(#21^4) + 0.0187(#21^5) + 1.4557(#19.L) + 0.4805(#19.Q) – 0.1604(#19.C) + 2.7118(#20.L) + 1.3462(#20.Q) + 0.6501(#20.C) + 0.1633(#20^4) + 0.0910(#20^5) + 0.0496(#20^6)

Residual standard error = 1.600, df = 699

Multiple R^2 = 0.7868, Adjusted R^2 = 0.7826

F-statistic = 184.30, F-stat p-value < 0.0000, F-stat df = 14 and 699

A5.13.1.3: African-American-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Mandible

Age = 9.9467 + 2.9022(#21.L) + 0.1961(#21.Q) – 0.2450(#21.C) + 0.2936(#21^4) – 0.3288(#21^5) + 0.8067(#19.L) – 0.0786(#19.Q) + 3.5786(#20.L) + 2.6294(#20.Q) – 0.2919(#20.C) + 0.1592(#20^4) – 0.2276(#20^5)

Residual standard error = 1.840, df = 55

Multiple R^2 = 0.7840, Adjusted R^2 = 0.7369

F-statistic = 16.64, F-stat p-value < 0.0000, F-stat df = 12 and 55

A5.13.1.4: Asian-American-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Mandible

Age = 9.2292 + 2.0706(#21.L) + 1.3337(#21.Q) + 0.6300(#21.C) + 0.1678(#21^4) – 0.1546(#21^5) + 2.2211(#19.L) + 0.4888(#19.Q) – 0.4158(#19.C) + 3.8871(#20.L) + 2.1059(#20.Q) + 1.1690(#20.C) + 0.7706(#20^4) + 0.6656(#20^5)

Residual standard error = 1.667, df = 42

Multiple R^2 = 0.8869, Adjusted R^2 = 0.8520

F-statistic = 25.35, F-stat p-value < 0.0000, F-stat df = 13 and 42

A5.13.1.5: European-American-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Mandible

Age = 8.6629 + 4.3002(#21.L) + 0.7194(#21.Q) + 0.4998(#21.C) – 0.0464(#21^4) + 0.1013(#21^5) + 6.9340(#19.L) – 3.8468(#19.Q) + 2.3787(#19.C) – 1.0479(#19^4) – 2.0059(#20.L) + 6.7370(#20.Q) – 2.9008(#20.C) + 2.9416(#20^4) – 1.3202(#20^5) + 0.5876(#20^6) + N/A(#20^7)

Residual standard error = 1.596, df = 729

Multiple R^2 = 0.8225, Adjusted R^2 = 0.8189

F-statistic = 225.30, F-stat p-value < 0.0000, F-stat df = 15 and 729

A5.13.1.6: Hispanic-Specific Mandibular Model based on Three Posterior Teeth with Narrowest Average CIs from Mandible

Age = 9.0147 + 3.5430(#21.L) + 0.6020(#21.Q) + 0.5415(#21.C) – 0.0583(#21^4) + 0.0082(#21^5) + 0.7374(#19.L) + 0.5488(#19.Q) – 0.0485(#19.C) + 3.2403(#20.L) + 0.8392(#20.Q) + 0.8708(#20.C) + 0.1614(#20^4) + 0.1907(#20^5) + 0.0286(#20^6)

Residual standard error = 1.547, df = 589

Multiple R^2 = 0.7473, Adjusted R^2 = 0.7413

F-statistic = 124.40, F-stat p-value < 0.0000, F-stat df = 14 and 589

A5.13.1.7: Native-American-Specific Model based on Three Posterior Teeth with Narrowest Average CIs from Mandible

Age = 11.3014 + 3.2307(#21.L) + 1.3249(#21.Q) + 0.3096(#21.C) + 0.4606(#21^4) + 1.1981(#19.L) + 2.1146(#20.L) + 0.5088(#20.Q) – 0.3271(#20.C) – 0.9570(#20^4)

Residual standard error = 1.466, df = 33

Multiple R^2 = 0.8302, Adjusted R^2 = 0.7839

F-statistic = 17.92, F-stat p-value < 0.0000, F-stat df = 9 and 33

Appendix A5.14: Orthogonal Polynomial Contrast Tables

Table A5.14.1: Orthogonal polynomial contrast table for an ordinal variable with eight potential scores, i.e., a table of seven contrasts, generated by R (R Core Team 2017). When all eight Demirjian et al. (1973) developmental scores are present in the sample that informs the linear model, a score of A is the 1st score, B is the second score, etc.

Ordinal Variable Value	.L (Linear)	.Q (Quadratic)	.C (Cubic)	^4 (Fourth Order)	^5 (Fifth Order)	^6 (Sixth Order)	^7 (Seventh Order)
1st Score	-0.5401	0.5401	-0.4308	0.2820	-0.1498	0.0615	-0.0171
2nd Score	-0.3858	0.0772	0.3077	-0.5238	0.4922	-0.3077	0.1195
3rd Score	-0.2315	-0.2315	0.4308	-0.1209	-0.3638	0.5539	-0.3585
4th Score	-0.0772	-0.3858	0.1846	0.3626	-0.3210	-0.3077	0.5974
5th Score	0.0772	-0.3858	-0.1846	0.3626	0.3210	-0.3077	-0.5974
6th Score	0.2315	-0.2315	-0.4308	-0.1209	0.3638	0.5539	0.3585
7th Score	0.3858	0.0772	-0.3077	-0.5238	-0.4922	-0.3077	-0.1195
8th Score	0.5401	0.5401	0.4308	0.2820	0.1498	0.0615	0.0171

Table A5.14.2: Orthogonal polynomial contrast table for an ordinal variable with seven potential scores, i.e., a table of six contrasts, generated by R (R Core Team 2017).

Ordinal Variable Value	.L (Linear)	.Q (Quadratic)	.C (Cubic)	^4 (Fourth Order)	^5 (Fifth Order)	^6 (Sixth Order)
1st Score	-0.5669	0.5455	-0.4082	0.2417	-0.1091	0.0329
2nd Score	-0.3780	0.0000	0.4082	-0.5641	0.4364	-0.1974
3rd Score	-0.1890	-0.3273	0.4082	0.0806	-0.5455	0.4935
4th Score	0.0000	-0.4364	0.0000	0.4835	0.0000	-0.6580
5th Score	0.1890	-0.3273	-0.4082	0.0806	0.5455	0.4935
6th Score	0.3780	0.0000	-0.4082	-0.5641	-0.4364	-0.1974
7th Score	0.5669	0.5455	0.4082	0.2417	0.1091	0.0329

Table A5.14.3: Orthogonal polynomial contrast table for an ordinal variable with six potential scores, i.e., a table of five contrasts, generated by R (R Core Team 2017).

Ordinal Variable Value	.L (Linear)	.Q (Quadratic)	.C (Cubic)	^4 (Fourth Order)	^5 (Fifth Order)
1st Score	-0.5976	0.5455	-0.3727	0.1890	-0.0630
2nd Score	-0.3586	-0.1091	0.5217	-0.5669	0.3150
3rd Score	-0.1195	-0.4364	0.2981	0.3780	-0.6299
4th Score	0.1195	-0.4364	-0.2981	0.3780	0.6299
5th Score	0.3586	-0.1091	-0.5217	-0.5669	-0.3150
6th Score	0.5976	0.5455	0.3727	0.1890	0.0630

Table A5.14.4: Orthogonal polynomial contrast table for an ordinal variable with five potential scores, i.e., a table of four contrasts, generated by R (R Core Team 2017).

Ordinal Variable Value	.L (Linear)	.Q (Quadratic)	.C (Cubic)	^4 (Fourth Order)
1st Score	-0.6325	0.5345	-0.3162	0.1195
2nd Score	-0.3162	-0.2673	0.6325	-0.4781
3rd Score	0.0000	-0.5345	0.0000	0.7171
4th Score	0.3162	-0.2673	-0.6325	-0.4781
5th Score	0.6325	0.5345	0.3162	0.1195

Table A5.14.5: Orthogonal polynomial contrast table for an ordinal variable with four potential scores, i.e., a table of three contrasts, generated by R (R Core Team 2017).

Ordinal Variable Value	.L (Linear)	.Q (Quadratic)	.C (Cubic)
1st Score	-0.6708	0.5000	-0.2236
2nd Score	-0.2236	-0.5000	0.6708
3rd Score	0.2236	-0.5000	-0.6708
4th Score	0.6708	0.5000	0.2236

Table A5.14.6: Orthogonal polynomial contrast table for an ordinal variable with three potential scores, i.e., a table of two contrasts, generated by R (R Core Team 2017).

Ordinal Variable Value	.L (Linear)	.Q (Quadratic)
1st Score	-0.7071	0.4082
2nd Score	0.0000	-0.8165
3rd Score	0.7071	0.4082

Table A5.14.7: Orthogonal polynomial contrast table for an ordinal variable with two potential scores, i.e., a table of one contrast, generated by R (R Core Team 2017).

Ordinal Variable Value	.L (Linear)
1st Score	-0.7071
2nd Score	0.7071

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