University of Tennessee, Knoxville

TRACE: Tennessee Research and Creative Exchange

Masters Theses

Graduate School

8-2003

A Radiographic Study of Third Molar Agenesis in a Sample from the American Midsouth

Alexandra Y. Hentisz
University of Tennessee - Knoxville

Follow this and additional works at: https://trace.tennessee.edu/utk_gradthes

Part of the Anthropology Commons

Recommended Citation

Hentisz, Alexandra Y., "A Radiographic Study of Third Molar Agenesis in a Sample from the American Midsouth. " Master's Thesis, University of Tennessee, 2003.
https://trace.tennessee.edu/utk_gradthes/1976

This Thesis is brought to you for free and open access by the Graduate School at TRACE: Tennessee Research and Creative Exchange. It has been accepted for inclusion in Masters Theses by an authorized administrator of TRACE: Tennessee Research and Creative Exchange. For more information, please contact trace@utk.edu.

www.manaraa.com

To the Graduate Council:

I am submitting herewith a thesis written by Alexandra Y. Hentisz entitled "A Radiographic Study of Third Molar Agenesis in a Sample from the American Midsouth." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

DR. RICHARD JANTZ, Major Professor

We have read this thesis and recommend its acceptance:

DR. MURRAY MARKS, DR. EDWARD HARRIS

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

للاستشارات المنارة
www.manaraa.com

To the Graduate Council:

I am submitting herewith a thesis written by Alexandra Y. Hentisz entitled "A Radiographic Study of Third Molar Agenesis in a Sample from the American Midsouth." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Anthropology.

DR. RICHARD JANTZ__________
Richard Jantz, Major Professor

We have read this thesis and
recommend its acceptance:

DR. MURRAY MARKS________________

DR. EDWARD HARRIS________________

Acceptance for the Council:

ANNE MAYHEW____________

Vice Provost and Dean of
Graduate Studies

المنارة للاستشارات

www.manaraa.com

A RADIOGRAPHIC STUDY OF THIRD MOLAR AGENESIS IN A SAMPLE FROM THE AMERICAN MIDSOUTH

A Thesis
Presented for the
Master of Arts
Degree
The University of Tennessee, Knoxville

Alexandra Hentisz

August 2003

www.manaraa.com

DEDICATION

This thesis is dedicated to my mother, Chryzanta Hentisz, my father, Roman Hentisz, my brother, Danyo Hentisz, and my sister, Ksenya Hentisz, for supporting me throughout all my endeavors and for always believing in me.

المنارة للاستشارات
www.manaraa.com

ACKNOWLEDGEMENTS

I would like to thank all those who helped me complete my thesis for the Master of Arts degree in Anthropology. I wish to thank Dr. Richard Jantz for encouraging my interest in biological variation in humans. I would like to thank Dr. Murray Marks for introducing me to dental anthropology and forensics. I wish to thank Dr. Edward Harris for access to the archives at the University of Tennessee Dental School in Memphis, as well as for his invaluable help with interpreting data and editing my thesis. I would also like to thank the preceding professors for their guidance and input throughout this study. I wish to thank Mike Newman of the Statistics Consulting Center at the University of Tennessee for his help with statistical analysis.

My gratitude is extended to my friends at school who helped me remain sane and grounded throughout my two years here, especially Carrie Srnka and Jeffrey Huber. To my Northern friends Adrian Dlaboha, Olenka Rojowsky and Larissa Babij, thanks for nothing, and, of course, everything. Finally, I'd like to thank my family for always being there and for keeping me entertained.

المنارة للاستشارات
www.manaraa.com

ABSTRACT

The purpose of this study was to determine the frequency of third molar agenesis in a sample from the American Midsouth. The sample included 118 black males, 115 black females, 100 white males and 100 white females. Panoramic radiographs of the dentition for each individual were studied to ascertain whether any of the third molars was congenitally absent. The results were submitted to statistical analysis.

The results showed that white males have a significantly higher propensity to be congenitally missing a third molar than black males, with $p<0.001$. Likewise, whites are more likely to be missing a third molar in the mandible than blacks, with $p=0.007$ in males and 0.041 in females. There was no significant difference between the sexes for each ancestry, nor was there a significant difference between sides.

The lower frequency of third molar agenesis in blacks (5.6%) compared to whites (15.5%) is consistent with results of earlier studies. The frequency for the white sample closely matches reported frequencies for American whites in Middle America. Since there are few studies of third molar agenesis in admixed African populations, the results of this study can be used as a baseline for American blacks.

المنارة للاستشارات
www.manaraa.com

TABLE OF CONTENTS

Chapter		Page
1.	**INTRODUCTION**	1
2.	**LITERATURE REVIEW**	3
3.	**METHODS AND MATERIALS**	30
4.	**RESULTS**	34
5.	**DISCUSSION**	44
6.	**CONCLUSION**	49
LITERATURE CITED		51
VITA		56

المنارة للاستشارات
www.manaraa.com

LIST OF TABLES

Table		Page
1.	Congenital Absence of Third Molars in Previous Studies	8
2.	Distribution of Congenitally Absent Third Molars	34
3.	Total Number of Missing Third Molars	40
4.	Number of Third Molars Missing Per Individual	41
5.	Odds Ratio for Ancestry by Sex - All Third Molars	41
6.	Odds Ratio for Ancestry by Sex – Mandible	42
7.	Odds Ratio for Ancestry by Sex – Maxilla	42

www.manaraa.com

LIST OF FIGURES

Figure		Page
1.	Supernumerary molar in mandible of black male	36
2.	Supernumerary molars in black female	36
3.	White male with hypodontia	38
4.	20-year old white male with extremely delayed dental development	38
5.	White female with cleft lip and palate and hypodontia	39

المنارة للاستشارات
www.manaraa.com

CHAPTER 1: INTRODUCTION

The third molar is phenotypically the most unstable tooth in the human dentition and the most subject to variation. It is the last of the permanent teeth to mineralize and erupt. The age for eruption of all four varies from 13 years of age in the most precocious individuals to about 25 years in the most delayed (Hassanali, 1985; Garn et al., 1972). The most significant variation, however, is the tendency for the third molar to not form at all, a phenomenon known as congenital absence. Although there is variation among populations, approximately 18-20% of contemporary people display agenesis of one or more third molars. Within that affected group, individuals tend to exhibit signs and symptoms such as agenesis of the mandibular second premolar and/or maxillary lateral incisor as well as size reduction of the remaining teeth. While third molar agenesis is relevant to dentistry (Tavajohi-Kermani et al., 2002), it also has important implications for anthropology.

The human dentition is considered to be an important marker of evolutionary trends. Teeth are the most tenacious of the hard tissues of the body and can be the only mineralized elements that survive millennia to represent different species of hominids. Likewise, dental variation among human populations may be indicative of selective pressures and genetic affiliations. This kind of variation is significant in studies of human variation in physical anthropology.

Difference among populations is of interest in the field of forensic anthropology. In identifying human remains, determining ancestral origin and age at death is vital.

المنارة للاستشارات
www.manaraa.com

Certain dental characteristics can aid in determining ancestry, such as shovel-shaped incisors or Carabelli's cusps (Scott and Turner, 1997; Goldstein, 1948; Brothwell at al., 1963). Likewise, the dentition can provide valuable clues to age. The third molar, though not ideal, is sometimes the only indicator of age that can be used when considering young adults (Mincer et al., 1993). Relying on the third molar can cause problems when hypodontia is concerned, however. Case reports have demonstrated that, in some instances, that age can be misestimated because of reliance on the presence of third molars (Nambiar et al., 1996). This, of course, may affect identification and the resolution of the case.

I suggest that ascertaining the rate of third molar agenesis in certain populations can improve reliance on third molars as indicators of age. The present study will discern the frequency of third molar agenesis in a sample of contemporary American blacks and whites. This sample consists of panoramic radiographs from patient archives at the Department of Graduate Orthodontics, College of Dentistry at the University of Tennessee, Memphis. Both males and females are included. The results will be compared with previous studies to gauge the differences between populations.

Determining the rate of third molar agenesis in American blacks and whites may prove useful to forensic anthropologists. If the ancestry of an unidentified individual is known, and there is a lack of one or more third molars, more refined guesses as to the age of the individual could be made. Knowing that third molar agenesis affects a certain percentage of the population can prevent an analyst from making a hasty assumption about age. This study will advance the utility of human variation research to the fields of forensic anthropology and forensic odontology.

المنارة للاستشارات
www.manaraa.com

CHAPTER 2: LITERATURE REVIEW

Congenital absence of the third molar has been studied in a variety of populations, such as East Africans (Chagula, 1960), Japanese (Daito et al., 1992) and Estonians (Peltola et al., 1997). Researchers offered reasons for third molar agenesis ranging from biocultural evolutionary processes to particular genetic mutations. Third molar agenesis is a phenomenon with a complex etiology that is not yet fully understood. Before it is explored further, an overview of dental development, especially that of the third molar, is necessary.

Development of the Human Dentition

As stated before, the third molar is the most variable tooth in the human permanent dentition. Although it is the last of the permanent teeth to form, it follows the same pattern of histogenesis and morphogenesis.

Tooth development begins around the 6^{th} week after conception, with the differentiation of the dental lamina. The dental lamina is a sheet of epithelial cells in the developing maxillary and mandibular arches which gives rise to 20 enamel organs that will serve as the basis for the 20 primary deciduous teeth. Each enamel organ has a lingual projection for its succeeding permanent tooth (Harris, 2002). The permanent molars have no deciduous predecessors and develop from the distal aspect of the dental lamina. Independently, each enamel organ develops through characteristic stages known as bud, cap, and bell. In bud stage the enamel organs are just beginning to coalesce and form a rounded contour. In the cap stage they continue to grow and develop a concave

www.manaraa.com

shape at the leading edge. Final morphogenesis occurs at the bell stage when the shape of the tooth, based on its class, is determined (Bath-Balogh and Fehrenbach, 1997). From around the 3rd – 4th month in utero, mineralization begins to occur through the deposition of dentin and enamel. The tooth mineralizes first from the cusps of the crown down to the apex of the root. However, with just a third of root formation complete, the process of eruption begins. The tooth moves into the oral cavity partly to give the root room to form completely and because of the proliferation of fundic bone, pulp, fluid and other soft tissues underneath the crown pushing it. The periodontal ligament provides the most important motive force by exerting a pull on the tooth, helping to bring it into the oral cavity (Avery, 2000).

The primary dentition begins emergence starting at around 6-8 months after birth and continues until about 2.5 years of age. The first permanent tooth begins around 6 years of age and continues, except for the third molar, until about age 12 (Bath-Balogh and Fehrenbach, 1997). This is the period of mixed dentition, when the permanent teeth are replacing their primary predecessors. The exfoliation, or shedding, of the primary teeth occurs when their roots are undermined and dissolved by the advance of the erupting permanent teeth. In general, the mandibular teeth erupt slightly in advance of their maxillary counterparts.

The third molar begins to mineralize at around 7 years of age. The crown is completed by 16 years and erupts into the oral cavity starting at around 17 years (Avery, 2000). There is much variation in the timing of the development and eruption of the third molar and of the rest of the permanent dentition. Studies on the subject have been undertaken for both sexes and for different races and geographical areas.

المنارة للاستشارات
www.manaraa.com

Most studies agree that people of African ancestry show earlier mineralization and eruption times for the permanent teeth than do whites, especially in the later forming teeth such as third molars (Garn et al., 1972; Krumholt et al., 1972; Garn et al., 1973; Hassanali, 1981; Harris and McKee, 1990). Garn and coworkers (1972), in a sample of 953 blacks and 998 whites, found that lack males were on average 0.38 standard deviations ahead of their white counterparts in terms of permanent tooth emergence, while black females were 0.48 standard deviations ahead of white females. A later study by Garn and colleagues (1973) found that a sample of 3022 black boys and girls were dentally advanced over 2188 white boys and girls of similar income level by an average of 0.30 standard deviations. Harris and McKee (1990) found that black males were significantly ahead of white males in 26% of the developmental stage comparisons while black females were advanced over their white counterparts 42% of the time. Interestingly, the white sample in Harris and McKee's (1990) study, whose regional origin was the American Midsouth, was significantly behind a white sample from Ontario (10% slower among males, 15% slower among females). Similarly, Hassanali (1985) found that a sample of 1343 Kenyan Africans was slightly behind Chagula's (1960) sample of other East Africans in third molar emergence, although he attributed this to a possible misestimation of ages in Chagula's study. These cases show regional variation within populations of similar ancestry.

Differences in the timing of third molar emergence are especially striking. The ages range from as early as 13.0 years in some African males (Chagula, 1960; Hassanali, 1985) to as late as 25.6 years in a sample of white females (Garn et al. 1972). Garn and coworkers (1972) found in their study that blacks were significantly ahead of whites in

المنارة للاستشارات
www.manaraa.com

emergence of the mandibular third molars (5.6 years difference) and in the maxillary third molars (3.7 years difference). Hassanali (1985) found that third molar emergence in his sample of 1343 Kenyan Africans was on average 2-3 years ahead of a sample of Asians living in Nairobi (n=1092), which in turn was about 0.25 years behind Fanning's (1962) white sample from Boston.

Studies show that, for the most part, females are ahead of males in development and eruption of the permanent teeth (Garn et al., 1972; Mincer et al., 1993). This holds true for all teeth except the third molars. A study of the development and emergence of the mandibular third molar in a sample of 2362 French-Canadian females and 2278 French-Canadian males found that while females are ahead of males during crown formation, the males pull ahead of the females during root formation and eruption (Levesque et al., 1981). Similar results were found by Mincer and coworkers (1993), who found an average of 3-4 months difference between males and females from the beginning of third molar root formation to the completion of the root apex, with the males being ahead.

Knowledge of variation in dental development is important in a forensic context. Third molars, though variable, are often used as indicators of age during the adolescent period. Since the resolution of a criminal case may rest on the adult status of the individual in question, accuracy in estimating the age is crucial (Mincer et al., 1993; Nambiar et al., 1996). Therefore, studies underlining differences among populations and between sexes during dental development, and especially concerning the third molar, are valuable.

المنارة للاستشارات
www.manaraa.com

Population Studies

Many studies on dentition, including tooth agenesis, have been undertaken since the establishment of anthropology as a discipline in the early part of the 20th century (see Table 1). These have included a range of subjects from non-human primates to contemporary human populations. These studies recorded the frequency of agenesis and ventured theories of explanation for it. Similar studies were conducted in dentistry, but with an eye towards clinical significance.

Certain problems arise when considering these studies. The methods used by the investigators to determine agenesis vary. While radiographic examination is a better way to determine agenesis, some researchers used visual observation to make their determinations. This approach can lead to over- or underestimation of the frequency of third molar agenesis. However, careful inspection can be just as good as radiographic examination, if not better, depending on the methods used. Sengupta and coworkers (1999), for example, confirmed third molar agenesis by examining the alveolar bone of the mandible and maxilla, transilluminating the specimen, shaking, probing, and in some cases removing small pieces of bone. To confirm problematic cases they also used radiographic examination. While Sengupta and colleagues reported their methods in detail, other studies neglect to discuss the methods used to ascertain agenesis.

Another problem that arises when reporting the frequencies of dental agenesis is that the frequencies themselves are often arrived at by different methods. The two primary methods of ascertaining frequency are the individual count method and the total tooth count method. Most studies use the individual count method, wherein each

www.manaraa.com

Table 1: Congenital Absence of Third Molars in Previous Studies

Group	Sample Size	% Individuals With At Least One Congenitally Absent M3	Author
Prehistoric and Historic			
Neanderthal	28	0	Brothwell (1963)
Upper Paleolithic France	34	11.8	Brothwell (1963)
Mesolithic Europe and N. Africa	53	1.9	Brothwell (1963)
Neolithic Sweden	134 mand	14.2	Brothwell (1963)
Neolithic NW Europe	156	16.7	Brothwell (1963)
Neolithic-Medieval Greece	278	20.5	Angel (1944)
Prehistoric Canary Islands	3210[1]	9.3[2]	Bermudez de Castro (1989)
Prehistoric Texas	173	19.5	Goldstein (1948)
Predynastic Egypt	156	12.2	Ruffer (1920)
Medieval England	100 max	12.0	Sengupta et al. (1999)
Victorian England	100 max	22.0	Sengupta et al. (1999)
European Ancestry			
Boston Females	200	9.0	Nanda (1954)
Pittsburgh Adolescents	1016	8.8	Tavajohi-Kermani et al. (2002)
SW Ohio Young Adults	476	16.4	Garn et al. (1963)
Canada Adolescents	218	20.2	Anderson and Popovich (1982)
England	185 mand	24.3	Brothwell (1963)
Bristol, England	100	21.0	Sengupta et al. (1999)
England Children and Adolescents	550	14.0-15.0	Gravely (1965)
Finland Adolescents	298	20.8	Haaviko (1971)
Sweden	1064	25.0	Grahnen (1956)
Estonia Schoolchildren	392	17.3	Peltola et al. (1997)
Australia Males	535	23.4	Lynham (1989)
Australia Females	127	19.6	Lynham (1989)
African Ancestry			
East Africa Males	188	1.9[3]	Chagula (1960)
West Africa	163	2.5	Brothwell (1963)
America	119	11.8	Hellman (1928)
England	1000	24.7	Lavelle and Moore (1973)
Brazil Trihybrid Males	490	8.0	Crispim et al. (1972)
Asian Ancestry			
China	118	32.2	Brothwell (1963)
Singapore Adolescents	786	28.5	Mok and Ho (1996)
Japan	11,880	51.1	Daito et al. (1992)
Burma	100	11.0	Brothwell (1963)
Alaska Inuit	759 mand	26.6	Goldstein (1932)
SW Greenland Inuit	210	29.5	Hellman (1928)

[1] Maxillae and mandibles from 3 islands
[2] Average of maxillae and mandibles
[3] Frequency ascertained by total tooth count method

المنارة للاستشارات
www.manaraa.com

individual person or specimen in the study that exhibits agenesis of one or more third molars is considered anomalous (Bermudez de Castro, 1989). For example, if 20 people out of a sample of 100 have one or more third molars congenitally absent, the frequency of agenesis is reported as 20%. In the total tooth count method, the frequency is reported as the total number of third molars missing out of the total possible number of third molars. In a sample of 100 people, there would be a possible number of 400 third molars. If 40 third molars are missing, regardless of how many individuals they involve, the frequency would be reported as 10%. Therefore, while the frequencies may be accurate for each particular study, a direct comparison of them from published figures may not be possible.

While there is disparity among some results of the following surveys, several generalizations about the distribution of third molar agenesis among different populations have been produced. Unless otherwise noted, all frequencies are based on the individual count method.

Non-human Primates, Prehistoric and Historic Human Populations

The primate dentition is of interest to anthropologists because of the close biological and evolutionary relationship between non-human primates and hominids. By ascertaining the frequency of third molar agenesis in primates, comparisons can be drawn to its frequency in humans. However, since non-human primates and modern humans have not shared an evolutionary course for millions of years, direct inferences about modern human dental agenesis from that of non-human primates cannot be made. A study by Lavelle and Moore (1973) analyzed the adult dentitions of a sample of 978 Old

المنارة للاستشارات
www.manaraa.com

World monkeys, 390 great apes, and 194 lesser apes. Frequencies of agenesis were found to be similar among the different primates, ranging from 0.0-1.2%, with a higher frequency of agenesis in the mandible. The molar region showed the highest frequency of agenesis, followed by the premolar and incisor areas. The great apes showed a low frequency of agenesis overall. In fact, all the primates showed a higher frequency of dental polygenesis or supernumerary teeth. The great apes showed the highest frequencies at 6.2%, especially in the molar region. As we shall see, this polygenesis is in opposition to the evolutionary trends apparent in humans.

Unfortunately, there are few studies conducted on third molar agenesis in early hominids. There has been no dental agenesis reported from *Australopithecus* or *Homo erectus.* A study of Neanderthal dentition found no third molar agenesis in a sample of 28 specimens (Brothwell et al., 1963). The first reported cases of hypodontia in paleoanthropology appear during the Paleolithic.

Archaeological samples indicate that the frequency of third molar agenesis in prehistoric Europeans increased from the Paleolithic to the Neolithic. An Upper Paleolithic sample from France exhibited 11.8% third molar agenesis in 34 individuals (Brothwell et al., 1963). A Neolithic sample from Sweden, represented only by mandibles, exhibited an frequency of 14.2% while a sample of French, Belgian and English Neolithic individuals had a 16.7% frequency of third molar hypodontia (Brothwell et al. 1963). A study including English individuals ranging from the Mesolithic to the Bronze Age, but mostly Neolithic, exhibited a 12% frequency of third molar agenesis (Sengupta et al. 1999). Angel's (1944) study of Neolithic to medieval Greeks found a high overall frequency of 20.5% for third molar agenesis. Interestingly,

المنارة للاستشارات
www.manaraa.com

he noted that the congenital absence of all 4 third molars was the most common pattern of third molar agenesis in his sample. This is in contrast to most other studies that find a greater frequency of one or two third molars missing. Regrettably, there are little data on hypodontia during the Mesolithic. A sample from Europe and North Africa showed just 1.9% third molar agenesis, which does not seem to fit the trend of increasing frequency seen in the aforementioned Paleolithic and Neolithic studies (Brothwell et al. 1963).

Studies of relatively more recent populations report not only the general frequency of third molar agenesis, but differences between the sexes, arcade and side. Goldstein's (1948) sample of proto-historic American Indian skulls from Texas exhibited a higher frequency of third molar agenesis in females (21.5% of 79 individuals) than in males (18.1% of 94 individuals). He also noted that third molars were more likely to be congenitally absent in the mandible than in the maxilla. A study conducted by Bermudez de Castro (1989) on a sample (n=3210) of the prehistoric inhabitants of 3 of the Canary Islands, who are culturally connected to Northwest Africa, found a range of 7.5 - 12.0 % for third molar agenesis. For the island of Tenerife he found that the frequency of third molar agenesis in the maxilla was significantly higher in females than in males. However, when the samples from the 3 islands were combined, there was a greater frequency of third molar agenesis in the mandible. Likewise, bilateral absence was more common than unilateral absence. There was no statistically significant side difference. He also found no significant sex difference.

Studies of medieval populations are mostly confined to Europe, and produce generalized results. For example, an English sample consisting of individuals from the tenth and fifteenth centuries was found to have a third molar agenesis frequency of 12.0%

المنارة للاستشارات
www.manaraa.com

(Sengupta et al., 1999), while a sample from medieval Belgium showed a frequency of 7.4% (Brothwell et al. 1963). Differences between sex, arcade and side with regard to third molar agenesis were not made. Unfortunately, studies of third molar agenesis in populations from the fifteenth to the eighteenth centuries are not available. By the eighteenth century, the frequencies of third molar agenesis approximated those of modern humans. Therefore, they will be included in the discussion of contemporary populations.

Studies of modern human populations have focused on differences among and within races. These data are usually from living dental patients rather than from skeletal material.

European Ancestry

A study of third molar agenesis among white female dental patients from Boston between 18 and 21 years of age found a frequency of 9.0% (Nanda, 1954). The third molars were absent in the mandible more often than in the maxilla. A southwestern Ohio white sample exhibited a figure of 16.4% (Garn et al., 1963). This sample consisted of children over 14 years old who were radiographically examined for the presence of third molars. Congenital absence of the third molar was more frequent in the mandible than in the maxilla and there was no significant side difference. Females had higher frequencies of third molar agenesis than males. It should be noted that Garn and coworkers (1963) reported the results for each sex based on a predetermined sex ratio of 103:100 for human populations. That is, they assumed that in a normal population there would be slightly more females than males. Thus, their estimation of the difference between the males and females in the sample may be overstated. Anderson and Popovich (1982) found a

www.manaraa.com

frequency of 20.2% third molar agenesis in a sample of modern Canadian children. They found that children with third molar agenesis had significantly more caries in general than children who had their full complement of third molars. They also noted that the children with congenitally absent third molars had first molars that were mesiodistally larger than those in unaffected children.

While the figures for North America are within a range of 9.0-16.0%, European white samples generally show higher results. Sengupta and coworkers (1999) studied a Victorian British sample and found that the frequency of third molar agenesis was 22.0%. This was comparable to findings for a modern white population from Bristol, with a 21.0% frequency. Based on these results they considered the populations to be essentially the same, though separated by more than a hundred years. They supported this claim by comparing these frequencies to the lower frequencies for their English medieval population (12.0%).

Another English population had a frequency of 24.3%, though this study included only mandibles (Brothwell et al., 1963). Gravely's (1965) radiographic investigation of third molar development in British children found a frequency of third molar agenesis of 14-15%. However, in generating this frequency he assumed that no third molar formation begins after age 13, which may have excluded cases of more delayed development and compromised his estimate. One modern Swedish sample had a third molar agenesis frequency of 25% (Grahnen, 1956). A 1988 study conducted on Australian army recruits, who for the most part have genetic ties to the British Isles, found a frequency of 22.7% (Lynham, 1989). There was no significant difference between the sexes in terms of third molar agenesis. These results are similar to those of Haaviko (1971), who found a

المنارة للاستشارات
www.manaraa.com

frequency of 20.8% in her sample of Finnish children with no significant sex difference. Haaviko also found a higher frequency of third molar agenesis in the mandible than in the maxilla. Slightly farther south, a sample of Estonian children was found to have an overall frequency of 17.3% (Peltola, 1997).

One difficulty that arises when considering whites is the vague definition of the term "white" itself. In the popular conception it denotes "white" people of European origin. Neglected are populations with white features who are not considered white, for example, people of Turkish or Arabic origin. Although they may not fit into the classic white description, neither are they considered black nor Asian. The particular relevance of this issue to the present inquiry is that there are few modern studies of third molar agenesis in groups that fall outside the categories of white, black, and Asian. This narrows the scope of inquiry and perhaps precludes a more informed view of variation. The problematic use of traditional racial categories is likewise applicable to studies involving people of African descent.

African Ancestry

There is a disparity between study results involving native Africans and those who have lived outside of Africa for several generations. Chagula (1960), for example, in his study of young men in East Africa found a frequency of third molar agenesis of only 1.9%. However, he arrived at this frequency using the total tooth count method, the results of which are consistently lower than in the individual count method. Other studies of peoples from West Africa have found a range of 0-4.4% (Chagula 1960; Brothwell 1963) for third molar agenesis. Except for the Chagula study, it is unclear whether both

المنارة للاستشارات
www.manaraa.com

men and women were assessed and whether children were examined. As indicated, the frequencies from Africa are low compared to those for whites.

One could expect the results of studies on black dentition to be different from those conducted in Africa proper due to admixture with white and other populations. In fact, the frequencies are slightly higher. Hellman (1928) found an 11% frequency of third molar agenesis among blacks. These were individuals whose families had lived in the United States, though the specific region is unclear, for generations. It is surprising then that Lavelle and Moore (1973) reported a high frequency of 28.2% third molar agenesis in a sample of 1000 people of African descent who had lived in the United Kingdom for less than five years. They found no difference in the frequency of third molar agenesis between males and females or between the maxilla and the mandible. Special care was taken not to include black-white hybrids in their sample. Since radiographic examination was used, and observations of agenesis verified by dental histories for each subject, it is unlikely that errors in observation could have accounted for such a high frequency. Lavelle and Moore acknowledged that their results were unusually high, and attributed the disparity to sampling differences and error. They also ventured that there may have been varying degrees of homogeneity within various ethnic groups that may have caused the figure to be exaggerated (Lavelle and Moore, 1973).

Also of interest here are studies of hybrid populations. Crispim and coworkers (1972) conducted a study of a trihybrid Brazilian population whose racial character was 30% African, 60% white and 10% American Indian. Expectation was that the strong tendency for African third molar agenesis frequency to be low would act in the hybrid population to keep its frequency low. Instead they found that about 8.0% of individuals

المنارة للاستشارات
www.manaraa.com

exhibited third molar agenesis, which is within the reported frequencies for whites. They also decided to divide the sample into those who were more “white” and those who were more “black,” but found no significant difference between them in terms of third molar agenesis. They postulated that perhaps the previous studies were in error and that there really is not that much difference between white and black frequency of third molar agenesis. However, they also considered that perhaps admixture had gone sufficiently far in this population to assure that even those who looked extremely different phenotypically had a large number of genes in common (Crispim et al., 1972).

Studies of the effects of admixture on third molar agenesis frequencies should be performed to gain a clearer understanding of the strength of third molar agenesis as a trait. Since the present study involves blacks as well as whites, a review of admixture in the United States is useful.

Admixture in Blacks

While there are different proportions of white genes in various black populations across the United States, blacks share a similar genetic history. The first Africans were brought to the American South as slaves from West and West-Central Africa starting in the 17th century. Phenotypically, they represented 4 groups: tall tropical savannah inhabitants, broad tropical rain forest and wet savannah dwellers, tall desert dwellers and short arid savannah and scrub forest inhabitants (Jackson, 1993). Estimates of the total number of slaves brought into the United States until the slave trade ended in the early 19th century range from 380,000-570,000 (Parra et al., 1998). The majority of blacks remained in the South until the post-World War I period. At this time, around 90% of the

المنارة للاستشارات
www.manaraa.com

black population moved into northern urban areas such as New York, Detroit, Philadelphia and Chicago (Parra et al., 1998). Today, blacks number over 36 million.

Studies of admixture have been conducted by using genetic markers common to each of the parental populations and to the admixed population. These are known as population-specific alleles, or PSAs. Those most commonly used for studies of black admixture are FY and AT3, both of which are autosomal markers (Parra et al., 1998; Reed, 1969). The frequency of FY in the ancestral African population is less than .03, while in the white population it is about .43 (Reed, 1969). By determining the frequency of FY in a population, and knowing the frequencies in the parental populations, the proportion of admixed genes can be ascertained (Politzer, 1999). The same holds true for AT3. The use of mtDNA markers and Y Alu Polymorphic (YAP) markers helps to determine the female and male white contribution to the black population (Parra et al., 1998). Using these methods, a variety of proportions for black populations have been determined.

In general, the proportions of admixture are lowest in the American South, with the proportions highest in northern urban areas. For example, the frequency of white genes in chiefly rural black populations in South Carolina and Georgia ranges from 4.0 to 10.0% (Politzer, 1999). The relatively isolated Gullah population has a frequency of only 3.5% (Parra et al., 2000). In contrast, black populations in the Chicago area, Detroit, New York City and Pittsburgh have frequencies ranging from 16.9-20.2% (Parra et al., 1998). There are exceptions to this rule, however. Parra and colleagues (1998) found a frequency of 22.8% in New Orleans and 12.6% in Philadelphia. Of interest to the present study is the moderate frequency of 17.5% found for a small black sample (n=97) from

المنارة للاستشارات
www.manaraa.com

Memphis (Workman, 1968), which was ascertained by tracing the G6PD allele. Therefore, while there is strong evidence for higher admixture proportions in the North, each geographical area must be considered individually for accurate frequencies to be determined. Admixture proportions are important in mapping disease genes and the prevalence of biological traits in different populations, such as third molar agenesis.

Asian Ancestry

Studies of individuals of Asian descent have shown the highest frequencies of third molar agenesis among contemporary populations. The range of variation within Asian populations produces a related range of differences in frequencies of third molar agenesis. While Southeast Asians tend to exhibit the lowest frequencies (Brothwell, 1963), East Asians (Daito et al., 1992) and the Inuit, who are genetically of Northern Asian stock, show the highest (Goldstein, 1932).

A study of 100 Burmese individuals found a frequency of 11% for third molar agenesis (Brothwell, 1963), which is similar to the frequencies for whites. Moving farther north, a sample of 786 Singaporean Chinese adolescents was found to display 28.5% third molar agenesis (Mok and Ho, 1996). No significant difference in third molar agenesis frequency was found between the sexes. In contrast to most other studies, Mok and Ho found that there were significantly more third molars congenitally absent in the maxilla than the mandible. No predilection for side was found. A slightly higher frequency of third molar agenesis of 32.2% was found in a Chinese sample of 118 individuals, (Brothwell et al., 1963). As mentioned, Daito and colleagues (1992) found a much higher frequency of 51.1% third molar agenesis in their large (n=11,880) sample

المنارة للاستشارات
www.manaraa.com

from Japan. They noted the frequency of third molar agenesis was higher in females than in males, and, as in the Singapore sample (Mok and Ho, 1996), higher in the maxilla than in the mandible.

In crossing the Bering Strait to the Americas the frequencies of third molar agenesis remain high. A sample of Inuit mandibles from Alaska exhibited a frequency of 26.6% (Goldstein, 1932). Females had a higher frequency of third molar agenesis than males. There was a greater tendency for agenesis to be bilateral than unilateral. Interestingly, more third molars were congenitally absent from the left side of the dentition than from the right. Moving south, a population of Native Americans showed a relatively lower frequency of 12.6% third molar agenesis (Brothwell et al., 1963).

Congenital Illnesses

Most studies of third molar agenesis have focused on variation among different populations and between sexes. These studies have used either healthy "living" subjects or archaeological specimens in their samples. It is unclear whether provision was made in these studies for subjects who may have had congenital illnesses. It is probable that individuals with observable conditions were excluded from the various samples, but on this point the literature is unclear. Nonetheless, a consideration of the frequency of hypodontia associated with congenital illnesses is important.

There is a suite of congenital diseases in which hypodontia is often a symptom. Individuals with ectodermal dysplasia, which involves tissues and structures derived from the ectoderm during embryonic development (Jones, 1988), may exhibit hypodontia of permanent teeth including the third molars. Ectodermal dysplasia is a component in

المنارة للاستشارات
www.manaraa.com

conditions such as Hay-Wells Syndrome, Autosomal Recessive Hypohidrotic Ectodermal Dysplasia Syndrome and Chondroectodermal Dysplasia (Jones, 1988). Congenital disorders involving growth deficiencies, such as Aarskeg Syndrome and Johanson-Blizzard Syndrome, often include hypodontia as a symptom as well. Hallerman-Streiff Syndrome, which causes cranial malformation, likewise includes hypodontia among its symptoms. Cleft lip and cleft palate, including Van Der Woude Syndrome, are also associated with dental agenesis (Jones, 1988; Harris, 2002; Vieira, 2003). Other syndromes associated with hypodontia include Osteogenesis Imperfecta Type I, a skeletal disorder, and Incontinentia Pigmenti, a dermatological disorder (Jones, 1988). Dental agenesis in Down Syndrome has been the subject of several studies, including the following that focused on the absence of third molars.

One 1973 study found that 48% of Down syndrome patients experience third molar agenesis (Shapira et al., 2000). Shapira and colleagues (2000) found an even higher frequency, with 74% of patients experiencing some extent of third molar agenesis. In addition, these people were much more likely to be congenitally missing other teeth. Some conditions associated with Trisomy 21, such as underdevelopment of the jaw and compromised vascularization and innervation, may be responsible for the exacerbation of hypodontia in people with Down syndrome (Shapira et al. 2000). Related conditions, such as the absence of other teeth and a size reduction of the remaining dentition, are found both in those with Down syndrome and in the general population. The significance of these anomalies to understanding the reasons behind third molar agenesis will be explored later.

المنارة للاستشارات
www.manaraa.com

Associated Variations

Research has shown that third molar agenesis is not an isolated condition. There are several anomalies that may occur in people who have third molar agenesis. For example, if one is congenitally missing a third molar, the likelihood that other teeth will be missing rises 13-fold (Garn et al. 1963). Other missing teeth are most likely to be maxillary lateral incisors or mandibular second premolars. However, instances where other incisors, premolars and the second molar were missing have been recorded. Moreover, individuals with a higher degree of third molar agenesis, four third molars missing rather than two, for example, are more likely to be missing other teeth (Garn et al. 1963). This trend is demonstrated in the sample of Down syndrome individuals, wherein 60% of the people with third molar agenesis had at least one other congenitally missing tooth (Shapira et al. 2000). The only tooth almost never missing is the first molar, which is considered to be one of the most phenotypically stable teeth in the human dentition.

Another related condition is the overall size reduction of the remaining teeth when third molars fail to form. A study of 240 white children found that those with at least one third molar missing possessed teeth with a relatively smaller mesiodistal diameter. This included the anterior teeth (incisors and canines) as well as the posterior teeth (premolars and molars). The tendency was greater in boys than in girls, and in the maxilla more than in the mandible (Garn et al. 1963b).

Also associated with third molar agenesis is a general delay in dental development. A study conducted by Garn and his colleagues (1961) found that a sample of children who had third molar agenesis also exhibited a much later formation of the rest

المنارة للاستشارات
www.manaraa.com

of the posterior dentition than their unaffected peers, both in cusp mineralization and in eruption into the oral cavity. The tendency for the hypoconulid of the first mandibular molar to be missing or decreased in size was associated with this phenomenon. Moreover, unaffected siblings of these children also showed a delayed development of posterior teeth, especially the third molar, compared to an unaffected and unrelated sample. This points to a degree of expressivity for the trait that causes third molar agenesis. Agenesis of all four third molars could be seen as the extreme expression of a trait that involves delayed tooth development.

Another way to interpret these findings is to assume the existence of a "critical point" for the formation of teeth. There is a point at which the body tells tooth formation to stop, whether or not it is delayed. In a person with delayed dental development, then, there would be no opportunity for the third molars to form (Garn et al. 1963). By determining the degree of development of the other teeth, it may be ascertained whether the third molars could be missing due to a lack of time to develop.

This relationship to individual dental development also points to the etiology of third molar agenesis. A slower rate of development could be partly to blame for congenital absence of the third molar. Conversely, an evolutionary trend towards the reduction of the human dentition may also be part of the cause. As will be seen, one of these explanations alone is not sufficient to account for the range of variation in frequencies of third molar agenesis. Rather, an approach where these two are combined with modern genetic studies gives a better explanation for congenital absence of the third molar in humans.

المنارة للاستشارات
www.manaraa.com

Biocultural Hypothesis

The hypothesis that third molar agenesis is related to selection for a reduced human dentition is popular. Studies suggest that the explanation for human dental reduction then lies not only in physical anthropology but also in cultural anthropology. The two reasons posited for this are the change in human diet and the advance in human tool use over the last 40 millennia.

There is no question that there has been a reduction in the size of the posterior teeth from the time of our hominid ancestors to the present (Smith, 1982; Brace, 1971). Greene (1972) hypothesized that dental reduction was an evolutionary response to dental caries, which increased as the diet became more nutritionally varied. Greene posited that reducing the dentition would in turn reduce the frequency of carious lesions. However, one recent study conversely found that people with third molar agenesis had a higher frequency of caries and extractions (Anderson and Popovich, 1982). While the nutritional substance of the newer diet may not have played a large part, the reduction in jaw size and changes in the shape of the skull may be due to changes in the biomechanical stresses of mastication. The transition from a nut and seed diet to one based on meat may have spurred such change. Furthermore, advances in food processing, such as the use of tools for grinding and cutting and especially the use of fire in cooking, may have reduced the need for a strong masticatory apparatus (Smith 1982).

A noted proponent of the idea that technological advances spurred dental reduction is C. Loring Brace. Among the advances he cites are pottery and the fork (Brace, 1971). His theory of the "probable mutation effect" holds that when a species enters a new environment where the adaptive importance of a trait is reduced, selective

المنارة للاستشارات
www.manaraa.com

pressures to maintain that trait will be relaxed. Random mutations will be allowed to accumulate and the trait will be compromised or erased from the population (Brace, 1971). Brace considers the invention of certain tools as producing new environments. Hence, the spread of pottery use allowed a reduction in size of the teeth, since small, soft or liquid foods could be stored and transported (Brace, 1971). Softer food reduced the need for large, powerful jaws and teeth. Such a causal connection between culture and biological evolution is oversimplified and impossible to prove. The probable mutation effect has been empirically and theoretically rejected by the scientific community, and is not considered a valid explanation for human dental reduction (Calcagno, 1989).

The idea of linking cultural change and evolution can be demonstrated in a study of Inuit children. Their parents had grown up in the traditional culture, where tough meat was the staple. Consequently, the parents' jaws were rugged. The children, on the other hand, had grown up at a missionary station where they consumed soft foods high in carbohydrates. As adults the children displayed small jaw dimensions relative to their parents (Waugh, 1937). While one generation is insufficient to suggest evolutionary change, the study showed how environmental stressors can affect the development of the dentition. In her study of Mesolithic foragers in Yugoslavia, Y'Edynak (1978) found that the functional masticatory dimensions of the jaw decreased over the horizons. These included bigonial jaw breadth, thickness of the chin, and height of the body of the mandible at the canine. She also found a reduction of cusps on the third molar over time from seven to three. Altogether, there is a definite trend towards reduction. The agenesis of the third molar might be seen as a consequence of this trend. However, there is a problem with this hypothesis. The problem is that tooth size and frequencies of third

المنارة للاستشارات
www.manaraa.com

molar agenesis do not reflect the technological status of given populations. For example, the Inuit populations that exhibit the highest degree of third molar agenesis (Goldstein, 1932) are not more technologically advanced than modern European populations, whose frequencies of agenesis are lower. Likewise, the size of teeth among different populations does not reflect technological advance (Bailit and Friedlaender 1966). Perhaps, as Smith suggests (1982), dental reduction is related to changes in diet and skeletal robusticity, but it varies with ancestry more than technology. Obviously, there is more to the evolutionary trend than diet and tool use.

Some scholars argue that the trend towards third molar agenesis is a component of the evolutionary trend towards a smaller overall facial skeleton. This is supported by the fact that tooth agenesis in humans is far more common than dental polygenesis and that humans have the highest frequency of agenesis of any primate (Bermudez de Castro 1989). Some scholars have posited that frequencies of malformation, impaction and agenesis of the third molar are due to insufficient jaw space in modern populations. Sengupta and coworkers (1999) suggest that this is why their medieval sample, which was larger-jawed, had a lower rate of third molar agenesis than their modern samples. However, the variation in frequency of third molar agenesis does not support this theory. There is a higher frequency in large-jawed Inuit than in smaller-jawed whites. This is evident in prehistoric samples as well. A study of mid-Pleistocene European hominids found that though the size of their lower canines was reduced, it was not accompanied by a reduction in size of the mandible (Bermudez de Castro 1989). Ruffer (1920) found in his Predynastic Egyptian sample that the mandibles of those with third molar agenesis

المنارة للاستشارات
www.manaraa.com

were generally large and had enough room to accommodate the third molars. Therefore, an association of third molar agenesis with smaller jaw size cannot be made.

Developmental Hypothesis

As noted, there may be relationship between the rate of tooth development and agenesis of the third molar. Taken further, agenesis could be related to overall body growth and maturation. Frequencies of development among different populations are known to vary and correlate with the timing of formation and eruption of the third molars.

The third molars are the last teeth to form and erupt. While there is only about a year's difference between the completion of the first molar's crown and the initial mineralization in the second molar, there is a much longer interval between completion of the second molar crown and calcification of the third molar (Avery, 2000). Any delay in development of the permanent dentition will affect the time of formation and eruption for the third molar. Chagula's (1960) East African population showed a low frequency of third molar agenesis and precocious eruption of the third molars. whites, whose frequency of agenesis is higher, showed a later eruption of third molars in general (Chagula 1960). As noted earlier, for all teeth, but particularly for the third molar, the mean age of eruption is younger for black children (Garn et al., 1973; Hassanali, 1985). This points to an overall slower development of whites compared to Africans.

Anderson and colleagues (1978) studied height and weight gain related to third molar agenesis. They conducted a longitudinal study of white Canadian children to determine rates of growth. They found that preadolescent height and weight gain for all

المنارة للاستشارات
www.manaraa.com

the children was fairly regular. However, the increments of height growth decreased in males with third molar agenesis. Overall, the children with third molar agenesis had less adolescent prepeak gain in height and weight. While maximum increments of growth in height occurred between ages 13 and 14 in all males, in those with third molar agenesis the mean age of maximum increment was 14.0 years, which was significantly later than unaffected males at 13.3 years old (Anderson et al. 1978). Females with third molar agenesis also showed a delay in attainment of maximum height increment, but it was not statistically significant. Both males and females with third molar agenesis also showed a delay averaging one year in attainment of maximum weight compared to their unaffected peers. However, males and females showed greater increments of postpeak height and weight gain compared to the normal population. Taken with the comparatively lower frequencies of gain in preadolescence, this accounts for all the children being of about the same height and weight at the end of their growth periods (Anderson et al. 1978).

When taken with Garn's (1963) findings of third molar agenesis related to delayed formation and mineralization of the dentition, one can see that growth and maturation do indeed play a large part in determining the presence of third molars. Garn proposed that congenital absence of one or more third molars is the extreme degree of expression of genes responsible for delayed formation (1963). Recent genetic studies support this theory. Vastardis and his colleagues (1996) have isolated a gene known as Msx1 that, in conjunction with Msx2, is responsible for initiating tooth formation. They found that a mutation within the Msx1 gene causes hypodontia in families. In fact, in the subjects who displayed complete expression of the Msx1 mutation, there was a congenital lack of all four third molars (Vastardis et al. 1996), along with the congenital

www.manaraa.com

absence of the second premolars. Vieira (2003) found that an Msx1 mutation is also responsible for some forms of facial clefting with associated hypodontia. Vieira also noted that three mutations in the Pax9 gene have been shown in families with congenital absence of molars and other teeth. However, while the Msx1 and Pax9 mutations may explain some cases of dental agenesis, they do not explain cases where fewer than four third molars are missing.

Third molar agenesis is a phenomenon with a complex etiology. Those of Asian descent are the most likely to experience third molar agenesis, with Japanese having the highest reported frequency. Whites are less likely to exhibit third molar agenesis, although the range of frequency is wide within the population. Sub-Saharan Africans exhibit the lowest frequency of third molar agenesis, though the frequencies reported for American blacks and people of African descent in Great Britain are unusually high.

Besides being a marker in population studies, third molar agenesis has relevance for forensic anthropology. Dentition is often used to positively identify individuals and also to estimate age. Knowledge of the different ages of eruption among populations is of course needed, but an understanding of the probability of third molar agenesis in a population must also be taken into account. In essence, just because an individual does not have erupted third molars is not enough to say that the individual is relatively young or immature. Other indicators of age must be used to support such a finding.

The studies that have been conducted to date have tried to determine whether third molar agenesis is more prevalent in males or in females, in the mandible or in the maxilla, and unilaterally or bilaterally. More population studies must be conducted using

المنارة للاستشارات
www.manaraa.com

radiographic techniques in order to address these issues and to refine our understanding of the population variation of third molar agenesis.

www.manaraa.com

CHAPTER 3: METHODS AND MATERIALS

The aim of the present study was to determine the frequency of third molar agenesis in a black and a white sample from the American Midsouth. To this end, a sample was drawn from the patient archives of the Graduate Department of Orthodontics, College of Dentistry, University of Tennessee, Memphis. These archived records are of patients who consulted the program for orthodontic treatment from the late 1970's through the present day. Orthodontic patients have been used in other studies (Nanda, 1954; Garn et al., 1973; Mok and Ho, 1996), and there is no suggestion that they might have significantly different frequencies of third molar agenesis than non-orthodontic individuals. Most of the files contain radiographs, photographs and clinical notes.

For inclusion in the study, several criteria had to be met. Since ancestry is a focus of this study, a clear assessment of ancestry had to be possible for each individual. This was accomplished by studying the photographs, either black and white or color, which were included in the patient files. In many cases, the ancestry of the patient was also noted in the clinical records. If the ancestry of the individual was unclear from the photograph and records, or if there was no photograph in the file, the individual was excluded from the sample.

Another inclusion criterion was age. The age of each patient was determined from either the clinical records or from captions on the panoramic radiographs and lateral cephalograms contained in the file. All the individuals in the sample fall between the ages of 10 and 28 years, with the bulk being between the ages of 12 and 18 years. By selecting younger individuals, it would be more likely that they have not yet had their third molars

المنارة للاستشارات
www.manaraa.com

extracted and therefore could present an accurate picture of their dentition. Studies have found that the third molar could be detected radiographically as early as age 7, with peak third molar formation occurring between 8 and 10 years of age (Gravely, 1965; Daito et al., 1992). Initiation of crown formation was not seen after age 13, suggesting that this may be a critical age for determining whether a third molar will be absent (Gravely 1965). Garn and colleagues (1973) suggested that the critical age was 14. Since most orthodontic patients are adolescents, the patient archives had many suitable examples for study.

Some adults were included in the archives as well. In most cases, their treatment began after their third molars had already been extracted, but the clinical record usually did not note the previous extraction. If the radiographs included in the adult's file showed no third molars, and there was no record of their extraction, it was impossible to determine whether any of the molars had been congenitally absent. Therefore, these adults were not included in the study. In some cases, the third molars had not been extracted, or there were radiographs included in the adult file that showed all four third molars in place. In these cases, the individual was included in the sample.

Last, each individual had to be represented by at least one panoramic radiograph. Panoramic radiographs are useful in detecting third molar agenesis because they provide a view of the entire dentition on one film. Usually there were several such radiographs contained within each file that tracked the patient's progress throughout orthodontic treatment. However, in some cases, there was only one panoramic radiograph. If the radiograph was stained, overexposed, or otherwise unclear for the purposes of determining the presence of third molars, the individual was excluded from the sample.

المنارة للاستشارات
www.manaraa.com

In all, 433 cases were included in the sample. These consisted of 118 black males, 115 black females, 100 white males and 100 white females. The procedure for determining agenesis consisted of several steps. The panoramic radiographs were first viewed on an illuminator. If there seemed to be a third molar missing, the clinical notes were reviewed to determine if the tooth had been previously extracted. As Lynham (1989) did in his study, a tooth was noted as being congenitally absent when it was not visible on the radiograph and there was no history of extraction. Furthermore, the area where the tooth would have been was carefully inspected to determine that the bone was smooth, regular and of uniform texture and density, showing no signs of crypt formation or extraction. Again, the use of young patients in the sample was useful in that if an extraction had occurred but was not recorded in the clinical notes, the radiograph nonetheless clearly showed the altered area of the extraction before it had enough time to completely heal.

Also effective in determining agenesis was noting the stage of development of any other third molars present. In Gravely's (1965) study, 32% of the 550 patients sampled had all of their third molars in the same stages of crown formation. In 97% of the cases, all third molars were within three stages of development of each other. Therefore, if all the third molars present radiographically were at least half formed, and there were no signs of crypt formation for a missing third molar, it was likely that that tooth was congenitally absent. When such cases were found, the absence of any third molars was established following the procedure noted previously.

For each patient, the name, age, date of the panoramic radiograph, and the presence or absence of each third molar was noted. When other permanent teeth were

المنارة للاستشارات
www.manaraa.com

found to be congenitally absent they were noted as well. Since the congenital absence of teeth other than third molars is uncommon, the other missing teeth were consistently addressed in the clinical notes of the patient. In addition, supernumerary teeth appeared in some cases. Their number and location were also recorded.

The frequencies of third molar agenesis were ascertained using both the individual count method and the total tooth count method. The results were subjected to odds ratio analysis, 2-sided Fisher exact tests and chi-square analysis to determine any significant associations among the variables. The SPSS statistical package was used for these analyses.

المنارة للاستشارات
www.manaraa.com

<u>CHAPTER 4: RESULTS</u>

The frequencies of third molar agenesis for the four ancestry-sex divisions of the sample under study are given in Table 2. The frequencies of agenesis for the black sample are lower than those for the white sample. The results are broken down for each group below.

<u>Black Males</u>

The sample of black males consisted of 118 individuals between the ages of 11 and 26 years. There was no predilection for side, as the right and left sides of the dentition each had 5 third molars missing. Four of the individuals were missing only one third molar, each a different one. One individual was missing both maxillary third molars, and one showed agenesis of all four third molars. Interestingly, 2 of the black males had supernumerary molars. One boy, aged 16, had an extra molar behind the left maxillary

Table 2: Distribution of Congenitally Absent Third Molars

<table>
<tr><th>Ancestry</th><th>Sex</th><th>Arcade</th><th>No.of Absent Teeth</th><th colspan="3">Total Tooth Frequency (%)</th><th>No.of Individuals</th><th colspan="2">Individual Frequency (%)</th></tr>
<tr><td rowspan="4">Black</td><td rowspan="2">M n=118</td><td>Max</td><td>6</td><td>2.5</td><td rowspan="2">2.1</td><td rowspan="4">2.5</td><td rowspan="2">6</td><td rowspan="2">5.1</td><td rowspan="4">5.6</td></tr>
<tr><td>Mand</td><td>4</td><td>1.7</td></tr>
<tr><td rowspan="2">F n=115</td><td>Max</td><td>8</td><td>3.5</td><td rowspan="2">2.8</td><td rowspan="2">7</td><td rowspan="2">6.1</td></tr>
<tr><td>Mand</td><td>5</td><td>2.8</td></tr>
<tr><td rowspan="4">White</td><td rowspan="2">M n=100</td><td>Max</td><td>18</td><td>9.0</td><td rowspan="2">9.3</td><td rowspan="4">6.9</td><td rowspan="2">18</td><td rowspan="2">18</td><td rowspan="4">15.5</td></tr>
<tr><td>Mand</td><td>19</td><td>9.5</td></tr>
<tr><td rowspan="2">F n=100</td><td>Max</td><td>6</td><td>3.0</td><td rowspan="2">4.5</td><td rowspan="2">13</td><td rowspan="2">13</td></tr>
<tr><td>Mand</td><td>12</td><td>6.0</td></tr>
</table>

www.manaraa.com

third molar, while the other, aged 15, had a fourth molar behind the right mandibular third molar (see Figure 1). No teeth were congenitally absent in these 2 individuals.

Black Females

There were 115 black females in the sample. They ranged in age from 11 to 28 years. There were 7 third molars missing from the right side of the dentition, and 6 from the left. 3 individuals were missing only one third molar, each a different one. 2 of the females were missing 2 third molars, and 2 individuals were missing 3 third molars. One of the girls missing 3 third molars was also missing both mandibular second premolars.

None of the black females displayed agenesis of all 4 third molars. In contrast, one of the black females had 4 supernumerary molars, giving her a total of 36 teeth (see Figure 2). No other case of supernumerary teeth occurred in the black female sample. However, 2 other individuals had congenitally absent teeth. One girl was missing both mandibular first molars, while the other lacked only the left mandibular first molar. Both of these patients had all of their third molars.

White Males

A total of 100 white males were in the sample, ranging in age from 10 to 24 years. There was no significant difference between sides, with 19 missing from the right and 18 from the left. Six males were missing only one third molar, with none missing the left mandibular third molar. Eight were missing 2 third molars. Of these, one boy had

المنارة للاستشارات
www.manaraa.com

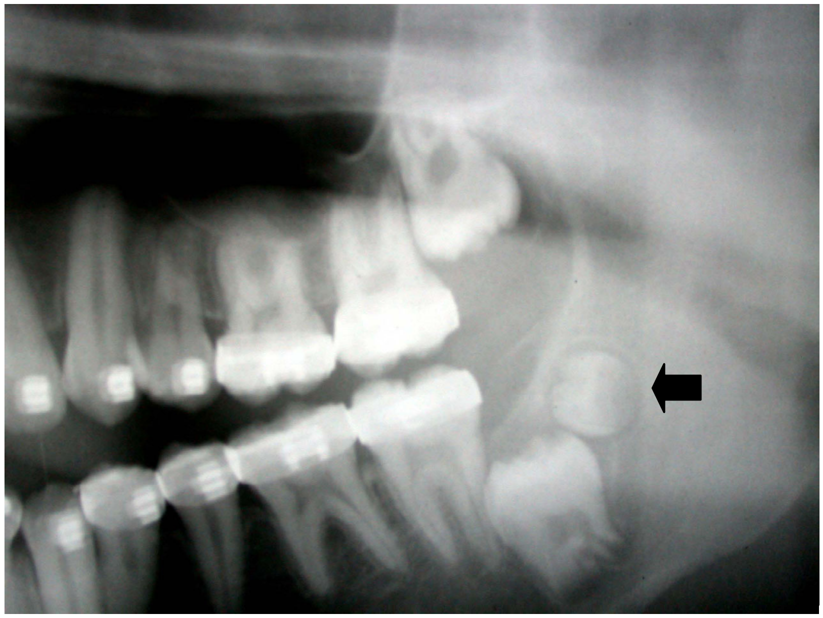

Figure 1: Supernumerary molar in mandible of black male

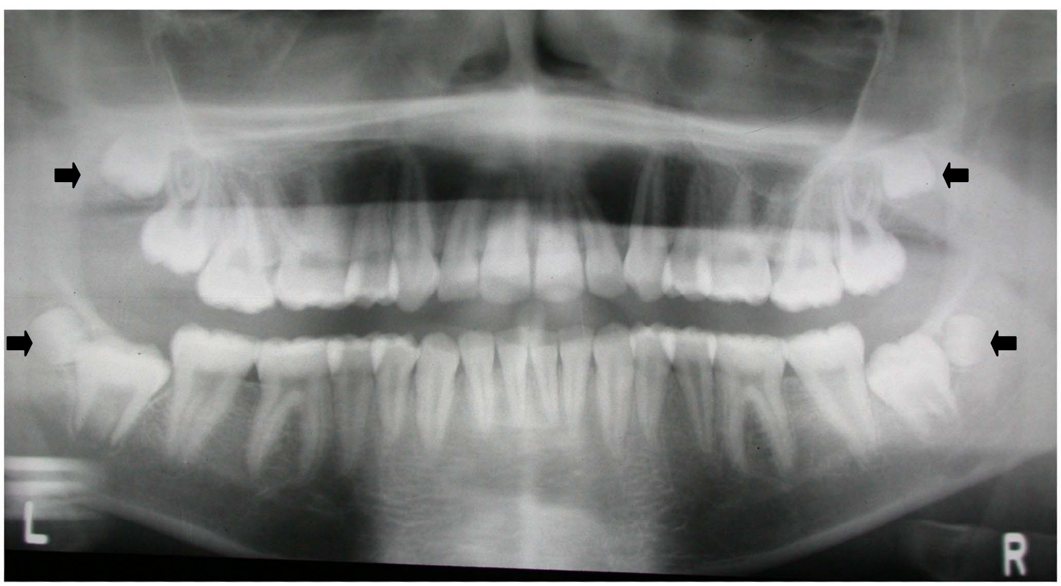

Figure 2: Supernumerary molars in black female

المنارة للاستشارات
www.manaraa.com

extensive hypodontia. Besides the two mandibular third molars, he was also missing his four maxillary premolars, his mandibular second premolars, and his right maxillary lateral incisor (see Figure 3). Only 1 individual was missing 3 third molars.

Three white males showed agenesis of all four third molars. Of these, one was markedly behind in terms of dental development, and had still not exfoliated his deciduous second molars at age 15. At age 20 his second permanent molars were erupting (see Figure 4). There was no supernumerary tooth noted in any person in the sample of white male patients.

White Females

The white female sample consisted of 100 individuals between the ages of 11 and 21 years of age. 10 third molars were missing from the right side of the dentition compared to 8 from the left side. 9 of the girls were missing only one third molar, with a majority of 7 third molars missing from the mandible. One girl who was missing her left maxillary third molar was also congenitally missing her right maxillary second premolar. 3 girls were missing two third molars. One of these had a complete unilateral cleft of the lip and palate and also lacked her mandibular second premolars and her maxillary right lateral incisor (see Figure 5). One girl was missing 3 third molars, and none was congenitally missing all 4 third molars.

One of the females had an absent left second mandibular molar, but had all 4 third molars. None of the white females had supernumerary teeth.

المنارة للاستشارات
www.manaraa.com

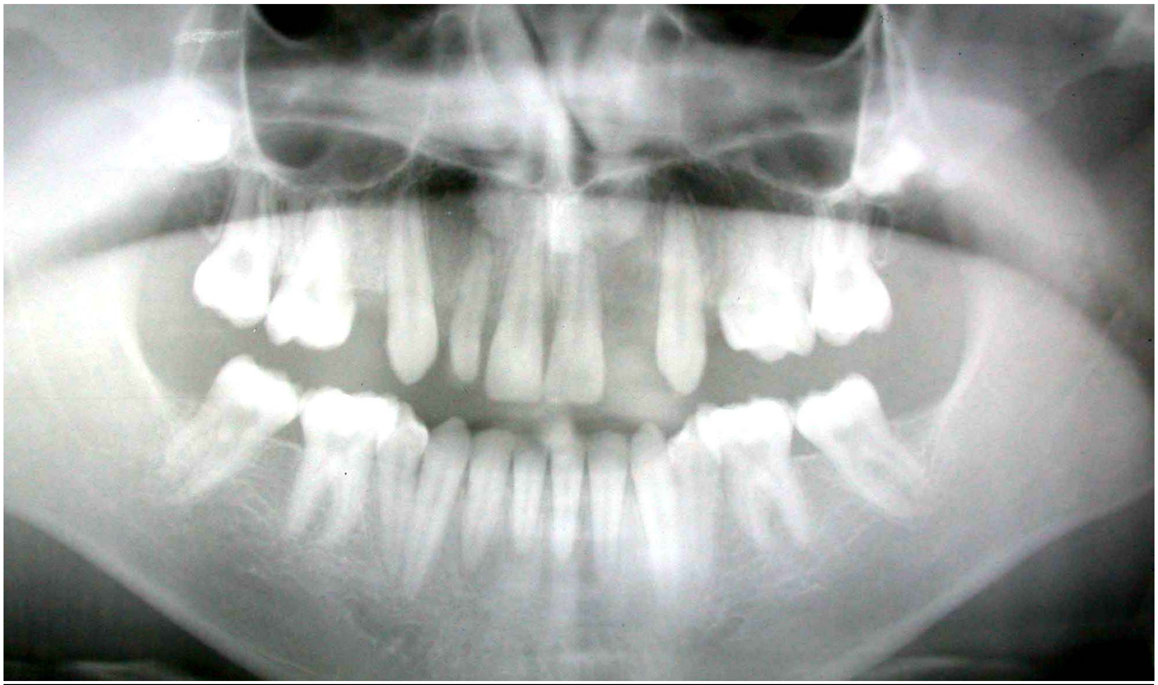

Figure 3: White male with hypodontia

Figure 4: 20-year old white male with extremely delayed dental development

المنارة للاستشارات
www.manaraa.com

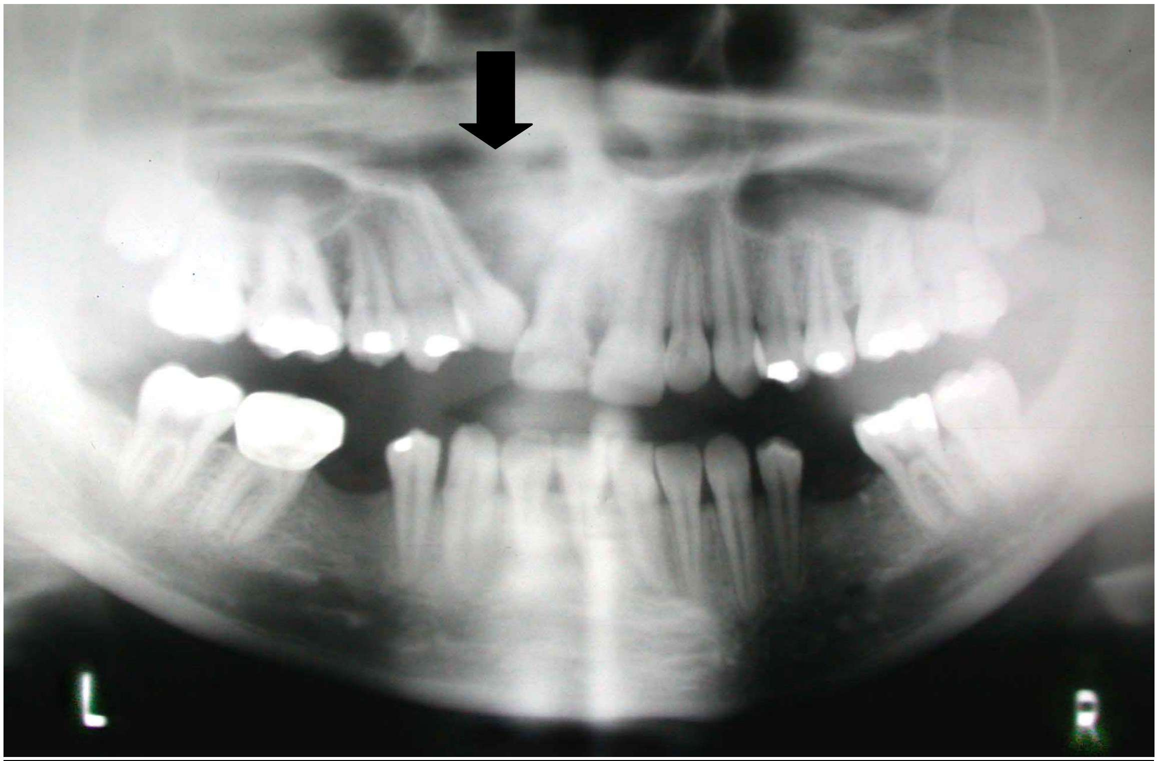

Figure 5: White female with cleft lip and palate and hypodontia

Total Sample

Considered separately, the four groups in the sample show significantly different results. When placed together, however, several patterns become apparent. Most interesting is that in each case where only 2 third molars were missing, these molars were from either the maxilla or the mandible. They never segregated by side. There was an equal number of these cases for both the mandible and maxilla at 7 each. Likewise, a nearly equal number of each third molar was missing for the entire sample. See Table 3 for exact results.

www.manaraa.com

Table 3: Total Number of Missing Third Molars

Tooth	Black Males	Black Females	White Males	White Females	Total
Right Max. M3	3	4	9	3	19
Left Max. M3	3	4	9	3	19
Left Mand. M3	2	2	9	5	18
Right Mand. M3	2	3	10	7	22

A total of 44 individuals displayed third molar agenesis to some extent, a frequency of 10.2% for the entire sample. Most of the affected individuals had either 1 or 2 third molars congenitally missing, while much fewer had either 3 or all of the third molars absent (see Table 4).

When subjected to statistical analysis, the data revealed a number of associations. There was a significant association between ancestry and congenital absence of a third molar, with Fisher's exact test producing a value of $p<0.001$. Interestingly, the results were divided when sex was introduced along with ancestry in the odds ratio analysis (see Table 5). While there was a statistically significant difference between the black males and the white males ($p=0.004$), there was no difference by ancestry between the females ($p=0.101$). Ancestry was also important when considering each dental arcade. Both white males and females were significantly more likely to have third molars absent in the mandible than their black counterparts (see Table 6). For males the p-value was 0.007, while for females it was 0.041. There was no significant difference for the maxilla, with $p=0.056$ for the males and 0.754 for the females (see Table 7).

المنارة للاستشارات
www.manaraa.com

Table 4: Number of Third Molars Missing Per Individual

No. of M3s Missing	Black Males	Black Females	White Males	White Females	Total
1	4	3	6	9	22
2	1	2	8	3	14
3	0	2	1	1	4
4	1	0	3	0	4

Table 5: Odds Ratio for Ancestry by Sex - All Third Molars

		Value	95% Confidence Interval		P-Value
Sex			Lower	Upper	
Male	Odds Ratio for Ancestry (Black / White)	0.244	0.093	0.642	0.004
Female	Odds Ratio for Ancestry (Black / White)	0.434	0.166	1.134	0.101

المنارة للاستشارات
www.manaraa.com

Table 6: Odds Ratio for Ancestry by Sex – Mandible

		Value	95% Confidence Interval		P-Value
Sex			Lower	Upper	
Male	Odds Ratio for Ancestry (Black / White)	0.191	0.052	0.699	0.007
Female	Odds Ratio for Ancestry (Black / White)	0.241	0.064	0.902	0.041

Table 7: Odds Ratio for Ancestry by Sex – Maxilla

		Value	95% Confidence Interval		P-Value
Sex			Lower	Upper	
Male	Odds Ratio for Ancestry (Black / White)	0.316	0.096	1.040	0.056
Female	Odds Ratio for Ancestry (Black / White)	1.321	0.362	4.821	0.754

المنارة للاستشارات
www.manaraa.com

When each sex was considered, there was no statistically significant association for the total number of absent teeth, mandible nor maxilla. In each case $p>0.05$. This held true both for the black sample and the white sample. There was no significant predilection for side either by sex or ancestry.

المنارة للاستشارات
www.manaraa.com

CHAPTER 5: DISCUSSION

These results are comparable with those of others. The combined frequency of 15.5% third molar agenesis in the white sample is close to Garn's (1963) frequency of 16.4% in a southwestern Ohio sample. Both of these fall within the lower range of frequencies reported for white samples. However, while Garn found that females had a greater frequency of third molar agenesis, the reverse is found in the present study. In fact, none of the previous studies cited found a higher frequency of third molar agenesis in the males. In this study the difference was not statistically significant. It could be that the relatively small sample size of 200 exaggerated the difference between the males and females. In a larger sample the results might be different.

The frequencies of third molar agenesis found in the black sample are similar to those found in Sub-Saharan African samples. The frequency for the black males, using the total tooth count method, was 2.1%, which is only slightly higher than the 1.9% found for an East African male sample (Chagula, 1960). However, the individual count method yielded a frequency of 5.6%, which is almost twice as high as the frequency reported by Brothwell and coworkers (1963) for a West African sample (2.5%). However, the present results are only about half as high as the frequency of 11.8% third molar agenesis found by Hellman (1928) in an American black sample.

In this case the question of admixture may be important. As noted, the bulk of Africans who were brought to the United States during the slave period were of West African origin (Parra et al., 1998). It would follow that blacks, therefore, would have a greater affinity with Brothwell and colleagues' (1963) West African sample than with

المنارة للاستشارات
www.manaraa.com

Chagula's (1960) East African sample. However, the exact provenance of the West African sample is unknown. Likewise, the extended family histories of the blacks included in the present study are unknown. No genetic study was conducted on either sample, nor on the East African sample. Moreover, it is not yet known how the genes possibly responsible for third molar agenesis, Msx1 and Pax9 (Vieira, 2003), might segregate in admixed populations. Therefore, no conclusions about the effects of admixture in this study can be reached. It can only be suggested that the individual count frequency of third molar agenesis for the present study is higher than that in the African samples due to moderate admixture with whites in the American Midsouth. Hellman's (1928) results may indicate a higher level of admixture in the region from which his sample was taken. Studies of the influence of genetic admixture on frequencies of third molar agenesis in American blacks must be conducted before firmer conclusions can be made.

In comparing the black and white samples, one of the significant differences was in the frequency of third molar agenesis in each dental arcade. There was a greater frequency of congenital absence of the third molar in the mandible for the white sample. This is consistent with most other studies (Goldstein, 1948; Nanda, 1954; Garn et al., 1963; Haaviko, 1971). The insignificant difference between the frequencies of third molar agenesis in the dental arches in the black sample is comparable to the results of Lavelle and Moore's (1973) study. They also found that there was a similar frequency for each arch. However, since the overall results of Lavelle and Moore's (1973) study are unusual, it is unclear whether their estimations of frequency of third molar agenesis in the arches are representative. The present study did find that there was a slightly higher

المنارة للاستشارات
www.manaraa.com

predilection for congenital absence of the third molars in the maxillae of the black sample, but this difference was not significant. Likewise, the insignificant difference in frequencies of third molar agenesis for each side of the dentition in both blacks and whites is supported by other studies (Garn et al., 1963; Bermudez de Castro, 1989).

Though the general findings for the samples in the present study are indicative of the variation in the frequency of third molar agenesis, some of the individual cases are also telling. One example is that of the white female with a cleft lip and palate (see Figure 5). Among her congenitally missing teeth were her right maxillary lateral incisor and mandibular second premolars. This hypodontia is consistent with other studies of facial clefting. While hypodontia is greatest in the area of the cleft, the tendency for teeth of all classes to be congenitally absent is generally higher (Harris, 2002). Perhaps this is why her mandibular third molars, which are far from the area of clefting, were also congenitally absent in this case. This possibility is supported by the studies of Vieira (2003), who found that oral clefts and associated dental agenesis, including third molar agenesis, are both linked to a mutation on the Msx1 gene.

The familial inheritance of Msx1 mutations may also be demonstrated in the case of the white boy with extensive hypodontia (see Figure 3). It was noted in his dental record that both his father and grandfather had also exhibited significant hypodontia. This individual was missing all 4 of his maxillary premolars and both of his second mandibular premolars, in addition to his mandibular third molars. The lack of second premolars and third molars is cited as one of the signs of Msx1 mutation (Vastardis et al., 1996). Of course, since genetic tests were not carried out on this boy or his kin, it cannot be established whether an Msx1 mutation played a part in his family's hypodontia.

المنارة للاستشارات
www.manaraa.com

The genetic component of third molar agenesis is apparent. However, in the case of the white boy with delayed eruption, the developmental hypothesis for third molar agenesis is also supported. The dental records noted that this boy had retained his deciduous molars through age 15, and at age 20 still did not have completely erupted permanent second molars (see Figure 4). All 4 of his third molars were congenitally absent. Tavajohi-Kermani and colleagues (2002) noted that dental agenesis is associated with delayed tooth formation, retention of deciduous teeth and prolonged exfoliation of the deciduous teeth. This supports Garn and coworkers' (1963) theory that there is a critical point for the development of teeth: if a tooth has not formed by a certain point in the individual's dental development, it will not form at all. The third molar is the last tooth to develop and it may be susceptible to agenesis during a delay in dental development. Developmental delay may have been a causal factor in the congenital absence of third molars in this case.

These several cases are illustrative of some of the explanations for third molar agenesis that have been offered by a variety of scholars. In the majority of the cases of third molar agenesis in this study, however, it was not clear why agenesis occurred or did not occur. While measurements were not taken, in the majority of the affected cases it seemed that there was sufficient room in the dental arch for third molars to develop. Therefore, in this case as in others, the idea that agenesis is due to constricted room in the dental arch seems unsupportable. Beyond this, conclusions about the etiology of third molar agenesis in this sample cannot be reached. Since third molar agenesis is not uncommon, its occurrence was usually not recorded in the clinical notes associated with each individual in the sample. The dentitions in most of the affected cases seemed normal

المنارة للاستشارات
www.manaraa.com

on the panoramic radiographs, except for the absent third molars. More studies on the genetics of third molar agenesis and its frequency in temporally and geographically varied human populations should be conducted to learn more about the causes of this trait.

www.manaraa.com

CHAPTER 6: CONCLUSION

A sample of 433 individuals from the American Midsouth was studied to determine the frequencies of third molar agenesis. Panoramic radiographs were examined and the presence and absence of each third molar recorded. The analysis considered the differences in frequencies of third molar agenesis between ancestry, sex, dental arcade, and side. It was found that, consistent with earlier studies, the black sample had a significantly lower frequency of third molar agenesis (5.6%) than did the white sample (15.5%). Also, there was no significant difference between the sexes. However, there was a higher frequency of third molar agenesis in the white males than in the white females. This is contrary to previous studies where females were more likely to have third molar agenesis. The white males were significantly more likely to be congenitally lacking a third molar than their black counterparts, while there was no such difference for the female samples. When ancestry was considered, white males and females were more likely to be congenitally missing third molars in the mandible rather than the maxilla. There was no significant difference between sides of the dentition, with the right and left being fairly equally likely to exhibit congenitally absent third molars.

The results of this study are generally consistent with earlier work, particularly the results for the white sample. The results for this study are comparable to those found for a sample of orthodontic patients from southwestern Ohio (Garn et al., 1973), indicating regional similarities in the middle United States. Unfortunately, comparative studies of the frequency of third molar agenesis in admixed African populations are rare.

المنارة للاستشارات
www.manaraa.com

This study, then, provides a baseline for blacks in a low to moderately admixed region of the United States.

The knowledge of frequencies of third molar agenesis provides anthropologists with a useful tool in ascertaining population differences. In forensic anthropology, awareness of the frequency of congenitally absent third molars may improve the estimation of age from dental remains. Further efforts should be made to discern the etiology of third molar agenesis in order to refine our understanding of its variation among human populations. Genetic studies hold promise for more insight into this phenomenon. These, in combination with anthropological research, will give the scientific community a more informed view of dental variation in humans.

www.manaraa.com

LITERATURE CITED

www.manaraa.com

Anderson DL, Thompson GW, Popovich F. 1978. Molar polymorphisms and body growth. Growth 42:205-212.

Anderson DL, Popovich F. 1982. Dental reductions and dental caries. Am J Phys Anthropol 47:381-386.

Angel JL. 1944. Greek teeth: ancient and modern. Hum Biol 16:283-297.

Avery JK. 2000. Essentials of oral histology and embryology: a clinical approach. 2nd ed. St. Louis: Mosby, Inc.

Bailit HL, Friedlaender JS. 1966. Tooth size reduction: a hominid trend. Am Anthropol 68:665-672.

Bath-Balogh M, Fehrenbach MJ. 1997. Illustrated dental embryology, histology and anatomy. Philadelphia: WB Saunders Co.

Bermudez de Castro JM. 1989. Third molar agenesis in human prehistoric populations of the Canary Islands. Am J Phys Anthropol 79:207-215.

Brace CL. 1971. Post-Pleistocene changes in the human dentition. Am J Phys Anthropol 34:191-204.

Brothwell DR, Carbonell VM, Goose DH. 1963. Congenital absence of teeth in human populations. In: Brothwell DR, editor. Dental anthropology. Oxford: Pergamon Press. p 179-190.

Calcagno JM. 1989. Mechanisms of human dental reduction: a case study from Post-Pleistocene Nubia. University of Kansas Publications in Anthropology 18.

Chagula WK. 1960. The age at eruption of third permanent molars in male East Africans. Am J Phys Anthropol 18:77-82.

Crispim J, Triguiero KG, De Sa E Benevides Filho FR, Salzano FM. 1972. Third molar agenesis in a trihybrid Brazilian population. Am J Phys Anthropol 37:289-292.

Daito M, Tanaka T, Hieda T. 1992. Clinical observations on the development of third molars. J Osaka Dent Univ 26:91-104.

Fanning EA. 1962. Third molar emergence in Bostonians. Am J Phys Anthropol 20: 339-346.

Garn SM, Lewis AB, Bonne B. 1961. Third molar polymorphism and the timing of tooth formation. Nature 192:989.

www.manaraa.com

Garn SM, Lewis AB, Vicinus JH. 1963. Third molar polymorphism and its significance to dental genetics. J Dent Res 42:1344-1363.

Garn SM, Lewis AB, Kerewsky RS. 1963b. Third molar agenesis and size reduction of the remaining teeth. Nature 200:488-489.

Garn SM, Wertheimer F, Sandusky ST, McCann MB. 1972. Advanced tooth emergence in Negro individuals. J Dent Res 51:1506.

Garn SM, Sandusky ST, Nagy JM, Trowbridge FL. 1973. Negro-Caucasoid differences in permanent tooth emergence at a constant income level. Arch Oral Biol 18:609-615.

Goldstein MS. 1932. Congenital absence and impaction of the third molar in the Eskimo mandible. Am J Phys Anthropol 16:381-388.

Goldstein MS. 1948. Dentition of Indian crania from Texas. Am J Phys Anthropol 6:63-84.

Grahnen H. 1956. Hypodontia in the permanent dentition: a clinical and genetical investigation. Odont Revy 7(Suppl 3):27-41.

Gravely JF. 1965. A radiographic survey of third molar development. Br Dent J 119:397-401.

Greene DL. 1972. Dental anthropology of early Egypt and Nubia. J Hum Evol 1:315-324.

Haaviko K. 1971. Hypodontia of permanent teeth. Proc Finn Dent Soc 67:1849-1854.

Harris EF, McKee JH. 1990. Tooth mineralization standards for blacks and whites from the middle southern United States. J Forensic Sci 35:859-872.

Harris EF. 2002. Dental development and anomalies in craniosynostoses and facial clefting. In: Mooney MP, Siegel, MI, editors. Understanding craniofacial anomalies: the etiopathogenesis of craniosynostosis and facial clefting. New York: Wiley-Liss. p 425-467.

Hassanali J. 1985. The third permanent molar eruption in Kenyan Africans and Asians. Ann Hum Biol 12:517-523.

Hellman, MB. 1928. Racial characters in human dentition. Proc Am Phil Soc 67:157-174.

Jackson FLC. 1993. Evolutionary and political economic influences on biological diversity in African Americans. J Black Stud 23:539-560.

Jones KL. 1988. Smith's recognizable patterns of human malformation. 4th ed. Philadelphia: W.B. Saunders.

المنارة للاستشارات

www.manaraa.com

Krumholt L, Roed-Petersen B, Pindborg JJ. 1971. Eruption times of the permanent teeth in 622 Ugandan children. Arch Oral Biol 16:1281-1288.

Lavelle CLB, Moore WJ. 1973. The frequency of agenesis and polygenesis in the primate dentition. Am J Phys Anthropol 38:671-680.

Levesque GY, Demerjian A, Tanguay R. Sexual dimorphism in the development, emergence, and agenesis of the mandibular third molar. J Dent Res 60:1735-1741.

Lynham A. 1989. Panoramic radiographic survey of hypodontia in Australian Defense Force recruits. Aus Dent J 35:19-22.

Mincer HH, Harris EF, Berryman HE. 1993. The A.B.F.O. study of of third molar development and its use as an estimator of chronological age. J Forensic Sci 38:379-390.

Mok YY, Ho KK. 1996. Congenitally absent third molars in 12-16 year Singaporean Chinese patients: a retrospective radiographic study. Ann Acad Med Singapore 25:828-830.

Nambiar P, Yaacob H, Menon R. 1996. Third molars in the establishment of adult status - a case report. J Forensic Odontostomatol 14:30-33.

Nanda RS. 1954. Agenesis of the third molar in man. Am J Orthod 40:698-706.

Parra EJ, Marcini A, Akey J, Martinson J, Batzer MA, Cooper R, Forrester T, Allison DB, Deka R, Ferrell RE, Shriver MD. 1998. Estimating African American admixture proportions by use of population specific alleles. Am J Hum Genet 63:1839-1851.

Parra EJ, Kittles RA, Argyropoulos G, Pfaff CL, Hiester K, Bonilla C, Sylvester N, Parrish-Gause D, Garvey WT, Jin L, McKeigue PM, Kamboh MI, Ferrell RE, Pollitzer WS, Shriver MD. 2001. Ancestral proportions and admixture dynamics in geographically defined African Americans living in South Carolina. Am J Phys Anthropol 114: 18-29.

Peltola JS, Wolf J, Mannik A, Russak S, Seedre T, Sirkel M, Vink M. 1997. Radiographic findings in the teeth and jaws of 14- to 17-year-old Estonian schoolchildren in Tartu and Talinn. Acta Odontol Scand 55:31-35.

Pollitzer WS. 1999. The Gullah people and their African heritage. Athens, GA: University of Georgia Press.

Reed TE. 1969. Caucasian genes in American Negroes. Science 165:762-768.

المنارة للاستشارات
www.manaraa.com

Ruffer A. 1920. Study of abnormalities and pathology of ancient Egyptian teeth. Am J Phys Anthropol 3:335-382.

Scott GR, Turner CG. 1997. The anthropology of modern human teeth: dental morphology and its variation in modern human populations. Cambridge: Cambridge University Press.

Sengupta A, Whittaker DK, Barber G, Rogers J, Musgrave JH. 1999. The effects of dental wear on third molar eruption and on the curve of Spee in human archaeological dentitions. Arch Oral Biol 44:925-934.

Shapira J, Chaushu S, Becker A. 2000. Frequency of tooth transposition, third molar agenesis and maxillary canine impaction in individuals with Down syndrome. Angle Orthod 70:290-296.

Smith P. 1982. Dental reduction: selection or drift?. In: Kurten B, editor. Teeth: Form, function and evolution. New York: Columbia University Press. p 366-379.

Tavajohi-Kermani H, Kapur R, Sciote JJ. 2002. Tooth agenesis and craniofacial morphology in an orthodontic population. Am J Orthod Dentofacial Orthop 122 :39-47.

Vastardis H, Karimbux N, Guthua SW, Seidman JG, Seidman CE. 1996. A human MSX1 homeodomain missense mutation causes selective tooth agenesis. Nat Genet 13:417-421.

Vieira AR. 2003. Oral clefts and syndromic forms of tooth agenesis as models for genetics of isolated tooth agenesis. J Dent Res 82:162-165.

Waugh LM. 1937. Influence of diet on the jaws and face of the American Eskimo. J Am Dent Assoc 24:1640-1647.

Workman PL. 1968. Gene flow and the search for natural selection in man. Hum Biol 40: 260-279.

Y'Edynak G. 1978. Culture, diet, and dental reduction in Mesolithic forager-fishers of Yugoslavia. Curr Anthopol 19:616-618.

المنارة للاستشارات

www.manaraa.com

VITA

Alexandra Hentisz was born in Newark, NJ on June 1, 1977. She was raised in Maplewood, NJ and went to grade school at St. John the Baptist School in Newark. She completed her high school diploma at Oak Knoll School in Summit, NJ. From there, Alexandra attended Columbia University in New York City, where she received her B.A. in archaeology with a concentration in anthropology in 1999, graduating Magna Cum Laude. She received her M.A. in anthropology from the University of Tennessee, Knoxville in 2003. Alexandra is currently residing in New Jersey.

المنارة للاستشارات
www.manaraa.com