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FLUOROQUINOLONES VS. DENTAL ATTRITION IN THE ETIOLOGY OF TEMPOROMANDIBULAR JOINT DISORDERS

By

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Abstract

This research focuses on the etiology of temporomandibular joint disorders (TMJD), specifically osteoarthritis (OA) of the jaw. The population samples studied include early medieval skeletal remains from Saleux, France (n=40) and a modern population samples reported from the studies conducted by Rando and Waldron (2012), Emodi-Perlman et al. (2012), and Yadav (2011). When studying the etiology of OA, this research looks at the role of fluoroquinolones and dental attrition as possible factors. Fluoroquinolones are anti-inflammatory drugs that can cause rupture in the Achilles tendon; dental attrition is the wear on teeth from tooth on tooth contact. Although there has been a dramatic increase in the frequency of TMJD between the early Middle Ages in Europe and today, the results of this study cannot conclusively identify fluoroquinolones or dental attrition as the culprit for OA of the temporomandibular joint.

Introduction

The temporomandibular joint (TMJ) has many functions. It is nearly always used, whether it be chewing, speaking, or posture; the TMJ also plays a role in showing emotion (Rando & Waldron, 2012). With its many functions, the TMJ is prone to much wear and tear. The pains associated with this area of the body are called temporomandibular joint disorders, or TMJD. TMJD can be detected when someone complains of pain of neck or face, often described as a headache or earache. It is important to note that wherever the pain is felt, it is increased with any movement of the jaw (Vallerand et al., 1989). Such symptoms in the jaw can be caused by an individual's lack of control of their muscles (Yadav, 2011).

In recent years it has been found that a class of antibiotics, called fluoroquinolones, have played a role in rupture of connective tissues, specifically the Achilles tendon (Casparian et al., 2000). This class of antibiotics was also regularly administered to poultry in the US until 2005, when the FDA banned their use (John Hopkins University, 2012). The focus of this current research is to find the role of fluoroquinolones in the etiology of TMJD by comparing frequencies in a medieval French skeletal sample (well before the age of antibiotics) compared to modern Americans. It is hypothesized that fluoroquinolones could cause problems in the TMJ, as has been demonstrated in the Achilles tendon and other connective tissues in the body. If this hypothesis is correct, data should indicate an increased incidence of TMJD in modern Americans compared to the French early medieval skeletal sample. It is also important to understand the anatomy of TMJ and different forms of TMJD before looking at the role of fluoroquinolones. This thesis will explore these multiple factors involved in the etiology of TMJD from the clinical literature and from a bioarchaeological analysis of human skeletal remains.

This research will then discuss possible connections between dental attrition (i.e. tooth wear) and TMJD. In a study done by Sangreeta Yadav (2011), the authors suggested that there was no clear evidence that attrition is a cause of TMJD. This study, however, did not specify which of the three types of TMJD that they were investigating, so it may be that the form of TMJD did not matter in the study. Although there was no link between the two, Yadav (2011) did find a higher rate of older individuals having TMJD and dental attrition. They also found that there was a lower rate in female subjects than in males. By looking at this study and others, it is hypothesized that the data from this research will find no sign that attrition is a cause of TMJD. It is also hypothesized that older individuals will have higher scores of dental attrition as well as TMJD.

Anatomy of the TMJ:

The temporomandibular joint is composed of four different parts: the condyle of the mandible, the auricular eminence of the temporal bone, the articular disc, and the mandibular fossa of the cranium. The mandibular condyle articulates with the articular disc. The muscles of the face allow it to rockback and forth, causing the jaw to open and close. The articular disc is a plate that lies superior to the mandibular condyle and inferior to the articular eminence. It actually separates the joint into upper and lower. This allows for each TMJ to be considered a separate joint. The mandibular fossa is a concave surface on the temporal bone where the mandible articulates with the temporal bone (see Figure 1 below). The TMJ is considered a synovial, or free moving, joint. It is, however, unique in its anatomy because it is composed of fibrocartilage on the articular surfaces. Such cartilage is designed to withstand "repeated and high-level stress." The joint is advantageous in the ability to repair and remodel due to the fibrocartilage. Most synovial joints are made of hyaline/articular cartilage, which is not as apt to repair and cannot withstand as much repeated, high-level stress (Rando &Waldron, 2012).

In recent research, the genes responsible for the formation of the TMJ were found by extracting RNA (ribonucleic acid) from isolated tissues. FGF and FGF receptors gene families "encode essential signaling molecules that function throughout stages of bone development (Purcell et al., 2009)." This is consistent with the fact that both the condyle and fossa form by endochondylar ossification since these genes are known to be involved in such a process (Purcell et al., 2009).

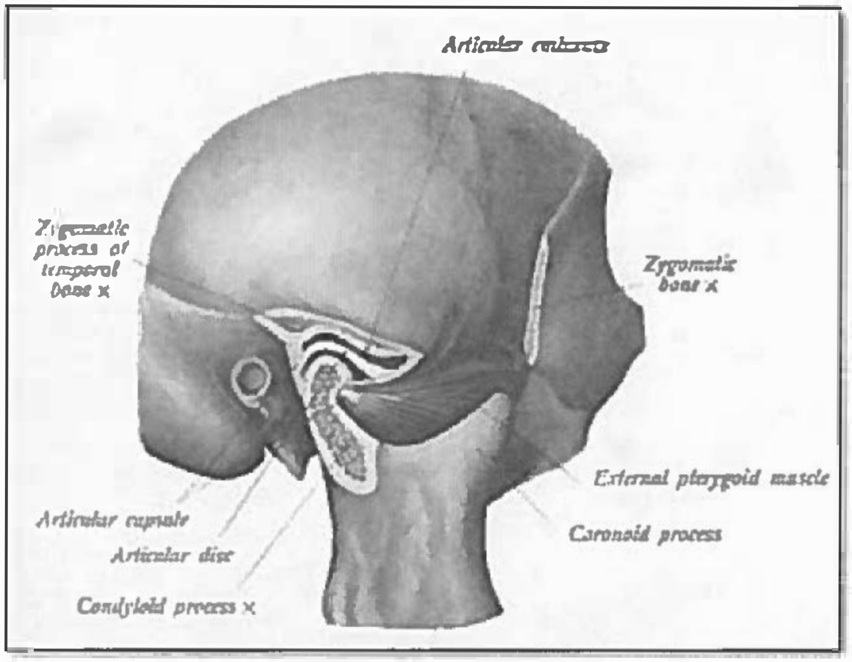

Figure 1. Diagram of the TMJ from a vintage anatomy lithograph published in the early 1900s (illustrator not known).

Forms of TMJD:

There is no one type of temporomandibular joint disorder. TMJD is an "umbrella term" used to describe the musculoskeletal conditions in the TMJ region. Pain can be felt in the muscles of mastication (chewing) or the joint itself (LeResche, 1997). There are three forms of TMJD: muscle disorders, derangement disorders, and degenerative disorders (Arabic Health Encyclopedia, 2016). Muscle disorders in the temporomandibular joint occur when there is pain in the jaw muscles that control the movement of the joint, as well as the neck and shoulders. This form of TMJD is called myofacial pain, and is the most common of the disorders. The next form of TMJD, derangement disorders, occur when the joint is dislocated; there is displacement of the disk; or the bone is injured. The final form is degenerative; this is when individuals develop osteoarthritis (OA) in the joint (Arabic Health Encyclopedia, 2016).

For the purpose of this research, this paper will focus only on osteoarthritis (OA) of the TMJ. OA affects synovial or freely moveable joints. It is the form of TMJD that is most observable when analyzing human skeletal remains. It results from breakdown of the articular cartilage, causing change in the morphology of the bony structure of the condyle. OA can lead to immobility of the joint; however, this is rarely found in the TMJ. In response to the breakdown, the body responds by creating more bone. This results in change in the morphology that can be observed on the remains (i.e. bony bumps on the mandibular fossa). According to Rando and Waldron (2012), symptoms of OA tend to decrease with age, making it difficult to detect. It is not clear why symptoms decrease, but there are many cases reported where this occurs. Also, correlation between clinical diagnosis and diagnosis using magnetic resonance imaging (MRI) scans is poor. For this reason, a diagnosis of OA is usually made via radiographs. Some radiographic signs include: subchondral bone sclerosis (an abnormal hardening of the body's tissue), erosion, osteophytes (marginal and/or new bone on deposited on the joint surface or border), deformation of the mandibular condyle, and reduction in the joint space (Rando & Waldron, 2012). Rando and Waldron (2012) researched frequencies of OA in European medieval, post-medieval (time period not specified), Southwest Native Americans, and modern populations in London.

The results from Rando and Waldron's experiment indicate a difference in the frequencies of osteoarthritis in the temporomandibular joint (TMJ OA) between males and females. In the medieval population, 13.8% of males showed signs of TMJ OA;

whereas females exhibited a frequency of 10.5%. Interestingly, however, the relationship flipped when looking at the post-medieval and modern skeletons. The frequency of TMJ OA in modern females jumped to 44.8% whereas the frequency in males only rose to 22.8%. Overall, the medieval population had a frequency of 13.3%. The post-medieval increased to 29.5%. Unfortunately, not enough information was given by Rando and Waldron (2012) regarding the populations. They never go into depth about why certain populations have higher overall frequencies. The Southwest Native Americans had the lowest frequency of 10.9%, and the modern remains did indeed reveal an increase in TMJD with an overall frequency of 30.2% when the sexes were pooled (Rando & Waldron, 2012). Additionally, in a survey conducted by Lipton et al. (2014), researchers found the highest frequencies were from ages 18-34 years (for both males and females). Six point nine percent of modern young adults ages 18-34 years experienced pain in the jaw (TMJ) or in front of their ear over the past six months (National Health Institute, 2014). When comparing European populations to those of North America, in a study done by L. LeResche (1997), TMJD was still more prevalent in women than in men. Overall, however, Europe revealed a lower frequency in TMJ than North America. Also, it was found that TMJD frequency was greater in adults than in children. Children under 18 years had frequencies less than 2.0%. After 18 years of age, frequencies increased dramatically (LeResche, 1997). Table 1 below shows a list of symptoms that individuals with TMJD may experience. Not all symptoms need to occur for someone to have TMJD, the form of the disorder may also affect what symptoms are being felt.

Table 1. Table listing symptoms of TMJD and the area affected.

Affected Area	Symptoms
Head Pain, Headache	Forehead, Temples, Migraine, Sinus, Shooting pain up back of head
Eyes	Pain behind eyes, bloodshot eyes, may bulge out, sensitive to sunlight
Mouth	Discomfort, Limited opening, Inability to open smoothly, Jaw deviates to one side when opening, Locks shut open, can't find bite
Teeth	Clenching, grinding at night, Looseness and soreness of back teeth
Ear Problems	Hissing, buzzing, or ringing, Decreased hearing, Ear pain, ear ache, no infection, Clogged "itchy" ears
Jaw Problems	Clicking, popping jaw joints, Grating sounds, Pain in cheek muscles, Uncontrollable jaw and/or tongue movements
Neck Problems	Lack of mobility, stiffness, Neck pain, Tired, sore muscles, Shoulder aches and backaches, Arm and finger numbness and/or pain
Throat	Swallowing difficulties, Laryngitis, Sore throat with no infection, Voice irregularities or changes, Frequent coughing or constant clearing of throat, Feeling of foreign object in throat constantly

Tendon Rupture due to Fluoroquinolones:

Fluoroquinolones are antibiotics used to treat infections. They have been used in humans and non-humans. When used on humans, these antibiotics are usually reserved for adults because evidence has shown that disruption and erosion of soft tissue was found in immature species, so use of these antibiotics are avoided in the case of children. Disturbingly, ruptures in adult tendons were reported when taking fluoroquinolones. The ruptures occurred around few weeks after a treatment was started. In a study done by Casparian et al. (2000), 100 cases were reviewed. Tendon ruptures are most commonly found in relation to the Achilles tendon. In the article, the researchers pay particular attention to two cases involving ruptures of the Achilles tendon. Ruptures associated with fluoroquinolones occur around 15 to 20% of every 100, 000 patients (Casparian et al, 2000). Figure 2 below show an illustration of the rupture of the Achilles tendon.

Case #1 by Casparian et al. (2000) was a 38-year-old male who suffered from vertebral and rib fractures in a motor vehicle accident. He was prescribed a one-week course of ciprofloxacin (a type of fluoroquinolone) after being in the hospital for three weeks. No signs of pain or rupture came until suddenly while he was out for a casual walk. He claimed to have felt a sudden sharp pain in his ankle. His Achilles tendon required surgical repair.

Case #2 dealt with a 54-year-old physician. He was prescribed the same medication as case #1 had been, this time for ten weeks. He was being treated for recurrent bacterial prostatitis. About two months later, he reported having shoulder pain from vertical push-ups. He was first told to cease the activity and to take nonsteroidal non-inflammatory drugs (NSAIDs). This, however, did not ease the pain. An MRI scan showed that there was a tear in his subscapularis tendon. Cessation of ciprofloxacin was recommended along with physical therapy and NSAIDs. Case #2 also showed signs of a slight tear in the subscapularis tendon, whereas Case #1 did not (Casparian et al, 2000). It seems that the rupturing of the Achilles tendon is much more common than of the subscapularis tendon. Although it does occur, rupture of the subscapularis tendon has not been reported in as many cases as the Achilles.

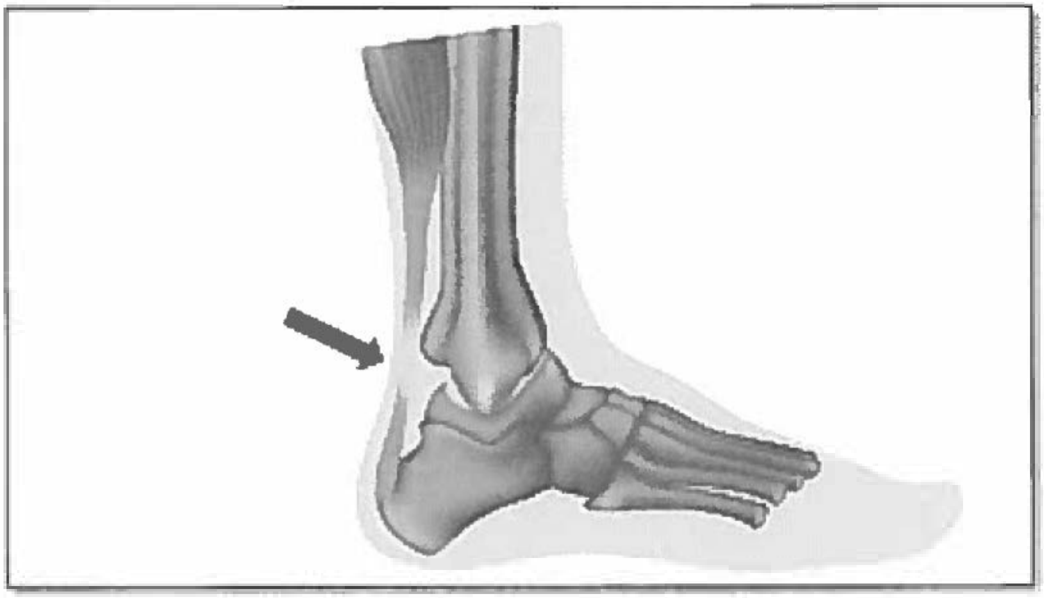

Figure 2. Diagram of Ruptured Achilles Tendon. Image from: The Stone Clinic, San Francisco, CA

Many researchers believe that there is a direct relationship between fluoroquinolones and tendinopathy. Others, however, do not, making this topic controversial. The Food and Drug Administration (FDA) has a "black-box warning," a phrase used for drugs that are deemed unsafe and should be used with extreme caution by the FDA if prescribing fluoroquinolones. This requires that such drugs should be prescribed with caution and only in a select population of patients.

Tendinopathy in the Achilles tendon related to fluoroquinolones was originally published in 1983 in New Zealand. It was found in a 56-year-old renal transplant patient who was being treated for a urinary tract infection and septicemia. The form of fluoroquinolone prescribed was norfloxacin. After this find, researchers looked for related cases, most of them located in France (Vani et al., 2000).

Recent research shows that many patients can experience tightness in their jaw (Brody, 2012). According to Dr. Mercola's website (2014), about 73% of patients experience musculoskeletal symptoms when taking fluoroquinolones. These include tendon ruptures, tendonitis, weakness, and swelling of joints. About 91% of patients have nervous system symptoms including: pain, tingling and numbness, dizziness, malaise, weakness, headaches, anxiety and panic, loss of memory, and psychosis (Mercola, 2014). Patients can experience a wide range of symptoms that affect various parts of the body. There are six types of fluoroquinolones that are prescribed by doctors, but only when patients are experiencing severe bacterial infections. These include: Ciprofloxacin (Cipro), Gemifloxacin (Factive), Norfloxacin (Noroxin), Levofloxacin (Levaquin), Moxifloxacin (Avelox), Ofloxacin (Floxin).

In terms of non-humans, fluoroquinolones were used in poultry until 2005, when they were banned by the FDA. Although they were banned from use in poultry, a study in 2012 found that there were traces of fluoroquinolones in the feather feed, or food for the animals to eat (John Hopkins University, 2012).

This research began with a focus on osteoarthritis in the temporomandibular joint, a form of temporomandibular joint disorder. Over the course of time, the research turned toward collecting data on dental attrition linked as another possible related factor to the development of TMJD. Before any links between the two can be made or not, discussing what dental attrition is will aid in understanding other possible culprits in the etiology of TMJD.

Before discussing what attrition is or its possible link to TMJD, it is important to explain the anatomy of human teeth. The tooth is made up of three different layers. The outer layer of the tooth is called the enamel. The enamel is what protects the rest of the tooth. It usually, in humans, covers most or all of the middle layer called dentine. Dentine is not quite as hard as the enamel and has a similar composition as bone. Dentine is the yellow part of the tooth. In the root of the tooth, below the gum line, the dentine is covered by another protecting layer of bone called cementum. Cementum is also less hard than enamel but is intermediate in strength between enamel and dentine. According to John A. Kaidonis, "the anatomical relationship and different wear characteristics of dentine and enamel together with the wear process, is essential for masticatory efficiency (2008)." Below, in Figure 3, is a diagram to illustrate the anatomy of human teeth (Encyclopedia Britannica, 2015). The image is from the Editors of Encyclopedia Britannica (2015).

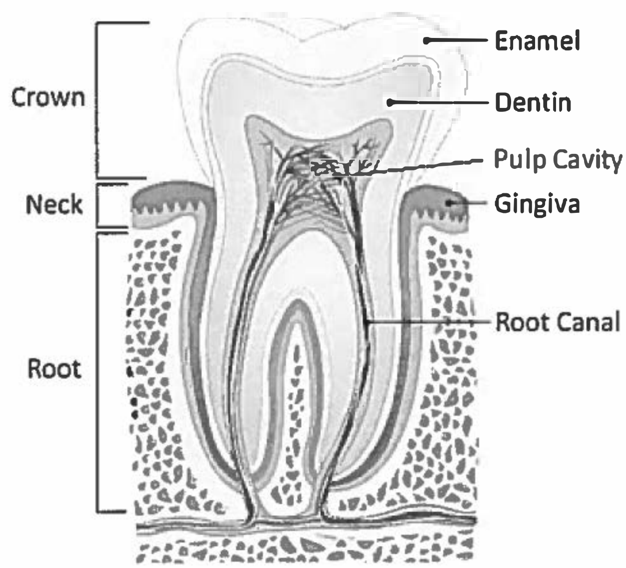

Figure 3. Cross section of a tooth showing the enamel, cementum, and the dentine. Image with permission from shutterstock.com.

According to an article by Kaidonis (2008), a separation between attrition, abrasion, and erosion must be explained. He says that attrition occurs when there is tooth-to-tooth contact with no food present; it is also known as grinding. It is indicated by when the tooth's dentine is exposed, and it remains flat, without cupping or scooping. This means that either over time, or from an extended period of serious amounts of grinding, the enamel is weakened and wears away. It is also important to know that enamel does not grow back. Kaidonis also says that microwear is present within the facet border; this is commonly found in pre-contemporary Australian Aboriginal populations (Kaidonis, 2008).

Figure 4. Illustration of the three causes of tooth wear. Image from https://www.pinterest.com/pin/152137293636024320/

Another type of dental wear is called abrasion. Kaidonis explains that abrasion is when the tooth comes into contact with another material such as food or a toothbrush (as shown in Figure 4 above). With abrasion, the dentine is again exposed. Though, unlike attrition, abrasion leaves a scooping appearance on the bite surface. The wear on the tooth/teeth can be caused by chewing fibrous foods such as raw broccoli. It is also important to note that the scooping in the tooth due to abrasion does not cause sensitivity in the tooth (Kaidonis, 2008).

The final form of tooth wear that Kaidonis (2008) presents is erosion. Erosion is the chemical dissolution, or breakdown, of the tooth. The common feature of erosion is scooping, but it is different from the scooping due to abrasion. As stated above, scooping due to abrasion does not cause tooth sensitivity. In erosion though, there is sensitivity. The depth of the scooping is higher than that of abrasion (Kaidonis, 2008). The diagram above gives an example of erosion as a result of drinking soda. Kaidonis also points out in his research that erosion seems to be relatively modern, though one can make the argument that acidic foods could also be found in hunter-gatherer diets. Kaidonis wrote that the consumption of acids "as an imbalance to the environment and perhaps the mechanism of erosion as pathological (2008)." He says that attrition and abrasion can be traced back as far as early *Homo* (about 2 million years ago). Kaidonis argues that abrasion dropped significantly in modern times because of industrialization. Industrialized food production made food softer, which puts less stress on the tooth and subsequently the jaw.

Now that an overview of tooth wear has been discussed, it is time to transition into speaking about one specific cause of tooth wear, bruxism. Bruxism is the grinding of teeth, which also causes attrition. There are two types of bruxism according to research done by Daniele Manfredini and Frank Lobbezoo (2014). There is sleep bruxism, when grinding and/or clenching occurs. It is also associated with "complex micro-arousal phenomena" during sleep. The next type is called "awake bruxism." This is when the grinding and clenching is due to psychological factors and psychopathological symptoms (i.e. stress or anxiety). See Figure 5 below for an example of what teeth might look like due to bruxism.

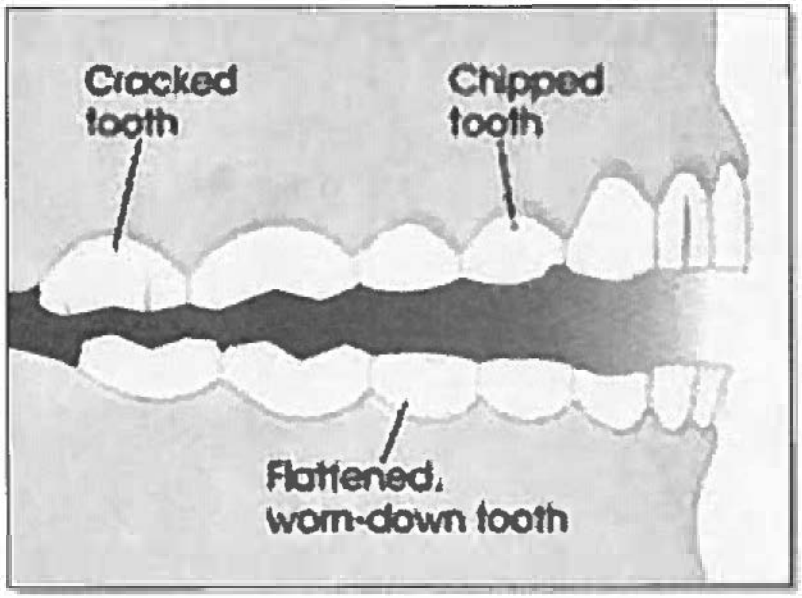

Figure 5. Example of severe attrition due to bruxism.Image from http://healthinessbox.com/tag/mouth-guard-for-bruxism/.

Next, it is important to give background on research regarding the relation between dental attrition and TMJD. According to the study conducted by Manferdini and Lobbezoo, tooth wear does play a role in TMJD. However, they state that it is not a significant factor (2008). Another study conducted in 2011, Sangeeta Yadav says that it is not certain whether attrition is a cause of TMJD. This is interesting because in another study done F. S. Seward (1976), a relationship was established between attrition and TMJD. Steward concluded that if attrition is considered normal, then TMJD must be as well. But if TMJD is looked at as pathological, it would only make sense that attrition would be too. It seems that earlier research found a link between the two but current research is more skeptical. Further research is clearly needed in order to see which hypothesis is true.

Materials and Methods

Materials

This research includes multiple population samples. One is a collection of skeletal remains from the early medieval archaeological site of Saleux, France. This is located on Northern France, near the city of Amiens. The population's diet most likely consisted of marine life, wheat and other grains for bread, apples, pears, berries, fungi, some legumes, and domesticated pig, sheep, cow, geese, chickens, among others (Pearson 1997:1-3). There is a good chance that they could have had particles of sand in their food, due to the milling of grains using stone. The collection consists of approximately 2000 individuals, including men, women, and children. The bones were exhumed and catalogued in the early 1990s by French state archaeologists (Catteddu, 1994). The individuals were numbered, and these numbers were recorded on the plastic bags in which the bones were found. Multiple individuals were then placed in boxes for protection and easier storage. Due to the deterioration of some bags over time, some individuals could not be used in research. Of the ones that were available, 40 individuals were tested for attrition and osteoarthritis. There is some overlap in the individuals scored for attrition and OA, though not complete overlap. Both males and females were included in the collection pertaining to this research. Also, individuals who were below 18 were not included in the study.

The second population used in the research was previously published in a study done by Rando and Waldron (2012). It was a collection of modern skeletal remains, mostly British and American. These authors also looked at both males and females in the populations they studied. Their collections consisted of a population from medieval

Europe, post-medieval (time not specified), modern British individuals, and Native Americans from the Southwest part of the United States. Rando and Waldron also looked at individuals 18 years and above.

Methods

The methods used in order to measure OA followed the study done by Rando and Waldron. Individuals' sex was determined and recorded if it was not already written down. This was using the methods provided by Buikstra and Ubelaker (1999). The individuals' mandibular condyle was scored for five characteristics: OA severity, eburnation, lipping, if there was any indication of pseudoarthritis, and porosity. The first three categories were scored on a 1-3 scale, 1 being minor and 3 being severe. For pseudoarthritis, a yes or no was denoted by "Y" or "N." The porosity was then labeled with the 1-3 scale or a written description. The bones were scored on site in France.

For attrition, there were two possible methods suggested in *Standards* by Buikstra and Ubelaker (1999). The two methods are the Smith Method (1984) and the Scott Method (1979). The Smith method scored all of the teeth, mandibular and/or maxillary, on a scale of 1 to 8. One denotes the cases where no dental wear was present and 8 signifies that there is a complete loss of the crown, enamel, and the "surface takes on the shapes of the roots," (Buikstra & Ubelaker, 1999). The Scott Method (1979) scored on a base of 10. For the molars, though, the tooth was divided into quadrants for scoring. The scores would then be added up for a possible total ranging from 4 to 40. For this research, only the first molar of the mandible was scored using the Scott Method. The scoring was done by looking at photographs taken of each individual from Saleux (courtesy of Megan K. Moore of the Sociology, Anthropology, and Criminology Department, and my mentor). In Table 2 below, the stages of dental attrition are listed according to the Scott Method (1979).

Table 2. Stages of Dental Attrition by molar tooth quadrant, from Littleton et al. (2013).

Score	Description
0	No data
1	Unworn, minimal wear
2	Large wear facets but cusps still present, pinprick dentine exposed
3	Cusps becoming obliterated rather than clearly defined
4	Quadrant flat - no dentine exposure rather than pinpricks.
5	Quadrant flat with dentine exposure on 1=4 of quadrant
6	Dentine exposure more than 1=4 of quadrant.
7	Enamel on only 2 sides of quadrant.
8	Enamel on only one side of quadrant but thick.
9	Enamel very thin.
10	No enamel on quadrant

Results

The Appendix has a table that shows the complete data collected from the population sample from Saleux, France. The following information contains the data for the presence of OA in the early medieval individuals. The age of each individual is included, as well as the sex. See the Appendix for the complete dataset. In the early medieval sample from Saleux, more females had OA than did males, although the severity was greater in the males (see Table 3 and Figure . The older individuals have a higher rate of OA than do the younger individuals. Interestingly enough, the more severe case of OA was found in a younger male individual. In contrast, according to Rando and Waldron, modern females are more likely to have OA and have more severe cases too (2012). See Table 4 below.

Table 3. Table of results of severe OA from Saleux by sex.

Female	Male
9.1%	17.6%

Table 4. Table of Rando & Waldron's results for OA (2012) by sex.

Female	Male
44.8%	22.8%

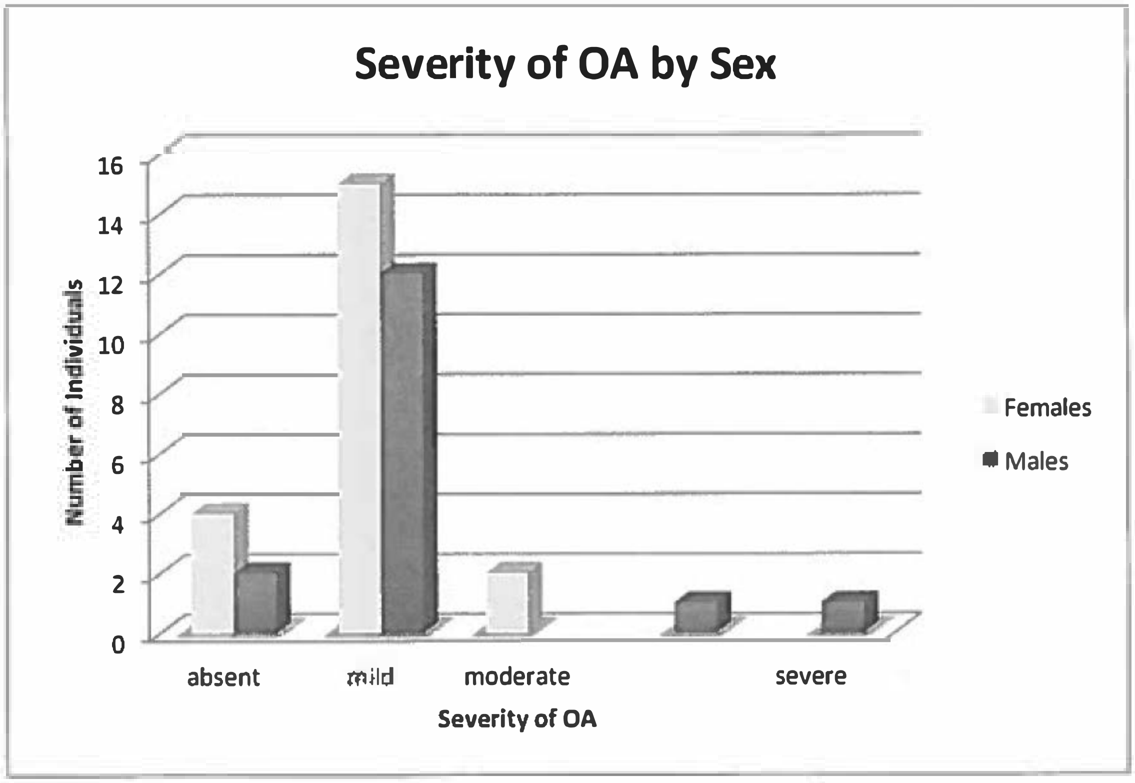

Figure 6. Severity of OA in the early medieval sample by sex.

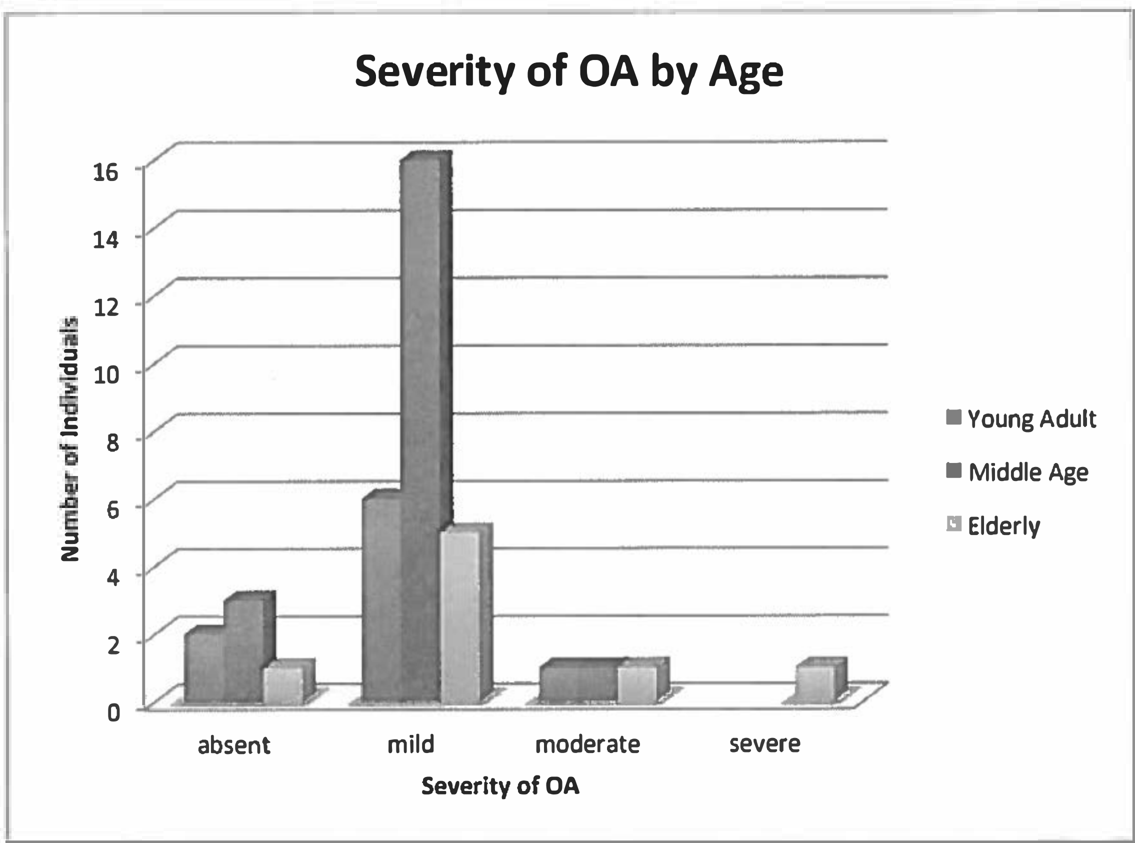

Figure 7. Severity of OA by age in the early medieval sample.

The results from Rando and Waldron's experiment indicate a difference in frequencies of osteoarthritis in the temporomandibular joint (TMJ OA) between males and females. In the medieval population, 13.8% of males showed signs of TMJ OA; whereas females showed 10.5%. Interestingly, however, the relationship flipped when looking at the post-medieval and modern skeletons as shown in Tables 3 and 4 and Figure 6 above. The frequency of TMJ OA in modern females jumped to 44.8% whereas frequency in males only rose to 22.8%, as shown in Table 4 above. Overall, the medieval population had a frequency of 13.3%. The post-medieval increased to 29.5%. The Southwest Native Americans had the lowest frequency of 10.9%, and the modern remains did indeed reveal an increase in TMJD with a frequency of 30.2% (Rando & Waldron, 2012).

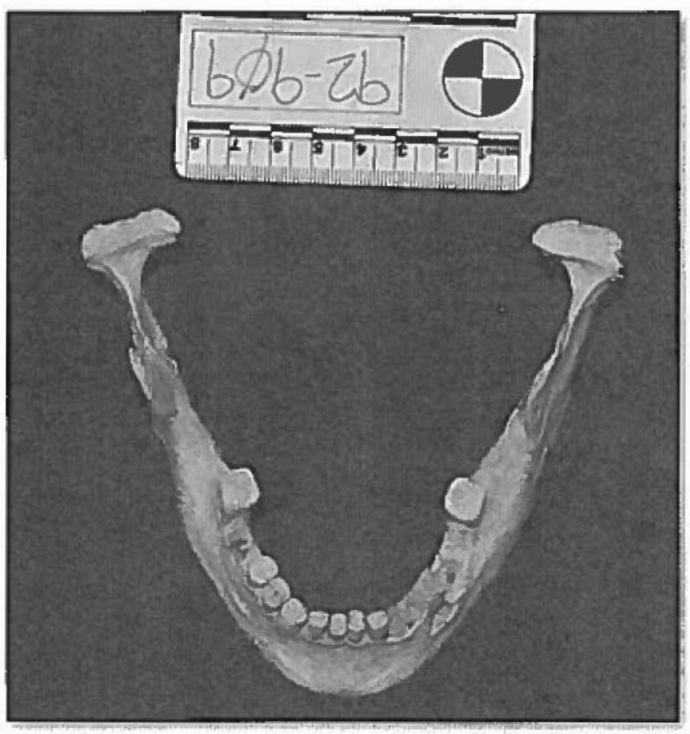

Figure 8. Case # 92-909, Male, 40-59 years old; Photo courtesy of Megan Moore

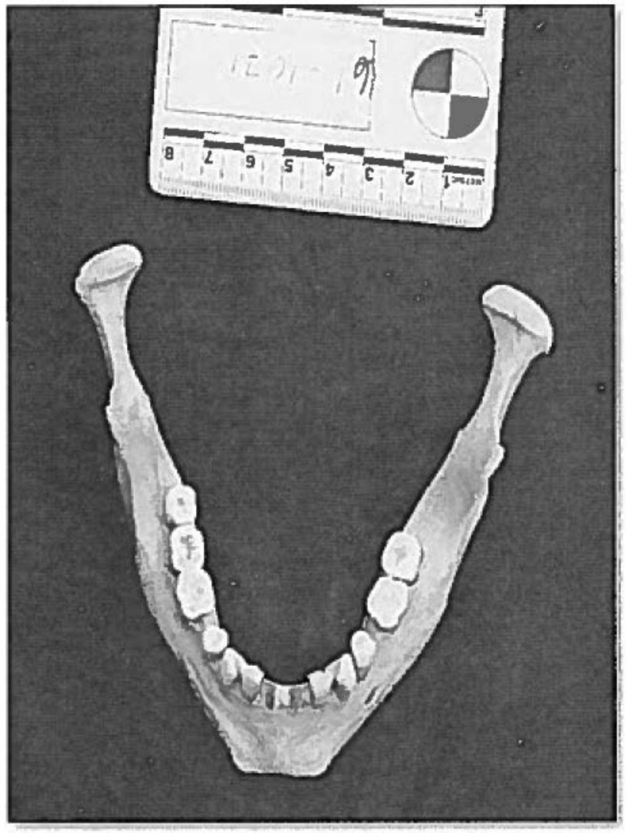

Figure 9. Case #67-1071, Female, 38-48 years old; Photo courtesy of Megan Moore

The images above are examples of the mandibles I was looking at in France. They are included in this research paper to give a visual presentation of what different stages of OA and dental attrition can look like. Figure 8 is of a male who is between the ages of 40 and 59. He has a very severe case of OA; his was actually the most severe case that was identified in France. It is clear that the mandibular condyles of Figure 8 are being reformed from the original roundness that can be seen in Figure 9. Figure 9 is a female individual between the ages of 38 and 48. The individual shows low signs of OA, but has a high score for dental attrition. The score for Figure 9 was 38 out of a possible 40. Figure 8, in contrast, scored around 19 for dental attrition.

Below, Table 5 shows the data collected for measuring dental attrition. If a tooth could not scored (due to being eroded away or lost) the column was filled in with N/A for "not available." OA was measured again so that the score could stand side by side with the attrition score.

Table 5. Degree of attrition and OA by age and sex

Case #	Attrition (M1)	OA	Age	Sex
49-126	4	1	6 yrs	F
50-74	32	N/A	AM	M
52-1093	36	1	A J/M	F
53-21	N/A (eroded away)	1	AM	F
52-778	eroded away	2	24 yrs	Ind
55-23	40	2	AM	Ind
55-724	both missing	2	AA	F
56-375	34	1	25 yrs	F
57-1047	half eroded, half=18	N/A	A M/A	Ind
57-1113	20	0	AM	M
57-1051	N/A	0	A J/M	M
61-1135	17	1	AJ	F
61-1071	15	1	AJ 25 yrs	F
62-1025	28	2	AM	F
62-239	N/A	2	4 yrs	Imm
69-1157	28	2	AA	M
59-S.29	N/A	1	AM	M
70-642	N/A	2	AM	F
76-558	18	2	AJ	Ind
76-263	37	2	AM	F
74-287	16	1	24 yrs	F
74-241	36	1	A M/A	F
73-670	24	1	A M/A	M
75-22	eroded away	2	A?	?
70-1121	N/A	2	A M/A	M
78-85	25	3	A?	?
77-862	38	0	AM	F
81-311	N/A	1	A J/M	F
81-122	34	2	AM	M
79-704	N/A severely worn	3	AM	F
81-312	18	2	6 yrs	Imm
68-467.1	38	2	A ind	M
86-27	19	3	AJ	M
63-832	N/A	3	12 yrs	Imm
76-1003	32.5 (had to avg.)	2	AA	M

87-1190	19	2	25 yrs	M
88-857	22	1	18 yrs	F
90-1013	26	2	AM	F
91-78	36	3	AM	F
101-468	11	1	A Ind	M
77-853	29	0	AJ	F
90-237	18 (half eroded away)	3	AM	F
101-968	17	1	25 yrs	M
115-490	17	3	24 yrs	F
115-77	36	3	AJ	F
106-747	30	2	AA	M

Discussion and Conclusion

When looking at the data for OA and fluoroquinolones, there seems to be some a relationship, though not definitive. Looking at Rando and Waldron's data (2012), the results show that 44.8% of females in the modern population had OA. This is in contrast to the data collected in Saleux, where only 9.1% of females had OA. The contrast is not as extreme in the males in which 17.6% of the males had OA in Saleux, whereas 22.8% had OA in the modern population from Rando and Waldron's study. The research conducted in Saleux matches that of the medieval sample from Rando and Waldron (2012). The medieval population from their research showed that 10.5% of females and 13.8% of males had OA. It is interesting to see the change in relationship between the different populations. The population in France and the medieval sample from Rando and Waldron (2012) would not have been exposed to any form of antibiotics. This in turn, could play a role in the prevalence of OA in the population because they were not exposed to medicine that could help prolong life expectancy. Higher rates in modern populations make sense also because the overall life expectancy has risen, even in the last few years.

In terms of the relationship between the sexes, it could be that females in modern populations have (on average) a higher life expectancy than that of males. Since OA is a degenerative disease, it makes sense that someone that is older would be more likely to have it. If females live longer, then it makes sense that they would show higher rates of OA. When looking at the sexes from the medieval populations, it is quite possible that this is an indication that males were living longer (on average) than females. In a presentation at last year's Eastern Michigan Undergraduate Symposium, a fellow classmate of mine gave a talk on dental enamel hyperplasia. This is when very stressful events cause the body to lay down less tooth enamel during development due to lack of nutrition. Many children around the age of weaning experience this because their body is under stress from transitioning from the mother's milk to other forms of food (Kirchoff, 2015). My fellow classmate, Taylor Kirchoff, also said that her research found that the women and children in Saleux were possibly not given as much food as the men. This was not as an intention to starve them; it was just believed that women and children did not need as much food as men because they were smaller in size. With a lack of nutrition, I feel that this could be a possible reason that would cause females in the population to not live as long as males. Males at least would grow up and be given more food to feed their bodies, but I do not expect there was much of an increase for females. This question of sex specific life expectancy in the early Middle Ages clearly needs further investigation.

From the data collected so far, there does not appear to be a relationship that can be drawn between TMJD and dental attrition. All the individuals that have OA have some level of attrition present; however, scores vary between individuals. For example, Case #77-862 shows no sign of OA, but the individual has a score of 38 for attrition. Conversely, Case #86-27 has severe OA and a score of 19 for attrition. This is relatively low, and it means that there is still enamel present on the tooth.

It is interesting, however, to see that some individuals as young as 6 or 12 years old showed signs of OA. They also showed signs of dental attrition, though not necessarily very high. Normally, OA is not present in young individuals. Some cases of OA in young individuals may be due to autoimmune disorders. It is difficult to tell though, if this is a population wide phenomena or only a few individuals who have OA so young. In order to look into this further, another research project would need to be executed in which the remains of younger individuals would be examined for OA. Due to many of them being so young, sex would not be a factor to take into account since the sexes are indistinguishable skeletally before puberty. The research could then look at cases in modern populations to see if the rates have risen, stayed the same, or decreased. According to research done by Emodi-Perlman et al., the prevalence of TMJD in children has a reported range of 7-68% (2012). This study was conducted on children from ages five to 12. They found that there was no difference in the prevalence of TMJD in boys and girls. They also found that age did not play a significant role in prevalence either. With this knowledge, it would be interesting to determine whether this holds true in other populations. The only drawback at looking at the older populations is that OA is really the only form that can be easily seen on the bones. One would have to look at other research to determine if the other forms are just as observable. It would probably work for looking at dislocation of the joint or injury to the bone, but looking for myofacial pain would be tricky since it pertains to the muscles.

In terms of attrition in younger individuals, the fact that it can show up so young may be due to stress from their environment and lack of nutrition. Again, I refer back to Taylor Kirchoff's presentation that said women and children possibly received less or lower quality food resources. If they were not given adequate nutrition, it is very possible that the stress they were under caused for them to clench their teeth. Also, the food they did eat may have left residual sediment because this population in Saleux lived somewhat near the coast. It is also very likely that they consumed marine animals as a main source of their diet.

When looking at the older individuals there is a range of scores. Again, if an individual has a high score for attrition, it does not mean that they will have a high score for OA. I would also like to revert back to the two photographs incorporated in this paper. The female individual had a higher score of attrition than the male. The male subject though, was at least ten years older. Due to the knowledge that the female subject probably did not receive as much food as the male subject during their lifetime, I think that she would have a similar case as the younger individuals discussed in this paper. This individual may have been under great amounts of stress with the lack of nutrition causing them to grind their teeth. It is also possible that they ate a lot of marine life and left over sand became stuck in their teeth. Another factor to consider as well is that this individual would not only have to feed her but also the children that she may have had. This would only put more stress on the body that the male subject would not have to endure. This concept could also become a future research project that could focus solely on attrition.

Appendix

Table 6. Results of OA from France to compare to Rando & Waldron, 2012 results

Case #	Age	Sex	OA Severity	Ebur-nation	Lipping 1,2,3	Pseudo-arthrosis	Porosity
Box 104; 1069	42-44 (P5?)	M	1	1	1	N	Porous
Box 104; 581	36-38 (P4)	F	1	1 or 2?	1	N	2 (more so on right side)
Box 77; 853	30-40 (P3-5)	M	2	0	2	N	3
Box 89; 223	45-55	F	0	0	0	N	Slight
Box 66; 67/46	35-45 (P3-4)	F	1	1 on RM	1		N
Box 69; 16	3 years old	N/A	0	0	0	N	N
Box 73; 1139	25-35 (P2-3)	M	0	0	0	N	Very Slight
Box 79; 704	3rd molars erupted, at least 21 yrs, probably 30-40*	F	2	2	2	N	Porous
Box 52; 1093	38-48 (P4-6?)	F	1	1	2	N	Slightly
Box 58; 981	30-40	F	0	0	0	N	N
Box 81; 311	30-40	F	0	0	0	N	slight
Box 81; 122	38-40 (P4 or 5?)	M	0	1	0	N	Very Slight
Box 54; 349R	20-30 (p1-2)	F	1	1	1	N	Slight
Box 54;349	20-30 (P1-2)	F	1	1	1	N	Slight
Box43; 885	35-45 (P4-5)	M (Juv)	2	0	2	N	Moderate
Box 43; 927	34-44 (P4-5)	M	1	0	1	N	Slight
Box 61; 1071	38-48 (P4-7)	F	1	1	1	N	Slight
Box 92; 1135	20-30 (from tubercle	F	1	0	1	N	N

	on R1)						
Box 56; 1050	~36 (P4)	F	1	1	1	N	Slight
Box 56; 375	35-45	F?	1	0	1	N	N
Box 76; 558	3rd molars erupted, at least 21 yrs.	F	0	1	0	N	Very Slight
Box 5; 572	no more than 20 (1)	F	1	1	1	N	Slight Micro
Box 27; 27	36-38 (P4)	M	1	0	1	N	N
Box 78; 85	36-38 (P4)	F	1	1	1	N	Micro and Macro
Box 78; 991	30-40 (judging by sutures)	M	1	0	1	N	Slight Micro
Box 76; 1003	older adult, no enamel on R Molars 1 &3	M?	1	1	1	N	Slight Micro
Box 65; 970	45-49 (phase 6)	M?	1	2	1	N	Moderate Micro
Box 86; 219	40-50	F	2	2	2	N	Slight Micro/Macr o
Box 92; 909	40-59 (phase 5-7)	M	3	3	3	Y-mc shape change	Macro porosity on mc
Box 76; 263	Adult, in their 30s	F	1	1	1	N	Slight Micro
Box 51; 106	40-49 (P5-6)	F	1	1	1	N	Slight Micro
Box 88; 969	35-45	M	1	1	1	Y	Slight Micro
Box 88; 857	18 yrs old	F	1	0	1	N	N
Box 57; 1051	35-45 Judged by sutures	M	1	0	1	N	N
Box 57; 1113	35-45	M	1	1	1	N	Slight Micro

Box 34; 240	30-40	M	I	I	I	N	Very Slight
Box 12; 407	24-34	F	I	I	I	N	N
Box 80; 93	40-60	M	I	I	I	N	N
Box 69; 1157	45-55	M	I	I	I	N	N

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