2013

Secular change in the rate of dental impaction

Kelly Heim
Louisiana State University and Agricultural and Mechanical College, kheim1@tigers.lsu.edu

SECULAR CHANGE IN THE RATE OF DENTAL IMPACTION

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Arts

in

The Department of Geography and Anthropology

by
Kelly Heim
B.A., Louisiana State University, 2011
May 2013

Acknowledgements

First, I would like to thank my advisor, Ms. Mary H. Manhein. She was integral both in leading me toward a project I enjoyed and in helping to edit and improve my writing style. I would also like to thank her for allowing me to investigate the individuals in the Forensic Anthropology and Computer Enhancement Services (FACES) Laboratory at Louisiana State University. This provided me with a sample of modern individuals and allowed me to hone my methodology before traveling to other collections. Finally, I would like to thank Ms. Manhein for granting me the opportunity to work as a graduate assistant in the FACES Lab for the last two years.

I would like to thank Dr. Ginesse Listi for serving on my committee, editing my thesis, and providing helpful suggestions regarding the direction of my research. I would also like to thank Dr. Robert Tague for serving on my committee and editing my thesis. Additionally, I would like to thank Dr. Tague for helping me define a more viable method for determining the relative dental arcade area.

Many thanks go to Dr. David Hunt for providing me access to the Robert J. Terry Skeletal Collection housed in the Museum Support Center of the Smithsonian Institute's National Museum of Natural History. I would also like to thank Dr. Dawnie Wolfe Steadman for providing me access to the William M. Bass Donated Skeletal Collection housed in the Forensic Anthropology Center at the University of Tennessee Knoxville.

I appreciate the permission of Dr. Jon Årtun and Elsevier Publishers for utilizing previously published photographs as examples in my thesis. Additionally, Figure 3 has been reprinted from Takashi Sasano, Naoyuki Kuribara, Masahiro Iikubo, Atsushi Yoshida, Shizuko

Satoh-Kuiriwada, Noriaki Shoji, and Maya Sakamoto's article "Influence of Angular Position and Degree of Impaction of Third Molars on Development of Symptoms: Long-Term Follow-up under Good Oral Hygiene Conditions," 2003, with permission from Tohoku University Medical Press.

I would like to thank the Geography and Anthropology Department at Louisiana State University for accepting my proposal and providing me with money from the Robert C. West Travel Fund placed towards the travels associated with my thesis work. Finally, I would like to thank the people in my life for their support and encouragement through the process of completing this thesis.

Table of Contents

Acknowledgements ii

List of Tables vi

List of Figures vii

Abstract viii

Chapter 1: Introduction 1

Chapter 2: Literature Review 3
- Definition of Impaction 3
- Teeth Most Affected by Impaction 3
- Degrees of Impaction 4
- Angulations of Impaction 5
- Prevalence of Impaction between Groups 7
- Etiology 8
- Secular Change in the Prevalence of Impaction 9
- Secular Change in Dimensions of the Dental Arcade 9

Chapter 3: Materials and Methods 11

Chapter 4: Results 17
- Prevalence of Impaction 17
- Maxillary and Mandibular Dental Arcade Areas 18
- Secular Change in Prevalence of Impaction and Maxillary and Mandibular Arcade Areas 20

Chapter 5: Discussion 24
- Prevalence of Impaction 24
- Maxillary and Mandibular Dental Arcade Areas 25
- Secular Change in Prevalence of Impaction 25
- Secular Change in Maxillary and Mandibular Dental Arcade Areas 28
- Relationship between Prevalence of Impaction and Relative Size of the Dental Arcade 30

Chapter 6: Conclusion 31

References Cited 33

Appendix 36

Vita 37

List of Tables

1: Total sample size and composition 11

2: Prevalence of impactions, overall and by sex and ancestry 17

3: Number of each tooth impacted and rates of angulations of impactions 17

4: Incidences of impaction in maxillae versus mandible and by tooth for historic and modern samples 18

5: Comparisons of rates of impaction by sex and ancestry 18

6: Maxillary dental arcade areas for overall sample and by sex and ancestry (mm^2) 18

7: Mandibular dental arcade areas for overall sample and by sex and ancestry (mm^2) 19

8: Comparisons of average maxillary dental arcade areas by sex and ancestry (mm^2) 19

9: Comparisons of average mandibular dental arcade areas by sex and ancestry (mm^2) 19

10: Comparisons between historic and modern proportions of impaction overall and by sex and ancestry 20

11: Comparisons between historic and modern proportions of impaction by ancestry 20

12: Comparisons between historic and modern maxillary dental arcade area for white individuals (mm^2) 21

13: Comparisons between historic and modern mandibular dental arcade area for white individuals (mm^2) 21

14: Eruption times for permanent dentition in the human mouth 36

List of Figures

1: Example of an impacted tooth (A) versus an erupted tooth (B). Reprinted with permission of Jon Årtun (Kim et al. 2003) 3

2: Degrees of impaction. A) complete eruption; B) partial impaction; C) complete impaction. Reprinted with permission of Elsevier Publishers (Quek et al. 2003) 5

3: Angulations of impaction. A) vertical; B) mesioangular; C) distoangular; D) horizontal. Reprinted with permission of Tohoku University Medical Press (Sasano et al. 2003) 6

4: Terry 1402 (black female) showing third molar impaction visible through the alveoli 12

5: Terry 1482R (white female) showing third molar impaction visible through the buccal cortex 13

6: Terry 405R (white female) showing canine impaction visible through the lingual cortex 13

7: Illustration of trapezoid used to determine relative dental arcade areas 15

8: Maxillary dental arcade area (mm^2) versus year of birth with regression equation to represent change in dental arcade area 22

9: Mandibular dental arcade area (mm^2) versus year of birth with regression equation to represent change in dental arcade area 23

Abstract

Current literature on the prevalence of impaction has not addressed the change over time (secular change) as it relates to the dimensions of the dental arcade. It has been suggested both that the prevalence of impaction is increasing and that the dimensions of the dental arcade may be decreasing, but no studies have investigated these two variables in conjunction with one another. This study aims to record secular change in the prevalence of impaction by utilizing two sets of data: individuals from the Terry collection represent a historic population from the late 19th and early 20th centuries, and individuals from the donated skeletal collections housed at the W. M. Bass Forensic Anthropology Center and the Forensic Anthropology and Computer Enhancement Services (FACES) Laboratory represent a contemporary modern population. In addition to recording dental impactions by visual inspection, dental arcade widths and depths were taken in both the maxillae and mandible; these measurements formed a trapezoid with which the relative dental arcade area could be calculated. This study found that the overall prevalence of impaction has increased significantly between the historic and modern samples. The maxillary dental arcade is significantly larger in the modern sample than in the historic; the mandibular dental arcade shows no significant difference. However, scatterplots and linear regression equations show a decrease in the size of the dental arcade area for both the maxillae and the mandible. These results show that secular change is occurring. The proposed negative correlation between the prevalence of dental impaction and the relative size of the dental arcade does appear to exist, although this cannot be statistically demonstrated in this study.

Chapter 1: Introduction

Dental impaction occurs when any tooth does not erupt into its proper anatomical position within the expected time frame (Eidelman 1979; Hattab and Abu Alhaija 1999). Previously published studies suggest both that the prevalence of impaction is increasing (Hattab and Abu Alhaija 1999) and that the dimensions of the dental arcade may be decreasing (Jantz and Jantz 2000; Lavelle 1973; Smith et al. 1986; Truesdell 2005). Yet, no studies have investigated these two variables in conjunction with one another. One of the most commonly cited causes of impactions is a lack of space in the dental arcade into which the teeth can properly erupt (Björk et al. 1956; Eidelman 1979; Farman 2007; Hattab and Abu Alhaija 1999; Richardson 1975, 1977). If this is the case, then a decrease in the size of the dental arcade should translate into an increase in the prevalence of impaction. Theories as to why there is a lack of space in the dental arcade include differential growth patterns of the mandibular condyle, reduced growth of the mandible due to a softer diet requiring less work to masticate, and delayed eruption or exfoliation of the deciduous teeth, among others (Begg 1954; Björk et al. 1956; Eidelman 1979; Farman 2007; Richardson 1977).

This study aimed to check for the presence of secular change in the prevalence of impaction by utilizing two sets of data: individuals representing a historic population from the late 19th and early 20th centuries and individuals representing a contemporary population. In addition to recording dental impactions, the relative area of the dental arcade was calculated for the individuals being studied. Dental arcade widths and depths were recorded in both the maxillae and the mandible, and these measurements formed a trapezoid with which relative dental arcade area could be determined. These dental arcade dimensions were compared to the prevalence of impaction to explore whether the two are negatively correlated. Based upon previously published literature, two proposed hypotheses emerged for examination in this study: that the prevalence of impaction is increasing and that the relative size of the dental arcade is decreasing. In other words, it would be expected that the prevalence of impaction would be lower and the dental arcade area would be larger in the historic sample; conversely, it would be expected that the prevalence of impaction would be higher and the dental arcade area would be smaller in the modern sample.

Chapter 2: Literature Review

Definition of Impaction

An impacted tooth can be defined as one which does not erupt into its proper position in the dental arcade in the expected time frame [see Appendix A for permanent dentition eruption times], instead staying below the gingival line (Eidelman 1979; Hattab and Abu Alhaija 1999). Alternatively, impacted teeth have been defined as those which are prevented from erupting into their proper positions by a physical barrier within their path (Farman 2007). Figure 1 illustrates an impacted tooth compared to one which has erupted into its proper position.

Figure 1: Example of an impacted tooth (A) versus an erupted tooth (B).
Reprinted with permission of Jon Årtun (Kim et al. 2003).

Teeth Most Affected by Impaction

The third molars are the most commonly impacted teeth, accounting for 98% of all dental impactions (Hattab and Abu Alhaija 1999), although there is debate about whether impaction of the mandibular third molar or maxillary third molar is more commonly seen (Dachi and Howell 1961; Eidelman 1979; Farman 2007; Hattab and Abu Alhaija 1999; Kim et al. 2003). After the third molars, the next most common tooth to become impacted is the maxillary canine (Eidelman 1979; Farman 2007), followed by the mandibular canine, and, most rarely, the premolars and incisors (Grover and Lorton 1985). In patients over 20 years of age, the modern prevalence of impaction has been shown to be 17% (Farman 2007). However, the prevalence of impactions, particularly for third molars, appears to be increasing (Hattab and Abu Alhaija 1999).

Degrees of Impaction

Impactions are categorized by two variables: degree and angulation. The different degrees of impaction refer to where the cementoenamel junction of the tooth in question lies in relation to the alveolar bone (Quek et al. 2003). These degrees can be described as complete impaction where the tooth is entirely encased in bone (Level C in Figure 2) and partial impaction where any part of the cementoenamel junction is below the alveolar bone (Level B in Figure 2). The final state for a tooth is complete eruption, where the cementoenamel junction is completely above the alveolar bone (Level A in Figure 2) (Quek et al. 2003; Sasano et al. 2003). Complete eruption implies that the occlusal surface of the tooth is on the same plane as the occlusal surface(s) of any adjoining teeth (Sasano et al. 2003), but it is possible for the cementoenamel junction to completely breach the alveolar bone without the occlusal surface of the tooth breaking the gingival line. In this case, the tooth is referred to as being impacted in soft tissue, rather than partially or completely in bone (Ventä et al. 1993). Partial impaction can also be further elaborated upon, for example, by creating more than a single gradation between the extremes of complete impaction and complete eruption (Sasano et al. 2003). As measured by Sasano et al. (2003), the most common status for third molars is complete eruption, followed by 2/3 impaction of the tooth crown, then 1/3 impaction, and, lastly, complete impaction. Alternatively, Quek et al. (2003) found the most common degree of impaction for third molars to be partial impaction, followed by complete eruption, complete impaction, and lastly soft tissue impaction.

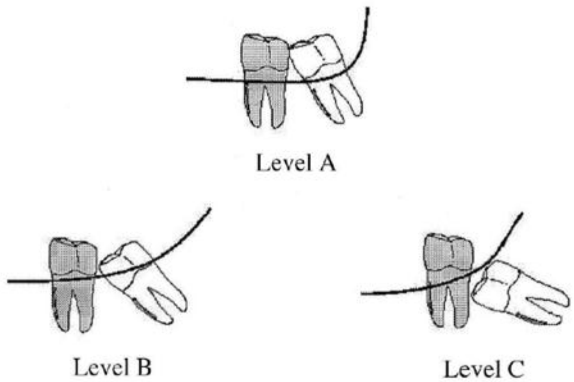

Figure 2: Degrees of impaction. A) complete eruption; B) partial impaction; C) complete impaction. Reprinted with permission of Elsevier Publishers (Quek et al. 2003).

<u>Angulations of Impaction</u>

The different angulations of impaction refer to the position of the tooth in question as it relates to the longitudinal axis formed by the occlusal surface of any adjoining teeth, both when viewing the teeth in the anterior-posterior plane and the lateral plane (Quek et al. 2003). The variations of angulation in the anterior-posterior plane include vertical, mesioangular, distoangular, and horizontal, as shown in Figure 3 (Quek et al. 2003; Sasano et al. 2003; Ventä et al. 1993). Vertical angulation is defined as any variation of the tooth in question within 10° of the defined occlusal plane, either mesially or distally, shown in x-ray (A) in Figure 3 (Quek et al. 2003; Ventä et al. 1993). Mesioangular and distoangular angulation are defined as any variation of the tooth in question between 11° and 70° (Ventä et al. 1993) or 79° (Quek et al. 2003) in either the mesial or distal direction, depending upon whose methodology is being examined (see x-rays (B) and (C) in Figure 3). Horizontal angulation is defined as any variation of the tooth in question above either 71° (Ventä et al. 1993) or 80° (Quek et al. 2003) in either the mesial or distal direction, again depending upon the chosen methodology (see x-ray (D) in Figure 3). The angulations in the lateral plane include buccoangular and linguoangular (Qirreish 2005) and can be defined as any variation in the tooth in question in either the buccal or lingual direction past the occlusal plane defined by any adjoining teeth.

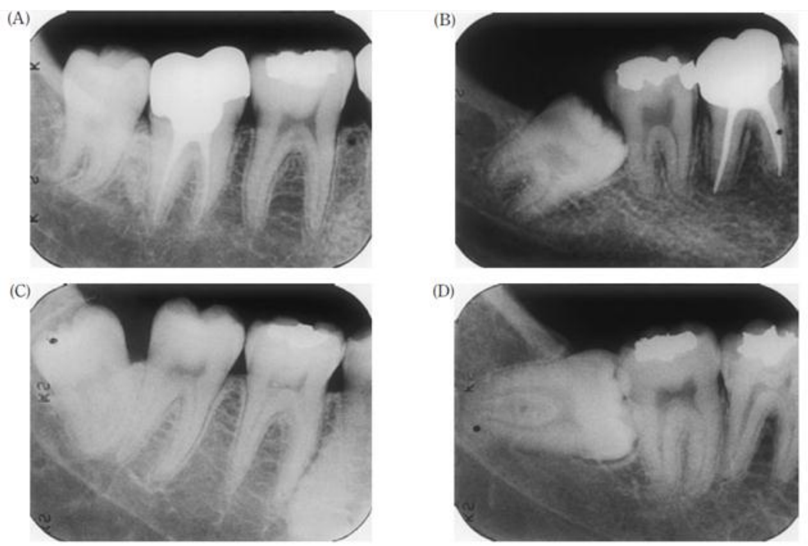

Figure 3: Angulations of impaction. A) vertical; B) mesioangular; C) distoangular; D) horizontal. Reprinted with permission of Tohoku University Medical Press (Sasano et al. 2003).

The prevalence for the angulations of impaction is not agreed upon, as different authors have found different results. As measured by Quek et al. (2003), mesioangular angulation of impactions is the most common type in the third molar, followed by horizontal, distoangular, vertical, and lastly buccoangular and linguoangular as the two angulations least prevalent. Alternatively, Sasano et al. (2003) did not study angulations in the lateral plane and found that vertical impactions were most common for third molars in both the maxillae and the mandible.

The second most likely angulation of impaction for maxillary third molars was distoangular followed by mesioangular, with horizontal impactions ranked as least likely with zero instances in this particular study. The second most likely angulation of impaction for mandibular third molars was horizontal, followed by mesioangular, and lastly distoangular.

Prevalence of Impaction between Groups

When the prevalence of impaction is being investigated, particularly between different groups, the possibility that intragroup differences may exist in these rates is noteworthy. Two biological variables in which differences in prevalence of impaction may exist are sex and ancestry. Two studies do not report a difference in the prevalence of impaction between males and females, specifically in the third molars (Aitasalo et al. 1972; Dachi and Howell 1961), while others claim a difference between the sexes. Studies have been conducted that state that the prevalence of impaction is greater in males than in females (Hattab and Abu Alhaija 1999; Murtomaa et al. 1985), while other studies report a greater incidence of impaction in females than in males (Hellman 1986; Quek et al. 2003; Ventä et al. 1991).

Differences in the prevalence of impaction between ancestral groups may also exist. Many studies conducted on white populations have reported similar incidences to each other (Dachi and Howell 1961; Kan et al. 2002; Murtomaa et al. 1985). Kan et al. (2002) report that the prevalence of impaction is comparable between European populations and Asian populations; in the same report, the prevalence of impaction for a population from the United States is comparable to that of Nigeria, and both are lower than the European or Asian samples. Quek et al. (2003) also report a lower prevalence of impaction in white populations than in Chinese populations.

Etiology

The most commonly cited etiology for the impaction of teeth is the lack of space in the dental arcade into which the tooth can erupt (Björk et al. 1956; Eidelman 1979; Farman 2007; Hattab and Abu Alhaija 1999; Richardson 1975, 1977). This lack of space in the dental arcade can occur for many different reasons, and none of the potential causes is necessarily mutually exclusive. Dental crowding is often cited as a cause for impaction (Farman 2007; Hattab and Abu Alhaija 1999; Richardson 1977), but dental crowding is a byproduct of the lack of space in the dental arcade. Dental crowding can be defined as the lack of space for any particular tooth within the dental arcade; this is measured by determining the difference between the space available for a tooth and the mesiodistal diameter of the tooth's crown (Lavelle 1973).

Björk et al. (1956) proposed that the lack of space in the dental arcade that leads to dental impaction is a product of four different variables, ranked from most important to least important: the mandibular condyle growing in a vertical direction as opposed to angled, reduced growth of the mandible, a distal direction of the eruption of teeth, and a delay in the maturation of the teeth (Björk et al. 1956). An alternate theory for the lack of space in the dental arcade comes from Begg (1954) who suggests that a modern diet may be the cause. The relative lack of effort necessary to masticate modern, processed foods leads to diminished development of the mandible, in turn leading to the lack of space for all teeth to erupt into their proper positions in the dental arcade (Begg 1954; Eidelman 1979; Richardson 1977). Other causes cited for the lack of space in the dental arcade include premature loss of the deciduous teeth (Eidelman 1979; Farman 2007), supernumerary teeth, retention of the deciduous teeth, abnormal position of the tooth crypt in which tooth development takes place, infections, and tumors (Eidelman 1979).

Related to a lack of space in the dental arcade is the possibility that teeth are becoming impacted because of a hereditary disproportion between the size of the teeth and the size of the maxillae or mandible (Eidelman 1979). In this case, a genetic predisposition to having teeth that are wider mesiodistally than the amount of space that is available in the dental arcade leads to a lack of space and subsequent dental crowding, all conditions that have been shown to contribute to dental impactions.

Other causes that have been cited in the etiology of dental impaction include an improper path of eruption (Farman 2007), heritability of impaction, specifically in maxillary canines (Peck et al. 2002), obstruction of the tooth's eruption due to cysts, and trauma (Eidelman 1979).

Secular Change in the Prevalence of Impaction

Secular change is defined as change occurring over time; this has been identified in the axial, appendicular, or facial skeleton in humans (Smith et al. 1986). These changes over time can be a product of both genetic and environmental factors (Jantz and Jantz 2000). With regards to the prevalence of impaction, the relevant secular change occurring is an apparent increase in the rate of impaction in recent years, particularly in the third molars (Hattab and Abu Alhaija 1999).

Secular Change in Dimensions of the Dental Arcade

Because lack of space is one of the most commonly accepted causes for the impaction of teeth, a decrease in the size of the dental arcade should contribute to an increase in the prevalence of impaction. Opinions as to the secular changes that are taking place in the dimensions of the dental arcade are not consistent throughout the field. Some studies agree that the facial skull is becoming narrower and taller over time (Jantz and Jantz 2000; Smith et al. 1986), contributing to a narrowing of the widths of the maxillae and mandible. Studies have been conducted that have not recorded any secular change in the dimensions of the dental arcade, specifically the maxillae (Wescott and Jantz 2005). Other studies have recorded secular change in the size of the dental arcade, but these changes are not consistent between authors. Some authors have noted increases in the dimensions of the dental arcade, specifically in the anterior maxillae (Jonke et al. 2007) and in the length of the mandible (Smith et al. 1986). Other studies show decreases in the size of the dental arcade, specifically with reference to the mandibular length as it relates to the maxillary length (Truesdell 2005). One study showed decreases in dental arcade dimensions and increases in tooth dimensions, leading to an increase in dental crowding over time (Lavelle 1973).

Chapter 3: Materials and Methods

This study assessed the secular change in the prevalence of dental impaction and whether this change could be related to a decrease in the size of the human dental arcade. Two sets of data were utilized in this study: individuals representing the more historic population from the late 19th century and early 20th century and individuals representing a contemporary modern population. The collection examined to represent the historic population is the Terry Collection housed at the Smithsonian National Museum of Natural History in Washington D.C. The collections examined to represent the modern population are the W. M. Bass Donated Skeletal Collection housed at the University of Tennessee at Knoxville and the donated skeletal collection housed in the Forensic Anthropology and Computer Enhancement Services (FACES) Laboratory at Louisiana State University. The composition of the sample from each collection is represented in Table 1.

Table 1: Total sample size and composition.

Secular Category	Collection	White Males	White Females	Black Males	Black Females	Total
Historic (1868-1933)	Terry	32	11	70	43	156
Modern (1941-1977)	W. M. Bass	30	9	2	0	67
	FACES Lab	9	3	8	6	
Total		71	23	80	49	223

The sample for this study included only those individuals who were between the ages of 30 and 59. Natural variation for the eruption of the third molar for white American males and females can occur between the ages of 14 and 24 (Mincer et al. 1993). Because this study examined dental impaction, eliminating specimens that may not show signs of a third molar because it has not yet erupted helped to prevent any misdiagnosis of this form. The maximum age of 59 was utilized to lessen the chance of encountering edentulous individuals. Based upon these criteria, the individuals included in this sample were all white and black individuals in each collection between the ages of 30 and 59 who were not edentulous.

The year of birth, sex, and ancestry were recorded for each individual before analysis was performed. Individuals utilized in this study were first examined for the presence or absence of impacted teeth. Because x-rays were not present for all collections examined, they were not used as a diagnostic tool for assessing impaction. Rather, the presence or absence of impaction was based upon visual inspection. Impactions that were noted in this sample were those that were visible through the cortical bone. Depending upon the angulation of impaction, impacted teeth could be visible either through the tooth's alveolus (see Figure 4) or through the buccal or lingual cortical plates (see Figures 5 and 6 respectively).

Figure 4: Terry 1402 (black female) showing third molar impaction visible through the alveoli.

Figure 5: Terry 1482R (white female) showing third molar impaction visible through the buccal cortex.

Figure 6: Terry 405R (white female) showing canine impaction visible through the lingual cortex.

If impactions were present, the presence, location, and angulation of impaction were recorded. Because x-rays were not utilized in the diagnostic process, individuals in which it was unclear whether impactions were present or not were marked as possible impactions. These specimens were not included in analyses as individuals with impactions. After the individuals were examined for impactions, the relative sizes of both the maxillary and mandibular dental arcades were determined. All measurements were taken using a dial caliper. The first measurement that was taken for both the maxillae and the mandible is the dental arcade width between the cusps of the left and right canine. The second measurement for the maxillary dental arcade width was taken between the metacones of the left and right second molar; in the mandible, this width was taken between the hypoconids of the left and right second molar. The third and fourth measurements were the dental arcade depths, the distance between the canine's cusp and the second molar's metacone in the maxillae or hypoconid in the mandible, for both the left and right sides. The relative area of the dental arcade was determined by using these measurements to create a trapezoid (see Figure 7) and define the area using the formula:

$$\text{Area} = \frac{1}{4} \times (\text{Base } 1 + \text{Base } 2) \times (\text{Height } 1 + \text{Height } 2)$$

The specimens from the Terry collection comprised the historic sample, and the specimens from the W. M. Bass and FACES Lab collections comprised the modern sample. Z-scores for comparing proportions in the historic and modern samples were calculated to determine whether prevalence of impaction shows secular change (Freund et al. 2010). Student t-tests were then performed to compare average maxillary and mandibular dental arcade areas between the historic and modern samples to determine if the size of the dental arcade shows secular change (Freund et al. 2010). The significance of both the Z-scores and t-scores was determined based upon an alpha of 0.05. P-values were calculated using SAS version 9.3.

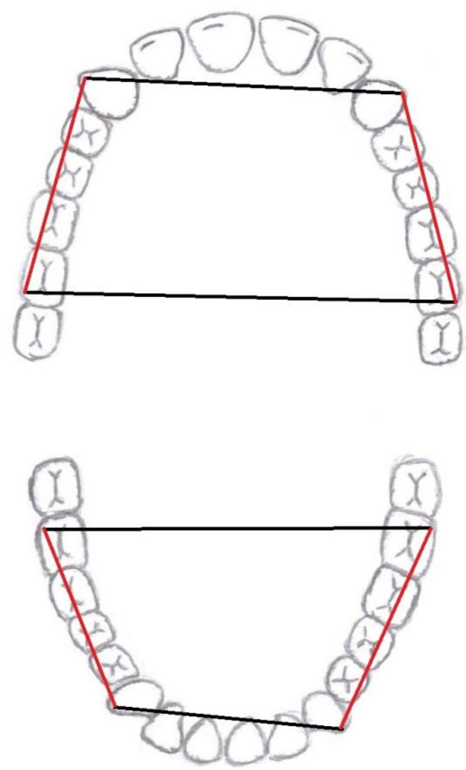

Figure 7: Illustration of trapezoid used to determine relative dental arcade areas.

In an effort to more clearly illustrate secular change in the relative area of the maxillary and mandibular dental arcades, all individuals for whom dental arcade area could be estimated were plotted on a graph along with year of birth. From these maxillary and mandibular graphs, Microsoft Office Excel 2010 was used to plot a linear regression equation to show the average rate of change of the dental arcade area within the time span examined.

In addition to the secular patterns in the rate of dental impaction and its relation to the size of the dental arcade, the data collected during this study were analyzed for other variables. Because four distinct groups were studied (white males, white females, black males, and black females), differences in the rate of dental impaction and change in the size of the dental arcade between sexes and between ancestries could be investigated. The same statistical analyses used to determine whether significant differences existed between the historic and modern samples were also performed to determine whether differences existed between the sexes and ancestries.

Chapter 4: Results

Prevalence of Impaction

The prevalence of impaction according to sex and ancestry is recorded in Table 2. This table shows that white males and females have higher percentages of individuals with impactions than black males or females. Of the 30 individuals with one or more impacted teeth, the number of incidences for each type of tooth and for the angulations of impaction are recorded in Table 3. This table shows that the most commonly impacted tooth in this sample was the maxillary third molar followed by the mandibular third molar; also notable in Table 3 is the fact that vertical impaction was the most common angulation of impaction. Table 4 shows the incidences of impactions for the historic and modern samples, both by maxillary versus mandibular and by tooth. This table shows that the number of impacted third molars increased from the historic sample to the modern sample, but there are no other significant differences.

Table 2: Prevalence of impactions, overall and by sex and ancestry.

		White Males	White Females	Black Males	Black Females	Total
Individuals with Impactions	Historic	2	5	6	2	15
	Modern	10	1	3	1	15
	Total	12	6	9	3	30
Total Sample		71	23	80	49	223
Percent Impacted		16.90%	26.08%	11.25%	6.12%	13.45%

Table 3: Number of each tooth impacted and rates of angulations of impaction.

Impactions by Tooth					
Maxillary Third Molar	Mandibular Third Molar	Maxillary Canine	Mandibular Canine	Mandibular Fourth Molar	Total
24	23	2	1	1	51
Angulations of Impaction					
Vertical	Mesioangular	Buccoangular	Linguoangular	Distoangular	Total
17	14	10	5	5	51

Table 4: Incidences of impaction in maxillae versus mandible and by tooth for historic and modern samples.

	Historic	Modern	Total
Maxillary	12	14	26
Mandibular	12	13	25
Total	24	27	51
Impactions by Tooth			
	Historic	Modern	Total
Third Molars	20	27	47
Canines	3	0	3
Fourth Molars	1	0	1
Total	24	27	51

Z-scores were calculated to compare rates of impaction between the sexes and between ancestry groups. The results are shown in Table 5. No significant difference was found in the rates of impaction between males and females, but the difference between blacks and whites is significant, with white individuals having a higher rate of impaction in this sample.

Table 5: Comparisons of rates of impaction by sex and ancestry.

	Males	Females	Black	White
Proportion	0.1391	0.1250	0.0930	0.1915
Z-Score	0.2886		-2.1289	
P-value	0.3864		0.0166	

Maxillary and Mandibular Dental Arcade Areas

Tables 6 and 7 present the summary statistics for area estimates of the dental arcade for the maxillae and mandible, respectively.

Table 6: Maxillary dental arcade areas for overall sample and by sex and ancestry (mm^2).

	White Males	White Females	Black Males	Black Females	Overall
Minimum	824	1227	1133	1154	824
Maximum	1681	1634	1872	1693	1872
Average	1383	1414	1547	1436	1452
Standard Deviation	195	103	168	117	188
Sample Size	42	17	55	27	141

Table 7: Mandibular dental arcade areas for overall sample and by sex and ancestry (mm^2).

	White Males	White Females	Black Males	Black Females	Overall
Minimum	671	963	884	1012	671
Maximum	1354	1352	1775	1357	1775
Average	1130	1140	1267	1186	1194
Standard Deviation	150	122	185	98	164
Sample Size	46	18	47	33	144

Results in Tables 6 and 7 show that black males and females have larger average dental arcade areas than white males and females.

Student t-tests were performed to compare the average maxillary and mandibular arcade areas between the sexes and both ancestry groups. These analyses are presented in Tables 8 and 9 for the maxillae and mandible, respectively. For the maxillae, significant differences exist in the average areas by both sex and ancestry. Males have significantly larger maxillary arcades than females, and black individuals have significantly larger maxillary arcades than white individuals. In the mandible (Table 9), the only significant difference is by ancestry; black individuals have significantly larger mandibular arcade areas than white individuals.

Table 8: Comparisons of average maxillary dental arcade areas by sex and ancestry (mm^2).

	Males	Females	Black	White
Average	1478	1425	1507	1396
Standard Deviation	201	114	163	181
T-Test	1.9912		3.7445	
Degrees of Freedom	139		139	
P-value	0.0242		0.0001	

Table 9: Comparisons of average mandibular dental arcade areas by sex and ancestry (mm^2).

	Males	Females	Black	White
Average	1191	1169	1253	1134
Standard Deviation	176	103	179	142
T-Test	0.9242		4.4796	
Degrees of Freedom	142		142	
P-value	0.1785		0.0000	

Secular Change in Prevalence of Impaction and Maxillary and Mandibular Arcade Areas

To evaluate secular change in this study, the historic and modern samples were compared. Results of the analyses of secular change in impaction rates are shown in Table 10. The modern rate of impaction is significantly greater than the historic rate for white males, black males, and for the overall sample. However, the historic rate of impaction for white females is significantly greater than the modern rate, and there is no significant difference between historic and modern rates for the black females.

Table 10: Comparisons between historic and modern proportions of impaction overall and by sex and ancestry.

	White Male	White Female	Black Male	Black Female	Overall
Historic Proportion	0.0625	0.4545	0.0857	0.0465	0.0962
Modern Proportion	0.2564	0.0833	0.3000	0.1667	0.2239
Z-Score	-2.169	2.025	-2.0062	-1.1507	-2.5624
P-value	0.0150	0.0214	0.0224	0.1249	0.0052

Because sex is not a significant factor in the prevalence of impaction (Table 4), only ancestry differences in the rates of impaction were assessed between historic and modern samples. These results are shown in Table 11. The modern proportion of impaction for the black individuals is significantly larger than the historic proportion. There is no significant difference for the white individuals.

Table 11: Comparisons between historic and modern proportions of impaction by ancestry.

	All Black	All White
Historic Proportion	0.0708	0.1628
Modern Proportion	0.2500	0.2157
Z-Score	-2.3099	-0.6493
P-value	0.0104	0.2578

Secular change in dental arcade area could only be examined for white individuals due to the small modern sample size of black individuals. Results are presented in Tables 12 and 13 for maxillary and mandibular arcade areas, respectively. Only males exhibited a significant difference, with the modern maxillary arcade being larger than the historic. Additionally, the overall difference between historic and modern values for maxillary arcade areas was significant; the modern maxillary arcade area is significantly larger than the historic value.

Table 12: Comparisons between historic and modern maxillary dental arcade area for white individuals (mm^2).

		White Males	White Females	Overall
Historic	Average	1224	1455	1319
	Standard Deviation	192	115	199
Modern	Average	1449	1382	1432
	Standard Deviation	104	94	162
T-Test		-3.2322	1.3614	-2.0515
Degrees of Freedom		35	14	51
P-value		0.0013	0.0974	0.0227

Table 13: Comparisons between historic and modern mandibular dental arcade area for white individuals (mm^2).

		White Males	White Females	Overall
Historic	Average	1121	1167	1136
	Standard Deviation	177	94	116
Modern	Average	1133	1129	1132
	Standard Deviation	172	121	159
T-Test		-0.2755	0.7031	0.1305
Degrees of Freedom		40	15	57
P-value		0.3922	0.4714	0.4483

To more clearly illustrate potential secular change in the prevalence of impaction and the maxillary and mandibular dental arcade areas, charts were made plotting these values against the year of birth for each individual. These results are presented in Figures 8 and 9.

Also included in each scatterplot is a linear regression equation based upon all individuals for whom dental arcade areas could be estimated.

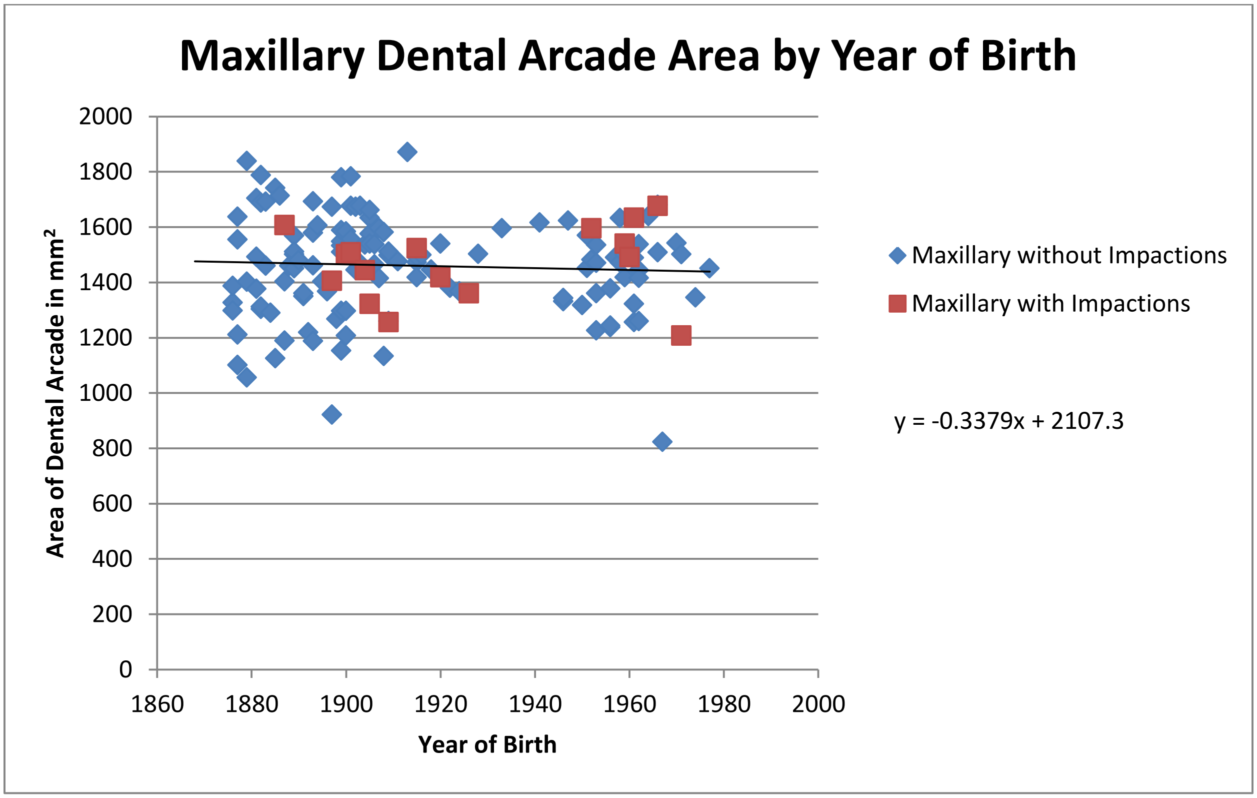

Figure 8: Maxillary dental arcade area (mm^2) versus year of birth with regression equation to represent change in dental arcade area.

These charts demonstrate a clear decline in the dental arcade area in both the maxillae and the mandible. The downward slope for the maxillary dental arcade area (Figure 8) is not as great as for the mandibular dental arcade area (Figure 9); the secular trend for maxillary dental arcade area translates to a decrease of 0.3379 mm^2 per year, versus a decrease of 0.9875 mm^2 per year in the mandibular dental arcade area. The coefficient of determination for the maxillary linear regression equation is 0.0033, while the coefficient of determination for the mandibular linear regression equation is 0.0398. This shows that the linear regression equation is stronger for the mandibular data, but neither line fits the data well. Also demonstrated by these charts is the increase in the prevalence of dental impactions (see Table 10). In the 65 year time span represented by the historic sample, 15 individuals had one or more impactions (9.62%). Comparatively, there were also 15 individuals with impactions in the modern sample (22.39%), which only covered 36 years.

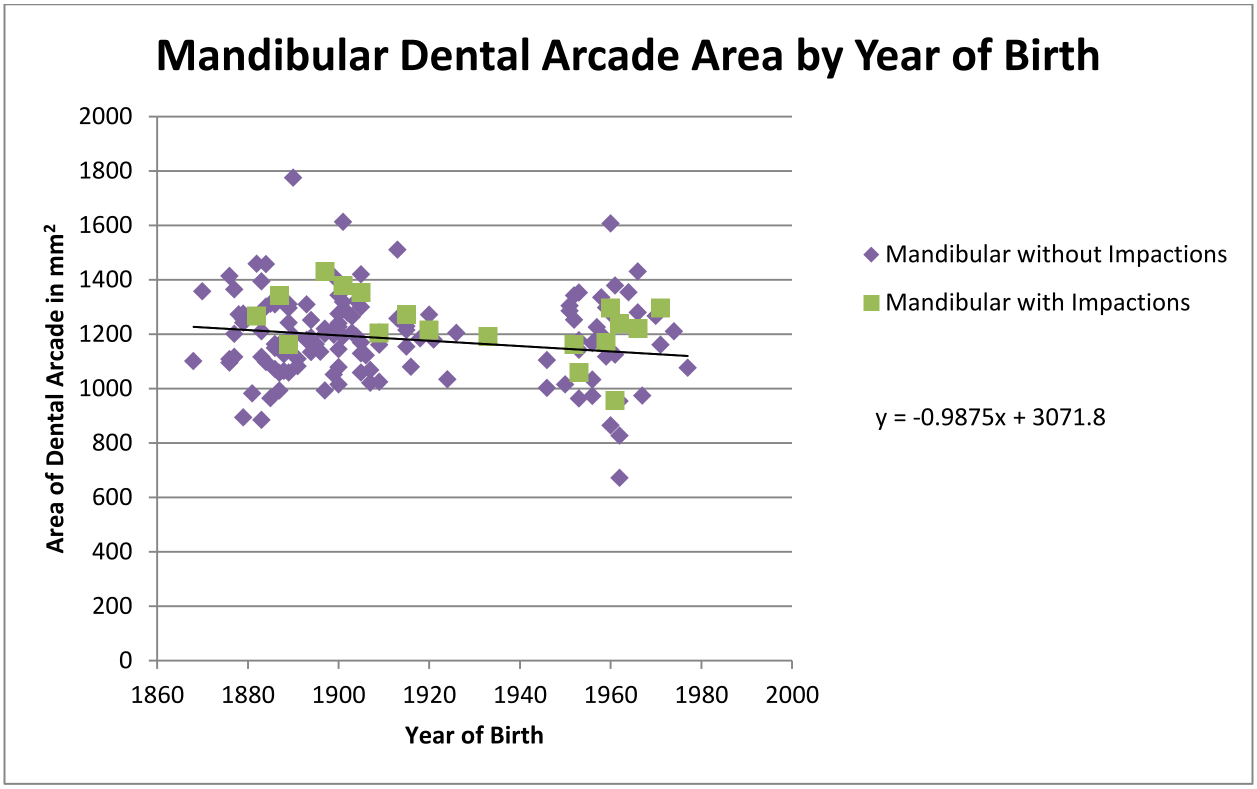

Figure 9: Mandibular dental arcade area (mm^2) versus year of birth with regression equation to represent change in dental arcade area.

Chapter 5: Discussion

<u>Prevalence of Impaction</u>

The analyses of the sample from the Terry, W. M. Bass, and FACES Lab collections support some overall trends in the data. The prevalence of each type of impaction coincides with previously conducted studies. Third molars were the most commonly impacted tooth in this study followed by canines (see Table 3), supporting previously reported results (Eidelman 1979; Farman 2007; Grover and Lorton 1985; Hattab and Abu Alhaija 1999). The sample examined also had a higher prevalence of impacted maxillary third molars than mandibular third molars, but the difference is not significant. One individual of import had 16 molars (Specimen 1235 from the Terry collection), and one mandibular fourth molar was impacted. This finding is rare as supernumerary molars are an uncommon occurrence in humans (White and Folkens 2005); Suzuki et al. (1995) reported the occurrence of mandibular fourth molars in 0.01% of a modern population.

Previously reported results on angulations of impaction have been variable in that the most common angulation of impaction cannot be agreed upon; this study mirrors that trend. Sasano et al.'s (2003) finding that vertical impactions are the most common angulation is supported by this study, but no other results coincide with previous research. In this sample, the second most common angulation of impaction was mesioangular, followed by buccoangular, and, lastly, linguoangular and distoangular (see Table 3).

The prevalence of impaction found during this study was examined in two ways: comparisons were made between the sexes and between ancestry groups to see if either showed significant differences. The difference between male and female rates of impaction was not significant (see Table 5), supporting some previously published studies (Aitasalo et al. 1972; Dachi and Howell 1961). However, there is a significant difference between the rates of impaction by ancestry. White individuals had an impaction rate of 19.15%, while black individuals had an impaction rate of 9.30% (see Table 5). These results do not disagree with previous literature; Kan et al. (2002) report similar rates of impaction between the United States and Nigeria, but European and Asian populations are much higher in their sample. This seems to show that ancestry is a greater determining factor in the likelihood of having impacted teeth than sex.

Maxillary and Mandibular Dental Arcade Areas

Maxillary and mandibular dental arcade areas were also examined in two ways: comparisons were again made between the sexes and between ancestry groups to determine if significant differences existed in the size of the dental arcade. Maxillary dental arcade areas yielded significant results from both comparisons. In this sample, males were found to have significantly larger maxillary dental arcade areas than females, and black individuals were found to have significantly larger maxillary dental arcade areas than white individuals (see Table 8).

Mandibular dental arcade areas yielded significant results in only one comparison. Males were not found to be significantly different from females for mandibular dental arcade area, but there was a significant difference between black and white individuals, with black individuals having a larger mandibular arcade area (see Table 9).

Secular Change in Prevalence of Impaction

After comparing sexes and ancestry groups for prevalence of impaction and maxillary and mandibular dental arcade areas, secular change was investigated. One problem to contend with during the study of the collections representing the modern population was the possibility that individuals may have been treated for impactions during their lifetime. In this case, the tooth would either no longer be present and would appear simply as a tooth lost antemortem or would appear to have erupted into its natural position of its own accord. This is a potential source of bias in this study. When there appeared to be antemortem loss of the third molars, the individual was not recorded as having had any impactions. Because of this fact, the prevalence of impaction may have been underrepresented in the modern sample in which treatment may have occurred.

Secular change in the prevalence of impaction yielded variable results. The modern rates of impaction were greater than the historic rates in both white and black males. White females, on the other hand, showed significant results in which historic rates of impaction were greater than modern rates. Black females showed no significant results in this comparison (see Table 10). However, because sex was not determined to be a significant variable in the prevalence of impaction, comparisons were then made between historic and modern rates of impaction for all black individuals and all white individuals. This again yielded variable results. When white males and females were pooled, there was no longer a significant difference between the historic and modern rates of impaction. However, when black males and females were pooled, the modern rate of impaction was significantly greater than the historic rate (see Table 11).

The type of tooth being impacted does not demonstrate secular change (see Table 4). The number of impacted third molars increased from the historic sample to the modern sample, but in both samples, this tooth was the most frequently impacted. Only one impacted fourth molar was present in this study, and that belonged to an individual in the historic sample. There were no fourth molar impactions in the modern sample, but this is unsurprising as the likelihood of having fourth molars is very low in a modern population. However, only three impacted canines were found in this study, and all three were in individuals in the historic sample. The significance of this change could not be tested due to the small sample size.

There was also no secular change in whether maxillary or mandibular teeth were impacted. Both the historic and modern samples were fairly evenly distributed as far as impactions in the maxillae versus mandible are concerned (see Table 4). Secular change in the prevalence of impaction is not greater in either the maxillae or mandible; both are increasing at a similar rate.

In regard to the overarching question of whether the rate of impaction has increased in the last century and a half, the answer is not simple. The overall rate of impaction does show a significant difference; comparisons between the historic rate of 9.62% and the modern rate of 22.39% show that the modern rate is significantly greater (see Table 10). This coincides with previous literature stating that the rate of impaction is increasing (Hattab and Abu Alhaija 1999). However, when the sample is divided by sex or ancestry, the increase in the prevalence of impaction is not always clear. When sex is included in the analysis, rates of impaction are not uniformly higher or lower in the modern sample versus the historic sample, nor are they necessarily significantly different. When ancestry is considered, the rate of impaction has increased for both the white and black individuals, but the difference is only significant for the black individuals.

An alternate explanation for the significant difference between the modern and historic rates of impaction could be due to the unequal representation of black and white individuals. Ancestry has been shown to be a significant variable with regard to the prevalence of impaction; white individuals have significantly higher rates of impaction than black individuals (see Table 5). Because of this finding, the possibility exists that the ancestry composition of the modern and historic samples could affect whether they are significantly different or not. The historic sample is predominantly composed of black individuals (113 out of 156 individuals), while the modern sample has primarily white individuals (51 out of 67 individuals). The historic sample comprising mainly black individuals could be contributing to a lower rate of impaction; additionally, the modern sample comprising mainly white individuals could be contributing to a higher rate of impaction. If the samples were more evenly distributed with regard to ancestry, the results of the comparison between the historic and modern rates of impaction may not be significant.

Secular Change in Maxillary and Mandibular Dental Arcade Areas

Secular change in the areas of the maxillary and mandibular dental arcades was only investigated for the white individuals in this sample; small modern sample size precluded the analysis of the black individuals. These tests could also only utilize the W. M. Bass Donated Skeletal Collection for illustration of the modern population. The FACES Lab collection is comprised of forensic cases, and as such, the year of birth is only available when a positive identification has been made. Without year of birth to confirm the individuals' stances in the modern sample, it could not be definitively said that the specimens from the FACES Lab do not belong in the historic sample.

Overall, change in the average dental arcade area from historic to modern showed variable results. The modern average was significantly greater than the historic average for the maxillary arcade area (see Table 12). This result coincides with previous findings that the dimensions of the dental arcade are increasing, specifically in the anterior maxillae (Jonke et al. 2007). The comparison between the historic and modern average mandibular dental arcade area did not yield significant results (see Table 13). This does not support previous literature which stated that the length of the mandible is increasing (Smith et al. 1986).

When the sample was further divided, few results were significant. The modern average maxillary dental arcade area was significantly greater than the historic average for white males (see Table 12). However, maxillary averages for white females and mandibular averages for both white males and females showed no significant difference between the modern and historic samples.

In regard to the overarching question of whether the size of the dental arcade is decreasing, the answer is, again, complicated. The data at hand cannot statistically support this hypothesis. The relative size of the mandibular arcade is decreasing overall, but the change is not significant. This sample also shows a significant increase in the relative size of the maxillary arcade area, which contradicts the proposed hypothesis. Alternatively, the scatterplots (see Figures 8 and 9) and linear regression equations illustrate an overall decrease in both maxillary and mandibular dental arcade areas in the last century and a half; however, the slopes are not drastic. Additionally, the coefficient of determination does not indicate strong relationships for either equation. This result could be interpreted one of two ways: either the relationship between year of birth and dental arcade area is weak, or the regression model that should be used to describe these data is something other than linear.

<u>Relationship between Prevalence of Impaction and Relative Size of the Dental Arcade</u>

According to the data collected in this study, the prevalence of impaction and the relative size of the dental arcade seem to be negatively correlated. This correlation is visible through the comparisons made between ancestries. Significant results were found showing that the white individuals had a significantly higher rate of impaction and significantly smaller average dental arcade for both the maxillae and the mandible. Conversely, the black individuals had a significantly lower rate of impaction and significantly larger average dental arcade. These results demonstrate a connection between the relative size of the dental arcade and the rate of impaction; when the relative size of the dental arcade is smaller, the rate of impaction is larger. These two variables appear to be related in some way, although it is difficult to say in which way that is. It could be that the rate of impaction and the relative size of the dental arcade are actually related to one another; this idea has been supported in the literature which states that the most common etiology of impacted teeth is a lack of space in the dental arcade (Björk et al. 1956; Eidelman 1979; Farman 2007; Hattab and Abu Alhaija 1999; Richardson 1975, 1977). Alternatively, there could be a separate factor unexamined in this study that affects both of these variables, causing them to appear connected.

Chapter 6: Conclusion

The first hypothesis proposed for examination in this study, that there has been an increase in the overall rate of dental impaction in the last century and a half, has been supported by the results. However, the second proposed hypothesis, that there has been a decrease in the relative size of the dental arcade, cannot be statistically supported by the data collected. The comparison between historic and modern white individuals demonstrated a significant increase in the maxillary dental arcade area, and the size of the mandibular dental arcade showed no significant change. However, the scatterplots and linear regression equations show a decrease in the size of the dental arcade area of both the maxillae and mandible, although the slopes are not drastic. The proposed negative correlation between the prevalence of dental impaction and the relative size of the dental arcade does appear to exist, although the reason for such a connection cannot be reasonably inferred from the data at hand.

This study also coincides with many of the existing ideas in the literature about the prevalence of impaction and the potential secular change in the relative size of the dental arcade. This study supports previously conducted research suggesting that third molars are the most frequently impacted teeth, followed by maxillary and mandibular canines. The most commonly found angulation of impaction in this sample was vertical, which coincides with one previously conducted study. However, the data on angulations of impaction were just as variable as the existing body of literature. Previously published literature regarding an increase in the size of the maxillary dental arcade is supported in this study, as well.

This study shows that both the prevalence of impaction and the relative size of the dental arcade are increasing. Further investigation utilizing more balanced samples with regard to sex and ancestry might clarify the relationship between impaction and dental arcade area and further elucidate secular change in these variables.

References Cited

Aitasalo, Kalle, Risto Lehtinen, and Erkki Oksala (1972). "An Orthopantomographic Study of Prevalence of Impacted Teeth." International Journal of Oral Surgery **1**(3): 117-120.

Bass, William M. (2005). Human Osteology: A Laboratory and Field Manual. Springfield, MO, Missouri Archaeological Society.

Begg, Percy (1954). "Stone Age Man's Dentition: With Reference to Anatomically Correct Occlusion, the Etiology of Malocclusion, and a Technique for its Treatment." American Journal of Orthodontics **40**(5): 373-383.

Björk, Arne, Elli Jensen, and Mogens Palling (1956). "Mandibular Growth and Third Molar Impaction." Acta Odontologica Scandinavica **14**(3): 231-272.

Dachi, Stephen F. and Francis V. Howell (1961). "A Survery of 3,874 Routine Full-Mouth Radiographs II. A Study of Impacted Teeth." Oral Surgery, Oral Medicine, Oral Pathology **14**(10): 1165-1169.

Eidelman, David (1979). ""Fatigue on Rest" and Associated Symptoms (Headache, Vertigo, Blurred Vision, Nausea, Tension and Irritability) Due to Locally Asymptomatic, Unerupted, Impacted Teeth." Medical Hypotheses **5**(3): 339-346.

Farman, Allen G. (2007). Tooth Eruption and Dental Impaction. Panoramic Radiology : Seminars on Maxillofacial Imaging and Interpretation. A. G. Farman (ed). New York, Springer**:** 73-82.

Freund, Rudolf J., William J. Wilson, and Donna L. Mohr (2010). Statistical Methods: Third Edition. Burlington, Elsevier Inc.

Grover, Pushpinder S. and Lewis Lorton (1985). "The Incidence of Unerupted Permanent Teeth and Related Clinical Cases." Oral Surgery, Oral Medicine, Oral Pathology **59**(4): 420-425.

Hattab, Faiez N. and Elham S. J. Abu Alhaija (1999). "Radiographic Evaluation of Mandibular Third Molar Eruption." Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics **88**(3): 285-291.

Hellman, Milo (1986). "Our Third Molar Teeth, Their Eruption, Presence and Absence." The Dental Cosmos **78**(7): 750-762.

Jantz, Richard L. and Lee Meadows Jantz (2000). "Secular Change in Craniofacial Morphology." American Journal of Human Biology **12**(3): 327-338.

Jonke, Erwin, Hermann Prossinger, Fred L. Bookstein, Katrin Schaefer, Marcus Bernhard, and Josef W. Freudenthaler (2007). "Secular trends in the facial skull from the 19th century to the present, analyzed with geometric morphometrics." American Journal of Orthodontics and Dentofacial Orthopedics **132**(1): 63-70.

Kan, Kwok Wing, Jerry K. S. Liu, Edward C. M. Lo, Esmonde F. Corbet, and W. Keung Leung (2002). "Residual Periodontal Defects Distal to the Mandibular Second Molar 6-36 Months After Impacted Third Molar Extraction." Journal of Clinical Periodontology **29**(11): 1004-1011.

Kim, Tae-Woo, Jon Årtun, Faraj Behbehani, and Flavia Artese (2003). "Prevalence of Third Molar Impaction in Orthodontic Patients Treated Nonextraction and with Extraction of 4 Premolars." American Journal of Orthodontics and Dentofacial Orthopedics **123**(2): 138-145.

Lavelle, C. L. (1973). "Variation in the secular changes in the teeth and dental arches." Angle Orthodontist **43**(4): 412-421.

Mincer, H. H., E. F. Harris, and H.E. Berryman. (1993). "The A.B.F.O. study of third molar development and its use as an estimator of chronological age." Journal of Forensic Sciences **38**(2): 379-390.

Murtomaa, Heikki, Lauri Turtola, Pekka Ylipaavalniemi, and Inkeri Ryötomaa (1985). "Status of the Third Molars in the 20- to 21-Year-Old Finnish University Population." Journal of American College Health **34**(3).

Peck, Sheldon, Leena Peck, and Matti Kataja (2002). "Concomitant Occurrence of Canine Malposition and Tooth Agenesis: Evidence of Orofacial Genetic Fields." American Journal of Orthodontics and Dentofacial Orthopedics **122**(6): 657-660.

Qirreish, Emad Eddin Yacob Juma (2005). Radiographic Profile of Symptomatic Impacted Mandibular Third Molars in the Western Cape, South Africa. Department of Diagnostics and Radiology. Western Cape, South Africa, University of the Western Cape, South Africa. Master's of Science in Dentistry.

Quek, S. L., C. K. Tay, K. H. Tay, S. L. Toh, and K. C. Lim (2003). "Pattern of Third Molar Impaction in a Singapore Chinese Population: A Retrospective Radiographic Survey." International Journal of Oral and Maxillofacial Surgery **32**(5): 548-552.

Richardson, Margaret E. (1975). "The Development of Third Molar Impaction." British Journal of Orthodontics **2**(4): 231-234.

Richardson, Margaret E. (1977). "The Etiology and Prediction of Mandibular Third Molar Impaction." Angle Orthodontist **47**(3): 165-172.

Sasano, Takashi, Naoyuki Kuribara, Masahiro Iikubo, Atsushi Yoshida, Shizuko Satoh-Kuriwada, Noriaki Shoji, and Maya Sakamoto (2003). "Influence of Angular Position and Degree of

Impaction of Third Molars on Development of Symptoms: Long-Term Follow-up under Good Oral Hygiene Conditions." Tohoku Journal of Experimental Medicine **200**(2): 75-83.

Smith, B. Holly, Stanley M. Garn, and W. Stuart Hunter (1986). "Secular Trends in Face Size." Angle Orthodontist **56**(3): 196-204.

Suzuki, Takao, Ayano Kusumoto, Hisashi Fujita, and Chang de Shi (1995). "The Fourth Molar in a Mandible Found in a Jomon Skeleton in Japan." International Journal of Osteoarchaeology **5**(2): 174-180.

Truesdell, Nicole Danielle. (2005). Secular Change in the Skull Between American Blacks and Whites. Department of Geography and Anthropology. MA Thesis. Baton Rouge, LA, Louisiana State University: 63.

Ubelaker, Douglas H. (1978). Human Skeletal Remains: Excavation, Analysis, Interpretation. Chicago, Aldine Publishing Company.

Ventä, Irja, Heikki Murtomaa, Lauri Turtola, Jukka Meurman, and Pekka Ylipaavalniemi (1991). "Clinical Follow-Up Study of Third Molar Eruption from Ages 20 to 26 Years." Oral Surgery, Oral Medicine, Oral Pathology **72**(2): 150-153.

Ventä, Irja, Lauri Turtola, Heikki Murtomaa, and Pekka Ylipaavelniemi (1993). "Third Molars as an Acute Problem in Finnish University Students." Oral Surgery, Oral Medicine, Oral Pathology **76**(2): 135-140.

Wescott, Daniel J. and Richard L. Jantz (2005). Assessing Craniofacial Secular Changes in American Blacks and Whites Using Geometric Morphometrics. Modern Morphometrics in Physical Anthropology. D. E. Slice (ed). New York, Kluwer Academic/Plenum Publisher: 231-245.

White, Tim D. and Pieter A. Folkens (2005). The Human Bone Manual. Burlington, Elsevier Academic Press: 133.

Appendix

Typical eruption times for the permanent dentition in the human mouth. The data presented are those from a chart of dental development created by Ubelaker (1978) and presented in Bass (2005). Each time of eruption is given in years with a range of time in which the tooth could naturally erupt, with the exception of the third molar. The eruption time of this tooth has been shown to be extremely variable, with a range for American white males and females between 14 and 24 years of age (Mincer et al. 1993).

Table 14: Eruption times for permanent dentition in the human mouth.

Permanent Tooth	Maxillary Eruption	Mandibular Eruption
Central Incisor	8 years (± 24 months)	7 years (± 24 months)
Lateral Incisor	9 years (± 24 months)	7 years (± 24 months)
Canine	12 years (± 30 months)	10 years (± 30 months)
First Premolar	10 years (± 30 months)	10 years (± 30 months)
Second Premolar	11 years (± 30 months)	11 years (± 30 months)
First Molar	6 years (± 24 months)	6 years (± 24 months)
Second Molar	12 years (±30 months)	12 years (± 30 months)
Third Molar	21 years	21 years

Vita

Originally from Baton Rouge, Louisiana, Kelly Heim began studying at Louisiana State University in the fall of 2008. She received her Bachelor of Arts in Anthropology with minors in French and Sociology after three years of school, additionally working to receive College Honors. Her undergraduate thesis consisted of studying the dentition in ancient Maya burials from Belize to investigate whether a female individual assumed to be a sacrificial victim originated from a location other than that in which she was interred. She began work on her Master of Arts in Anthropology, with a concentration in forensic anthropology, at Louisiana State University in the fall of 2011, studying under Ms. Mary H. Manhein. She currently works as a graduate assistant in the Forensic Anthropology and Computer Enhancement Services (FACES) Laboratory at Louisiana State University, allowing her the opportunity to work on both historic and forensic cases. Following graduation in May 2013, Kelly will pursue her Ph.D. in Anthropology at the University of Nevada Reno.