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Dental Attrition and the Third Molar

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Abstract

The third molars, or the 'wisdom teeth' as they are known commonly, are a set of teeth that develop and descend later in a human's life. Third molars are not exclusive to present-day humans. They are found in almost all anatomically modern humans, with some exceptions, including those from times well before any form of dental care is known to have existed. This leads to the main question addressed within this paper: What differences between ancient humans and modern humans may have allowed ancient humans to readily accept the third molar into their dentition, as compared to the issues faced by modern humans?

The main theory analyzed here will be the proposed idea that dental attrition in ancient humans would have provided room to allow the third molar to grow in relatively pain-free. In this project, I analyzed 50 skulls (a combination of maxilla and mandibles) from a combination of the Tepe-Hissar Collection (representing an 'ancient' population), the Morton Collection, and a handful of others (representing a 'modern' population), measuring values of length, width, tooth spacing, toot diameter, attrition, and presence of third molars. Through this comparative study, it was determined that there is strong evidence for higher attrition in the Tepe-Hissar skulls, and a far lower percentage of complications involving third molars in skulls that had third molars in Tepe-Hissar, 32.14%, then in the Morton, 57.14%, or the others, 75%. This shows that there may indeed be an inverse relation with dental attrition and third molar-related incidents.

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Problem Statement

The third molars, or the 'wisdom teeth' as they are known commonly, are a set of teeth that develop and descend later in a human's life. On average, the third molar erupts between the ages of 15 and 21 in modern humans (Byers, 222), and is often accompanied by a great deal of pain or discomfort. According to Byers, "the pain is caused by the crowns of these teeth bumping against bumping against the second molars due to a lack of space in both the upper and lower jaws" (Byers, 57).

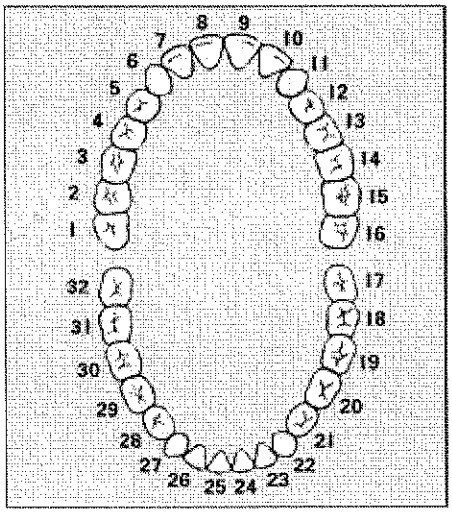
Third molars are not exclusive to present-day humans. They are found in almost all anatomically modern humans, with some exceptions, including those from times well before any form of dental care is known to have existed. This leads to the main question addressed within this paper: What differences between ancient humans and modern humans may have allowed ancient humans to readily accept the third molar into their dentition, as compared to the issues faced by modern humans?

The main theory analyzed here will be the proposed idea that dental attrition in ancient humans would have provided room to allow the third molar to grow in relatively pain-free. Through the comparative analysis of a modern collection, and an ancient collection, the validity of this theory will be tested.

Context

Humans grow teeth at different rates, and the focus for this study is the third molar. Typically, a human will have, including 3rd molars, 16 permanent teeth in their maxilla, and 16 in their mandible. The teeth grow in the pattern displayed in Figure 2-1. It has also been asserted that, on average, jaw size of present-day humans does not differ far from that of ancient humans.

Figure 2-1: Human Dentition (Dr. Gold, Online)



The collections selected for this are based on availability and pertinence to this study. On average, humans of European descent have smaller faces than those of other decent. Because of this smaller size, the problems with the eruption of the third molar are much more prevalent in peoples of European descent. Towards this end, I elected to use two skull collections from the University of Pennsylvania's collections. The Morton collection provided me with a range of fairly modern (within the past 100 or so years) skulls to analyze from varying descent. From these skulls, I selected mainly those marked as having been adults of European-descent.

For the ancient population, I used the skulls available from Tepe-Hissar. Tepe-Hissar is a site that was continuously inhabited from the fifth to the second millennium BCE. (Gursan-Salzmann, Online). It is located in present-day North-Eastern Iran (see figure 2-2), and while not directly in Europe, it is used to represent an ancient European population. The University of Pennsylvania Museum has a wide selection of specimens from Tepe-Hissar, and thus I was able to form a good basis for analysis and comparison on these two collections. Within this subset, I selected for mainly age; preferring to use only the skulls from fully-matured humans.

In addition to these skulls, I took a few samples from collections whose names I am unaware of, or skulls from non-European areas. Some of these samples were taken as comparative samples: something more to look at in light of my data, while many were taken simply as further representations of modern humans. Here again, I selected based on age, preferring those skulls that had been adults with near-fully to fully erupted dentition.

Methodology and Process

For this study, I measured 50 samples from the bone storage room of the University Museum. A 'sample,' as defined here, is a specific skull, or skull and mandible combination. Of these 50 samples, 15 came from the Morton collection, and an additional 6 came from other modern collections, for a total of approximately 20 modern samples. The rest of the samples came from the Tepe-Hissar collection, giving a 30 sample representation of 'ancient' skulls.

The main point of study for this paper is the dental attrition, and the presence of the 3rd molar, thus a number of observations were made to compliment measurements taken with a dial caliper. The data collected fell into a pair of classifications: general comparison, and molar attrition. Under general comparison, I conducted measurements of the length and width of the maxilla and mandibles available. The length was defined as the inner distance between the third molars (or the back-most portion of the maxilla or mandible). The width was defined as the distance from the back of the front teeth to the midpoint of the third molar (to give a sense of the original depth of the mouth). These measurements give a general basis for comparison of specimens, and for testing the assertion of size stability over time.

The molar attrition measurements were much smaller, more specific ones. In particular, the spacing between the 2nd and 3rd molars of each specimen was measured, taking measurements for both the right and left of the mandible and maxilla. In this study, "Right" is considered the right side of the sample from the sample's view, and left is similarly defined. This was taken as the maximum distance between the two adjacent teeth, which usually occurred at the base of the tooth. In a few cases, where the third

molar is missing and it was impossible to estimate its previous location (if indeed it had been there to begin with), the distance between the 1st and 2nd molars was taken instead. Secondly, the diameter of each second and third molar present, as well as those which had left enough evidence to estimate their diameter, was measured.

The series of observational data recorded dealt with measuring apparent attrition based on cusp-wear, the presence of the third molars, and the apparent 'fit' of the mouth (how well the teeth fit together, or if there were any misalignments). The scale I used for attrition was a generalized Low to High scale, with Low meaning virtually no attrition, Medium meaning that the cusps show a bit of flattening but still retain their shape, and high meaning that the cusps are completely flattened. As a corollary to this observation, I also noted the 'depth' of the enamel in the notes on a number of specimens, as the differences in this characteristic became apparent after working with many skulls. Additionally, the simple observation as to whether or not the third molars were present and what condition they were in were recorded to ease in analysis. Finally, the tooth position was accounted for when it was remarkable, such as the misalignment of teeth, or crowding, etc.

Results

The results to this study are presented in table form in the appendix section, as Table A-1. This table represents the compilation of the recorded data, sorted by collection, with those from the unknown collection presented first, followed my the Morton collection samples, which are in turn followed by the Tepe-Hissar samples. The mandible and maxilla are denoted as lower and upper, respectively, and this classification is used to separate measurements. Skulls with both pieces were simply recorded and entered twice: once for the mandible, once for the maxilla. To compile and analyze the data, the averages of each feature (i.e. spacing or length) were taken across each collection (and the 'Other' and Morton collections were averaged together). The original compilation of averaged data is presented in the appendix as Table A-2. Furthermore, I have also presented the original difference between the feature values in Table A-3 of the appendix, allowing for further comparisons.

In addition to these tables, side-by-side comparison charts provide a good graphical representation for comparison: Figure A-1 of the appendix presents the original comparison between collections of the general characteristics (length and width), while Figure A-2 presents a side-by-side view of the width, spacing, and tooth diameter. Finally, Figure A-3 presents a graphical representation of the difference between the Tepe-Hissar site and the other sites: this is an analysis of the values obtained from Tepe-Hissar minus those obtained from the other collections.

Upon inspecting my data, I have also found a number of 'reference' skulls and skulls that may unjustly misbalance the data. These skulls are those taken from the Morton Collection and used in general cross-culture analysis, and one juvenile taken

from the Tepe-Hissar collection (evidenced by the presence of deciduous teeth). I have provided the corrected tables and graphs here as Table 4-1, The Corrected Averages, Table 4-2, The Corrected Differences, Figure 4-1, The General Values' graph, Figure 4-2, The Width-Spacing-Diameter Values' graph, and finally Figure 4-3, The Corrected Differences Graph.

Table 4-1: Corrected Averages

		M	O	MO	TH
	Averages	Morton	Other	M+O Average	Tepe-Hissar
Length	Upper	1.695357	1.7058	1.700578571	1.698391304
	Lower	1.7213	1.82065	1.770975	1.773375
Width	U	1.630964	1.58192	1.606442143	1.566978261
	L	1.39564	1.5708	1.48322	1.420575
Spacing	U Right	0.09782	0.0949	0.09636	0.095111111
	U Left	0.077589	0.09126	0.084424444	0.137111111
	LR	0.1006	0.1155	0.10805	0.098125
	LL	0.10407	0.1355	0.119785	0.142184211
Diameter	UR 2nd	0.319	0.294625	0.3068125	0.309021053
	UL 2nd	0.316429	0.30275	0.309589286	0.307075
	UR 3rd	0.26816	0.25866667	0.263413333	0.27431875
	UL 3rd	0.271133	0.26366667	0.2674	0.281184211
	LR 2nd	0.385	0.36	0.3725	0.3165
	LL 2nd	0.365	0.346125	0.3555625	0.340222222
	LR 3rd	0.372	0.372875	0.3724375	0.356735294
	LL 3rd	0.391	0.39225	0.391625	0.342058824

Table 4-2: Corrected Differences

	Differences	TH-M	TH-O	TH-MO
Length	Upper	0.003034	-0.00741	-0.00219
	Lower	0.052075	-0.04727	0.0024
Width	U	-0.06399	-0.01494	-0.03946
	L	0.024935	-0.15023	-0.06265
Spacing	U Right	-0.00271	0.000211	-0.00125
	U Left	0.059522	0.045851	0.052687
	LR	-0.00248	-0.01738	-0.00993
	LL	0.038114	0.006684	0.022399
Diameter	UR 2nd	-0.00998	0.014396	0.002209
	UL 2nd	-0.00935	0.004325	-0.00251
	UR 3rd	0.006159	0.015652	0.010905
	UL 3rd	0.010051	0.017518	0.013784
	LR 2nd	-0.0685	-0.0435	-0.056
	LL 2nd	-0.02478	-0.0059	-0.01534
	LR 3rd	-0.01526	-0.01614	-0.0157
	LL 3rd	-0.04894	-0.05019	-0.04957

Figure 4-1: General Values

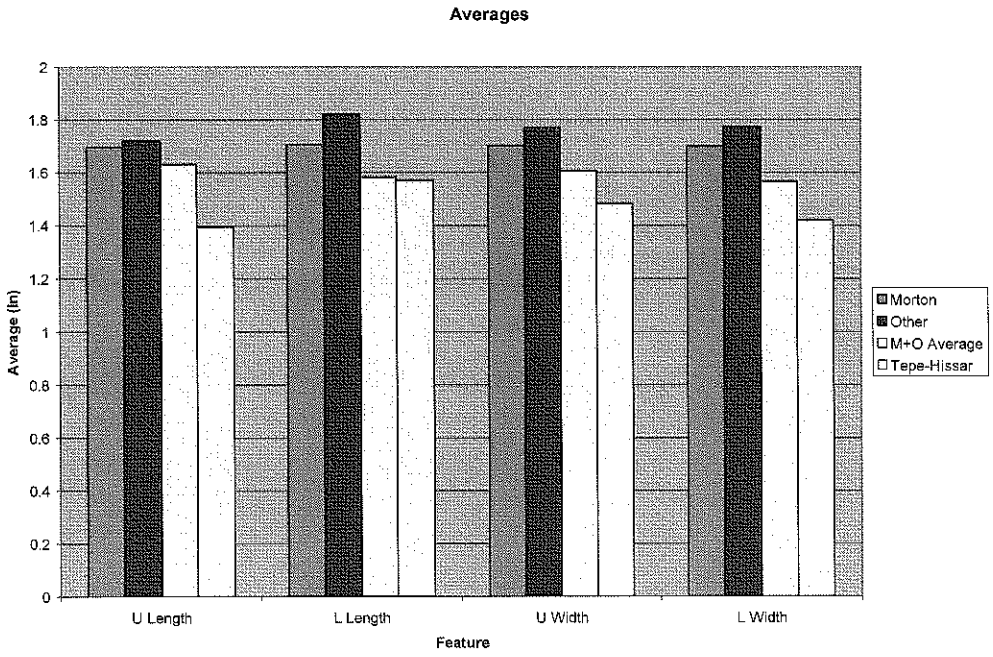


Figure 4-2: Width-Spacing-Diameter Values

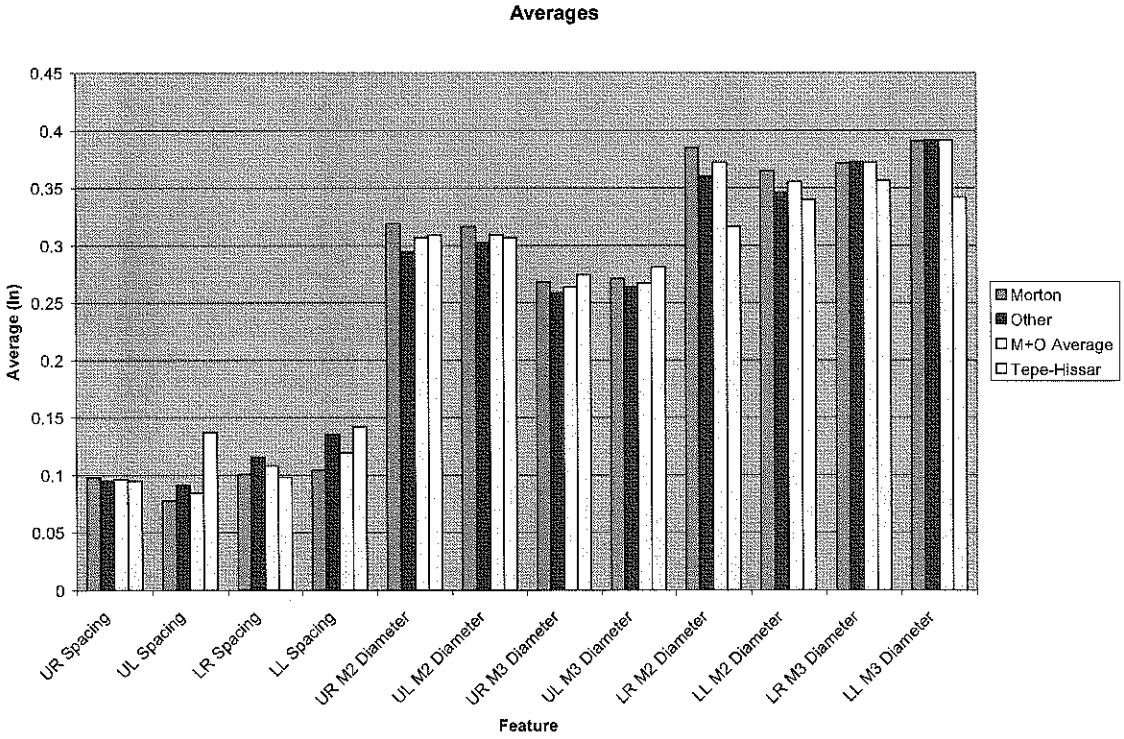
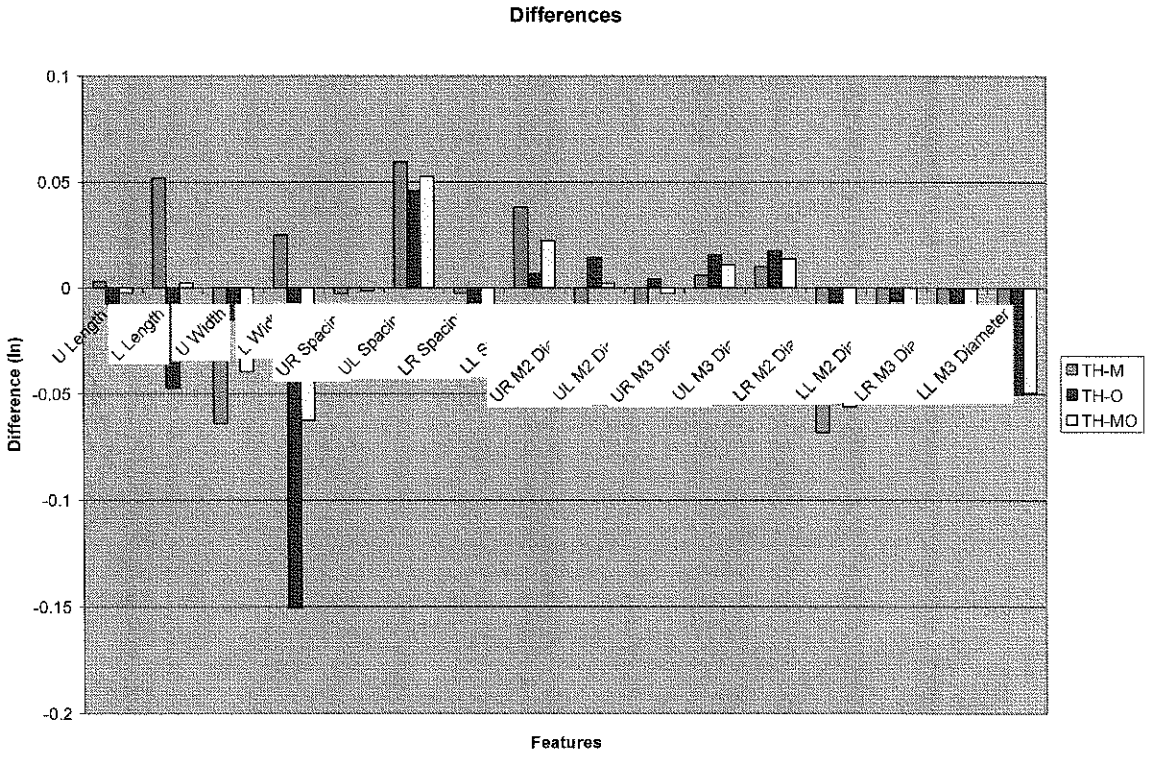


Figure 4-3: Differences



The Differences in Figure 4-3 may possibly show changes over time. In this case, a negative value represents an increase in size over Tepe-Hissar. While, a positive value means that the Tepe-Hissar values are larger than those of the more modern samples.

In addition to these results, it was found that 4 of the 6 'Other' skulls showed signs of having erupted 3rd molars, with 3 of them exhibiting some form of complications (mainly tooth skewing). 14 of 15 Morton skulls showed signs of having erupted 3rd molars, with 8 of them exhibiting some form of complications (mainly tooth skewing and crowding again, with one example of actual non-development of 3 3rd molars), and 2 additional skulls exhibiting reduced size of the 3rd molar. Finally, 28 of 30 Tepe-Hissar skulls showed evidence of 3rd molars; with 9 of them exhibiting some form of

complications (mainly intradontal carries pathologies, with only 3 examples of skewing/spacing issues).

Analysis

Maxilla and Mandible Sizes

To begin with, an inspection of Figure 4-1 shows that, at least for the samples studied, the Tepe-Hissar samples are consistently smaller than the other samples. Rather than size reduction over time, the modern samples appear to be larger than the ancient samples in every aspect (length and width of the maxilla and mandible). This is important to note, as it seems almost contrary to what would be expected if it were reduction in size that were causing the increased 3rd molar issues.

This issue may be explained through a number of factors. First, there could indeed be an increase in jaw size over time: this would certainly explain the values. Despite this seemingly straightforward explanation, however, there are a number of other possibilities. Perhaps the most dominant of these is that the skulls are simply from different locals. While close to European civilizations, Tepe-Hissar is considered near-east. The conditions there may have long effected human development, as compared to locales further North in Europe, and thus caused a reduction in size of the mandible and maxilla that was never paralleled elsewhere. Additionally, the skulls I selected from the Morton Collection, while mostly European, had great variability in terms of time and locale of origin. This second explanation seems to be the most feasible one.

Third Molar Eruption and Complications

Perhaps one of the most significant results, in terms of validating my research, were those presented at the end of the Results section: the results regarding the presence of the third molar, and complications within all of the sub-populations of the study. From the "Other" Category, 66.66% showed evidence of third molar eruption and of those 75% showed complications, mainly represented by tooth-skewing.

Furthermore, while 93.33% of the Morton samples examined showed signs of third molar eruption, 57.14% of those showing the third molars showed some a problem within their dentition. Again, this was mainly a problem with spacing and alignment, but a few intradontal cavities were observed, as well as the interesting sight of a skull that had only erupted a single third molar, and showed no sign of the other molars (erupted or not erupted). This one, in particular, may be a sign of a further 'evolutionary step' away from the development of the third molar.

Finally, 93.33% of the Tepe-Hissar samples showed evidence for having third molars. Of these, only 32.14% showed any signs of issues that could be linked to the third molar. Many of these issues were simply intradontal cavities which, while linked to the third molar (mainly because many of them occurred on the third molar), may not be caused by the appearance of said tooth. It is very likely that dental care at Tepe-Hissar was not at a very high standard, if there was actually any at all. Also, given the time-periods of occupation, and that it was an urban center the main meals of the inhabitants of Tepe-Hissar would likely have

consisted of a few meats, sticky breads/grains, and likely more than a few rock-particles from the tools used to grind the food. It is well known that, as humans moved to sedentary life-styles, the number of cavities apparent in any one sight increased (this is suspected to be caused by the change in diet: to more sticky breads, etc.). Therefore, it is likely that these cavities were not a result of the third molar erupting, but rather one of poor diet and lack of dental care.

What these results imply is that, while the number of occurrences of the third molar may have decreased slightly over time, it seems apparent that the rate of complications regarding this has increased a fairly large deal over the time. While there are arguments against this conclusion, this somewhat validates the statement made that in modern times, there are more issues with the third molar than there were in ancient times.

Dental Attrition and Spacing

One interesting point to note in this section is that, in general, the attrition level of the mandible seemed to be at least a few steps higher than that of the maxilla for any particular sample. This is likely an effect of gravity: the remaining foodstuffs and any other particles (as in rock dust), would naturally gravitate to the bottom of a person's mouth, and thus could cause a myriad of problems, such as many more cavities. This observation is simply a point that may warrant further investigation, though, as it has only a little bearing on the questions presently under investigation.

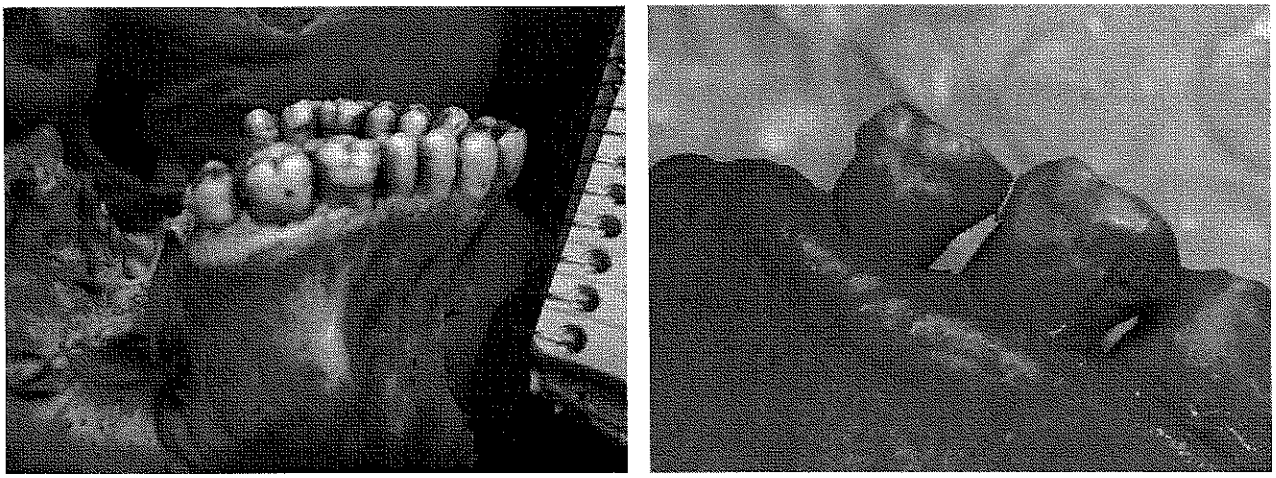
For this comparison, one of the most important data to analyze is the information about spacing of the molars. As dental attrition increases, the size of the teeth should decrease. It follows from this that the spacing between teeth should increase as well. Looking at Figure 4-2 shows a number of interesting factors: The spacing on the right side of the samples seems to be almost the same on average between each collection, varying by less than 0.003" in either direction from the Tepe-Hissar values for the maxilla values, and about 0.01" at max for the mandible values. This small variation can likely be accounted by sample variability and taxonomy (post-depositional deterioration of the samples).

When one looks at the left spacing values, however, the comparison is much different. For the maxilla, the Tepe-Hissar values are nearly 0.05" above the other values. Similarly, the mandible values are almost 0.03" above the Morton samples, and 0.22" larger than the Morton and Other samples combined. While it is possible that these values are caused by sample variability, it seems unlikely that there would be enough outliers to skew my collected data so far.

It is interesting that this great of a difference is only apparent in the left side of the samples, and while this may have cultural significance, again the theme of this report is dental attrition and the third molar. This large of a difference does seem to suggest an increase in intradontal room in the Tepe-Hissar samples. Corroborating with this observation are a number of observations of the enamel of the teeth. In general, the enamel of the Tepe-Hissar teeth does not extend as low as that of the Morton samples. In fact, many of the Morton samples had nearly full enamel, while most of the Tepe-Hissar had

only the top halves of their teeth still covered in enamel. This loss of enamel again can be caused by site taphonomy, and various post-mortem stresses on the remains, but, given the regularity of its occurrence (nearly every Tepe-Hissar sample showed a loss of enamel), and its magnitude (at least 1/3, to 3/4 of the enamel missing in some cases), I would say that it is likely that much of this enamel was worn away while the person was still alive, likely through the process of dental attrition. Figure 5-1 displays a picture of a 'reduced enamel' tooth besides a non-reduced tooth. How on the left, each tooth has almost the same thickness down to its base, as well as the same coloration. In the right picture, notice the variable thickness and the color gradation; this is a sign on teeth for eroded enamel.

Figure 5-1: Enamel Comparison Picture



Dental Size

One final question remains in this analysis: How does one explain the increase in dental problems associated with the third molar in modern-day populations when the modern population seems to have seen an increase in maxilla and mandible size? I believe that this question may be answered, or at least partially explained by once more returning to Figure 4-2 and inspecting the recorded molar sizes. It appears that, in most cases, the samples from more recent times have also shown an increase in molar size.

Inspecting the graph shows that the maxillary second molars are a little larger than the Tepe-Hissar second molars (about 0.009" at most). Looking further will show that the Tepe-Hissar samples' Maxilla's third molars are actually a bit larger than those of the other sections (by about 0.01" at most). Beyond these small differences, however, are the differences in the Mandible's second and third molars. In these two areas, the values obtained from the Tepe-Hissar specimens are much smaller than from those of the 'present-day' samples. This difference is at its max at the right second molar and the left third molars, at about 0.0685," and 0.05," respectively.

Once again, the difference in the data is so great that it is likely an effect that is seen throughout the whole population, rather than simply a proliferation of outliers, and thus this observation is likely to be significant. If jaw sizes have indeed increased over time, then it appears that tooth-size has, in general, also increased over time. Since the change in tooth-size does not necessarily match pace exactly with the change in jaw size, it may cause one of three things to

occur: First, if the rates do match each other, no net change will occur. However, the combined change may allow for more room in the jaw, should the jaw be growing faster than the teeth. Conversely, if the teeth have grown slightly faster than the jaw, this would explain some of the overcrowding and third molar-related complications, as the space in the mouth would thus be limited.

Conclusions

From the data analyzed in this study, there is a good case in favor of dental attrition assisting in allowing for the complication-free eruption of the third molar. Both the increasing size of teeth in the modern human samples, and the comparatively large between-teeth spacing in the ancient human samples seem to implicate at the very least that there was indeed more attrition occurring in ancient times. Beyond this, the comparative analysis showed that the complications related to third molars show up far less frequently in the ancient samples than they do in the modern samples.

There are a few major issues, though, that face my assertion. One major issue is that this relationship, the linking of these two events, does not necessarily prove a cause-effect relationship. There may be other factors that cause the problems I have deemed as associated with third molar complications, and thus may have confounded a number of my measurements and conclusions. In addition to this, I faced the issue of limited sample availability: while I had wanted to focus mainly on people of European descent, I had to limit myself to the materials at hand: The best collection representing an ancient population presently available to me was the Tepe-Hissar Collection.

In order to further solidify my claims, I would have to conduct further research on a much larger population size. To eliminate a number of uncertainties, working closely with a dentist, or someone better trained in the analysis of teeth would be very helpful as well. Working with such a person would help in determining oddities in the samples, and in more accurately taking observational notes (i.e. being able to properly tell when a tooth is impacted). Additionally, working with a much larger sample size would likely help a great deal: it would allow me to see if the averages I had obtained were correct, or deviations. Simply put, having a larger sample size allows a researcher to grow closer to the true value, as large sample sizes tend to normalize distributions. In association with the need of a larger population size, having an ancient population and a modern population from the same geography would eliminate much of the uncertainty in variations in development that were mentioned in the analysis section.

In conclusion, the third molar is a tooth that originally, before dental care, had the purpose of providing an extra tooth later in life, after the original permanent teeth have somewhat decayed. From this reasoning, it appears that there is validity in the theory that dental attrition is the major factor that allowed ancient, anatomically modern humans to be able to handle the eruption of the third molar with little pain or side effects presently associated with this event. The data, as I have presented it, supports this theory, and the next steps towards fully affirming it is simply to continue this research.

Appendix

Table A-1: Data Compilation

Specimen	Collection	#	Upper/Lower	3rd Present?	Attrition	Length	Width	Spacing Right	Spacing Left	Tooth Diameter Right 2nd	Left 2nd	Right 3rd	Left 3rd	Notes
1	??	15604	U	Yes	Medium-High	1.943	1.5341	0.0899	0.066	0.271	0.2955	0.2555	0.288	3rds in line; Cusps Flat
	??	15604	L	Yes	High	1.759	1.4875	0.108	0.087	0.3455	0.326	0.393	0.384	misaligned on left
2	??	15699	U	No (missing)	Medium-High (caries)	1.75	1.5	0.0931	0.1053					
	??	15699	L		High	2.09375	1.625	0.1	UN					
3	??	2143	U	Yes	High-Medium	1.5745	1.6575	0.104	0.0765	0.2665	0.3005	0.295	0.305	good teeth; thin at bottom, slightly askew
	??	2143	L	Yes	High	1.6615	1.5935	0.0805	0.1455	0.332	0.343	0.3715	0.35	Teeth slightly askew, enamel of 3rds almost to gums, cuts a 3/4 on other teeth
4	??	15985	L	Yes	Medium-High	1.802	1.631	0.1915	0.179	0.372	0.337	0.331	0.374	"Bolivia" Angled at left. Teeth Wide at top, Narrow at bottom
5	??	1961	U	Yes (Left, right hole)	Medium-Low	1.602	1.7385	0.0935	0.079	0.308	0.301	0.2255	0.196	Large teeth, broken enamel
	??	1961	L	Yes (Right, broken Left)	Medium	1.787	1.617	0.0965	0.1305	0.3905	0.3785	0.396	0.451	Impacted 3rds? Large Jaw
6	UNK	15893	U	No (not erupted)	Medium	1.6595	1.4495	0.094	0.1095	0.313	0.314	UN	UN	Full Enamel; Impacted/unerupted 3rds
7	Morton	1549	U	Yes	Medium-High	1.932	1.714	0.11	0.0665	0.3248	0.333	0.266	0.258	"Swede; Sudermanland" Right: bad cavity/attrition in 2nd/3rd inter dent.
8	Morton	909	U	Yes (Right)	Medium-low (cusps pointed)	1.8255	1.6062	0.0981	0.0906					evidence for left (possible)
	Morton	909	L	Yes	Medium-High	1.75	1.6875	0.1289	0.1181					
9	Morton	1687	U	Yes	High	1.731	1.5435	0.095	0.0745	NA	0.312	0.358	0.296667	"Greenland" Straight Teeth
10	Morton	1326	U	Yes	V. High	1.736	1.456	0.118	0.0845	0.277	0.275	0.246	0.254	"Peruvian from ancient cemetery at Pisco" Spacing is wide until cusps; Slight Spacing Issue on right; also missing R. Premolar 1 space
11	Morton	1716	U	Yes (holes)	Unknown (no teeth)	1.65	1.5765	UN	0.077					"San Marco, Peru" High Angle on Lower Right 3rd
	Morton	1716	L	Yes (Right)	High	1.9255	1.362	0.1115	0.1365					Large chip/cavity in 3rd molar and side of 2nd
12	Morton	905	U	Yes (left, R. Evidence)	High (Gum Disease?)	1.7044	1.603	0.08	0.075		0.254		0.275	"Egyptian Form" 3rd Molar "crooked"
13	Morton	1544	U	Yes (Right evidence)	Medium	1.631	1.508	0.1245	UN					
	Morton	1544	L	Yes	Medium-High	1.6156	1.37	0.093	0.13125					Left 3rd in at an angle
14	Morton	1108	U	Yes	Medium-Light	1.561	1.5365	0.0875	0.0665	0.313	0.3465	0.1775	0.242	"Anglo American" Reduced size of 3rds
	Morton	1108			Top			0.089	0.0905					High Crowding (tight Teeth); Cramped
	Morton	1108	L	Yes	Medium-Light	1.756	1.5555	0.069	0.0465	0.385	0.365	0.372	0.391	Reduced size of 3rds
	Morton	1108			Top			0.0325	0.0475					
15	Morton	1002	U	Yes (R; L is impacted)	Medium-High	1.676	1.5595	0.1335	UN	0.3345	0.3505	0.293	NA	"Ancient Mexican" Impacted Left 3rd Molar
16	Morton	1198	U	Yes (evidence)	No Teeth	1.6725	1.616	UN	UN					No Teeth
17	Morton	990	U	Yes (missing)	NA	1.58	1.629	UN	UN	0.348	0.344			"Maya of Yucatan"
	Morton	990	L	Yes	Mid-High	1.7655	1.6395	0.1305	0.125	0.3695	0.3755	0.444	0.391	Even teeth
18	Morton	88	U	Yes	High	1.598	1.5695	0.0495	0.08					"Anglo American" High Cavity on R 2 and 3; Cavity on L. 3rd; Missing spot for canine or premolar
19	Morton	1973	U	Yes	Medium (high on 3rds)	1.6442	2.099	0.0641	0.0635					
20	Morton	1157	U	No	Medium	1.7634	1.2168	NA	NA					"German"
21	Morton	1157	L	Yes (left only)	Medium-High (flat cusps)	1.5495	1.0032	0.1109*	0.088					
22	Tepe-Hissar	33-16-195	L	Yes	Light	1.9965	1.3305	0.13	0.146					3rds: sign of left
23	Tepe-Hissar	33-16-77	U	Yes (erupting)	Light	1.4404	1.2305	NA	NA	0.2859	0.2665			Young Specimen, deciduous teeth present; Erupting permanent teeth.
24	Tepe-Hissar	33-23-224	U	Yes	Medium	1.819	1.56	0.0705	0.0755	UN	0.274	0.272	0.2705	good spacing, large left 1st-2nd space
	Tepe-Hissar	33-23-224	L	Yes	High-Medium	1.9465	1.403	0.0785	0.0805	0.3155	0.317	0.3705	0.359	
25	Tepe-Hissar	33-16-144	U	Yes (left)	High-Medium	1.6405	1.5965	NA	0.0715	NA	0.282	NA	0.2995	
	Tepe-Hissar	33-16-144	L	Yes (evidence for left)	High	1.945	1.4085	0.0665	NA	0.331	NA	0.3275	NA	
	Tepe-Hissar	33-16-71						1st-2nd				1st		
26	Tepe-Hissar	33-16-71	U	No	High	1.6515	1.31	0.129	0.14	0.3855	0.4585	NA	NA	Unusually Large Molars
27	Tepe-Hissar	35-32-68	U	Yes (evidence)	High-Medium	1.7305	1.324	0.0925	NA	0.295	NA	0.3235	0.328	
28	Tepe-Hissar	33-23-79	U	Yes (Right, no Left space)	Mid-High	1.556	1.5775	0.095	NA	0.2825	0.288	0.2501	0.223	Large Attrition at Base
29	Tepe-Hissar	33-23-214	U	Yes	V. High	1.8295	1.604	0.122	0.1725	0.2775	0.2565	0.253	0.2515	3rd molars in good (good spacing)
	Tepe-Hissar	33-23-214	L (fragment)	Yes (evidence)	High	UN	UN	0.1115	UN	0.0325	UN	0.3315	UN	Fragment of Right, hole for 3rd molar
30	Tepe-Hissar	33-23-85	U	Yes	High	1.664	1.7300	0.0815	0.0735	0.339	0.3215	0.237	0.283	Left 3rd: Interdental, Cavity
	Tepe-Hissar	33-23-85	L (fragment)	Yes	High	UN	UN	UN	0.0665	UN	0.366	UN	0.3275	Fragment of lower, Left portion. 3rd in Well
31	Tepe-Hissar	33-16-162	U	UNK	High	1.7678	1.568	UN	UN					Missing much of dentition, Estimated values
	Tepe-Hissar	33-16-162	L	Yes	High	1.7415	1.3888	0.07	0.0745	0.1816	0.189	UN	0.197	Missing Teeth and holes
32	Tepe-Hissar	33-23-126	U	Yes	High-Medium	1.8	1.6945	0.104	0.0845	0.313	0.3205	0.3205	0.352	Large 3rd molars; Large Inter-dent cavity between right 2nd and 3rd
	Tepe-Hissar	33-23-126	L	Yes	High	1.753	1.536	0.093	0.116	0.413	0.4135	0.381	0.4185	Enamel: 1/2-3/4
33	Tepe-Hissar	33-23-176	U	Yes	Medium-Low	1.603	1.5605	0.11	0.9	0.292	0.2865	0.296	0.253	Young Enamel: 1/4-1/3
	Tepe-Hissar	33-23-176	L	Yes	Medium	1.6355	1.4685	0.0925	0.0905	0.321	0.3045	0.3565	0.2975	
34	Tepe-Hissar	33-23-212	U	Yes	Low	1.7506	1.7275	0.0825	0.101	0.3105	0.3185	0.289	0.2635	Left 3rd: tissues (pics)
35	Tepe-Hissar	33-23-107	U	Yes (evidence)	High	1.5705	1.568	UN	0.1005	0.2833	0.303	0.278	0.2485	
	Tepe-Hissar	33-23-107	L	Yes	High-Medium	1.611	1.5295	0.07	0.097	0.3255	0.3526	0.3515	0.3965	large amount of room
36	Tepe-Hissar	33-23-170	U	Yes (evidence)	Medium-Low	1.8965	1.707	0.112	0.143	0.303	0.31	NA	NA	
	Tepe-Hissar	33-23-170	L	No	High-Medium	1.6925	1.0595	UN	0.99	NA	0.3555	NA	NA	holes: see pictures
37	Tepe-Hissar	33-23-43	L	Yes	High	1.867	1.4825	0.266	0.1165	0.2635	0.383	0.371	0.357	Little enamel 3rd above 2nd
38	Tepe-Hissar	33-16-32	U	Yes	High	1.5165	1.561	0.1285	UN	0.303	NA	0.3095	0.289	Missing Parts Interdental, Cavity, Left 2nd and 3rd
	Tepe-Hissar	33-16-32	L	Yes	High	1.598	1.4995	0.1015	0.074	0.3475	0.364	0.3535	0.3805	Black Teeth, Lower Complications
39	Tepe-Hissar	33-23-16	U	Yes	High	1.872	1.6125	0.058	0.0675	0.3085	0.3065	0.2695	0.314	
	Tepe-Hissar	33-23-16	L	Yes	High-Medium	1.643	1.622	0.063	0.0435	0.3575	0.3525	0.43	0.422	Straight Teeth.
40	Tepe-Hissar	33-16-203	L	Yes	High (Pathology)	1.7885	1.1035	0.1125	UN	0.3535	NA	0.2695	NA	One surviving tooth on upper
41	Tepe-Hissar	33-16-114	L	Yes	Medium-High	1.558	1.3545	0.066	0.0535	0.3185	0.3345	0.3055	0.2575	
	Tepe-Hissar	33-16-114	U	Yes	Low-Medium	1.651	1.3655	0.092	0.0595	0.402	0.358	UN	0.3545	Uneven. No Right 3rd
42	Tepe-Hissar	33-23-76	L	Yes (Right; Left Hole)	High-Medium	1.93	1.338	0.101	0.13	0.2995	0.2955	0.335	0.3325	Good Teeth
43	Tepe-Hissar	33-23-110	U	Yes	High	1.6355	1.734	0.073	0.0765	0.302	0.287	0.2605	0.271	Enamel: 1/2 only
	Tepe-Hissar	33-23-110	L	Yes	High	1.7505	1.572	0.068	0.068	0.359	0.378	0.392	0.3875	Enamel: 1/2 (chipped too)
44	Tepe-Hissar	33-23-243	U	Yes (Left, right hole)	Medium-High	1.9135	1.514	0.0815	0.0585	0.294	0.255	0.18	0.225	Small 3rds, low enamel
	Tepe-Hissar	33-23-243	L	Yes (Right; Left Hole)	High	1.6825	1.4420	0.0505	0.0775	0.3185	0.3225	0.3015	0.2525	Small 3rds, low enamel
45	Tepe-Hissar	33-16-205	U	Yes	Medium-High	1.8895	1.5565	0.1105	0.0755	0.2955	0.25	0.2485	0.2585	Enamel: 3/4
	Tepe-Hissar	33-16-205	L	Yes (Left, right hole)	High-Medium	1.704	1.457	0.093	0.1625	0.329	0.34	UN	0.379	Enamel: 3/4
46	Tepe-Hissar	33-23-24	U	Yes (Holes)	Medium (With Cavities)	1.4545	1.738	0.0695	0.08	0.2895	0.333	0.294	0.2595	Front Teeth and Right Canine, forward
	Tepe-Hissar	33-23-24	L	Yes	Medium (With Cavities)	1.5445	1.5575	0.0985	0.051	0.3565	0.3595	0.443	0.4485	Full 3rds
47	Tepe-Hissar	33-23-171	U	Yes	V. High	1.7065	1.5905	0.106	0.1055	0.3065	0.3385	0.272	0.3125	Straight/Aligned
48	Tepe-Hissar	33-23-141	L	Yes (Right; Left Hole)	High	2.075	1.443	0.0795	0.1245	0.377	0.3825	0.346	0.2715	"Budge" on inner right. Enamel: only 1/4 down
49	Tepe-Hissar	33-23-179	U	Yes (Right; Left Hole)	High	1.6878	1.6325	UN	0.095	NA	0.295	UN	0.267	Odd-angled teeth
50	Tepe-Hissar	33-23-213	L	Yes	High	1.707	1.509	0.132	0.1255	0.3135	0.323	0.363	0.3365	Seems wild U-shaped

Table A-2: Original Averages

		M	O	MO	TH
	Averages	Morton	Other	M+O Average	Tepe-Hissar
Length	U	1.695357143	1.7058	1.700578571	1.698391304
	L	1.728666667	1.82065	1.774658333	1.773375
Width	U	1.630964286	1.58192	1.606442143	1.566978261
	L	1.469616667	1.5708	1.520208333	1.420575
Spacing	UR	0.09782	0.0949	0.09636	0.095111111
	UL	0.077588889	0.09126	0.084424444	0.137111111
	LR	0.10658	0.1155	0.11104	0.098125
	LL	0.107558333	0.1355	0.121529167	0.142184211
Diameter	UR2	0.319	0.294625	0.3068125	0.309021053
	UL2	0.316428571	0.30275	0.309589286	0.307075
	UR3	0.26816	0.258666667	0.263413333	0.27431875
	UL3	0.271133333	0.263666667	0.2674	0.281184211
	LR2	0.37725	0.36	0.368625	0.3165
	LL2	0.37025	0.346125	0.3581875	0.340222222
	LR3	0.408	0.372875	0.3904375	0.356735294
	LL3	0.391	0.39225	0.391625	0.342058824

Table A-3: Original Differences

Differences	TH-M	TH-O	TH-MO
	0.003034	-0.00741	-0.00219
	0.044708	-0.04727	-0.00128
	-0.06399	-0.01494	-0.03946
	-0.04904	-0.15023	-0.09963
	-0.00271	0.000211	-0.00125
	0.059522	0.045851	0.052687
	-0.00846	-0.01738	-0.01292
	0.034626	0.006684	0.020655
	-0.00998	0.014396	0.002209
	-0.00935	0.004325	-0.00251
	0.006159	0.015652	0.010905
	0.010051	0.017518	0.013784
	-0.06075	-0.0435	-0.05213
	-0.03003	-0.0059	-0.01797
	-0.05126	-0.01614	-0.0337
	-0.04894	-0.05019	-0.04957

Figure A-1: Original General Values

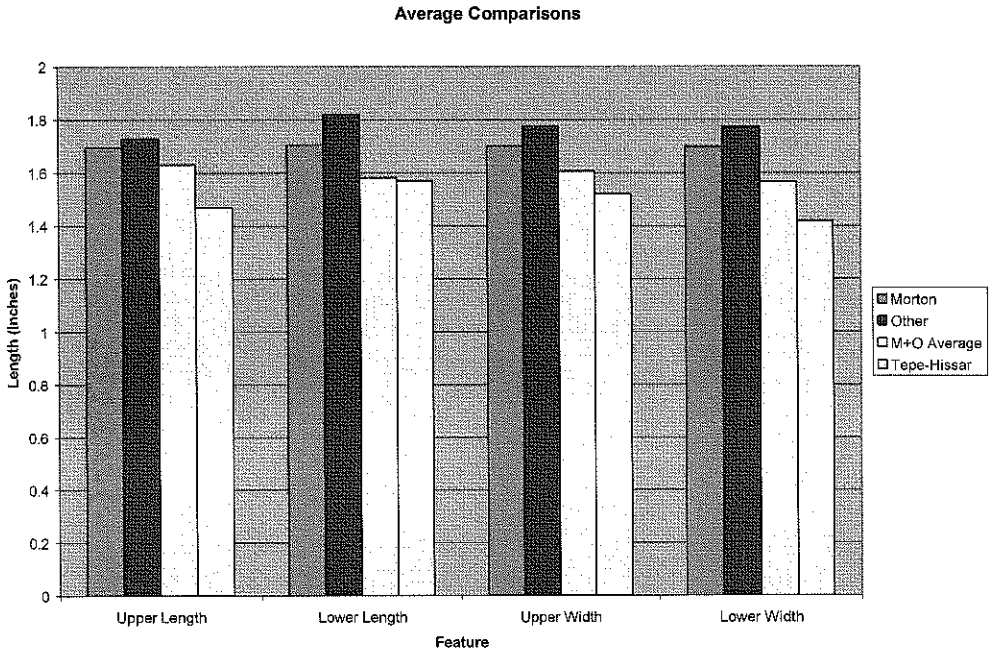


Figure A-2: Original Width-Spacing-Diameter Values

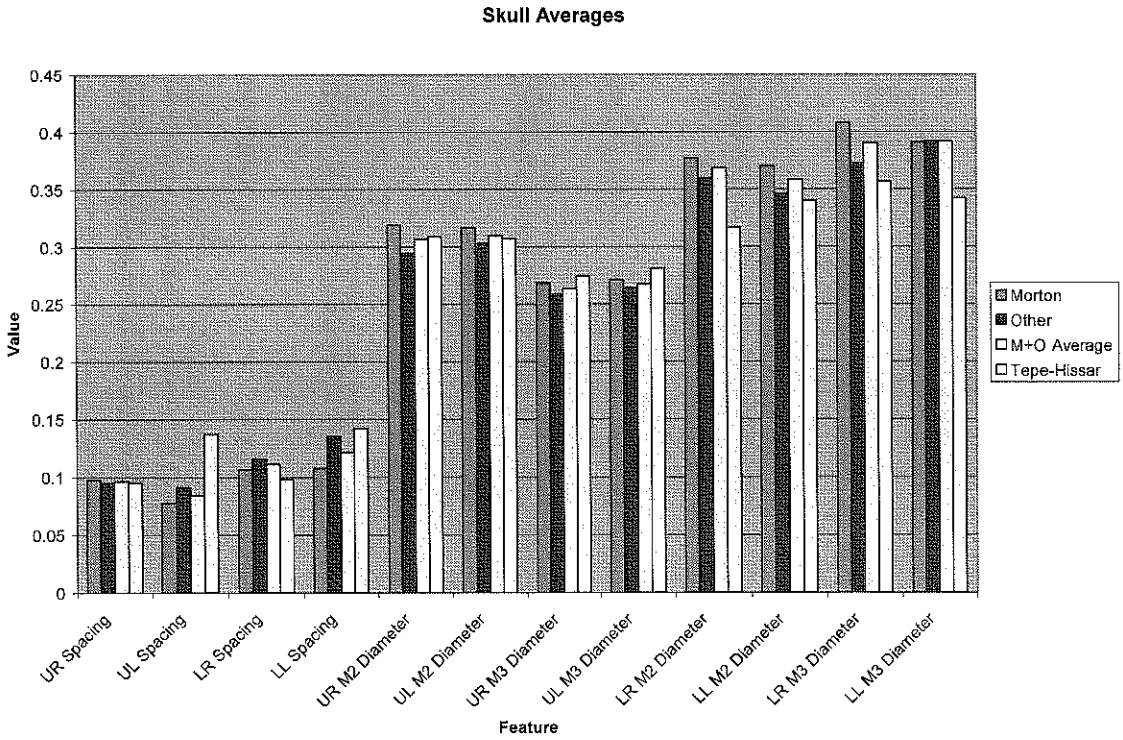
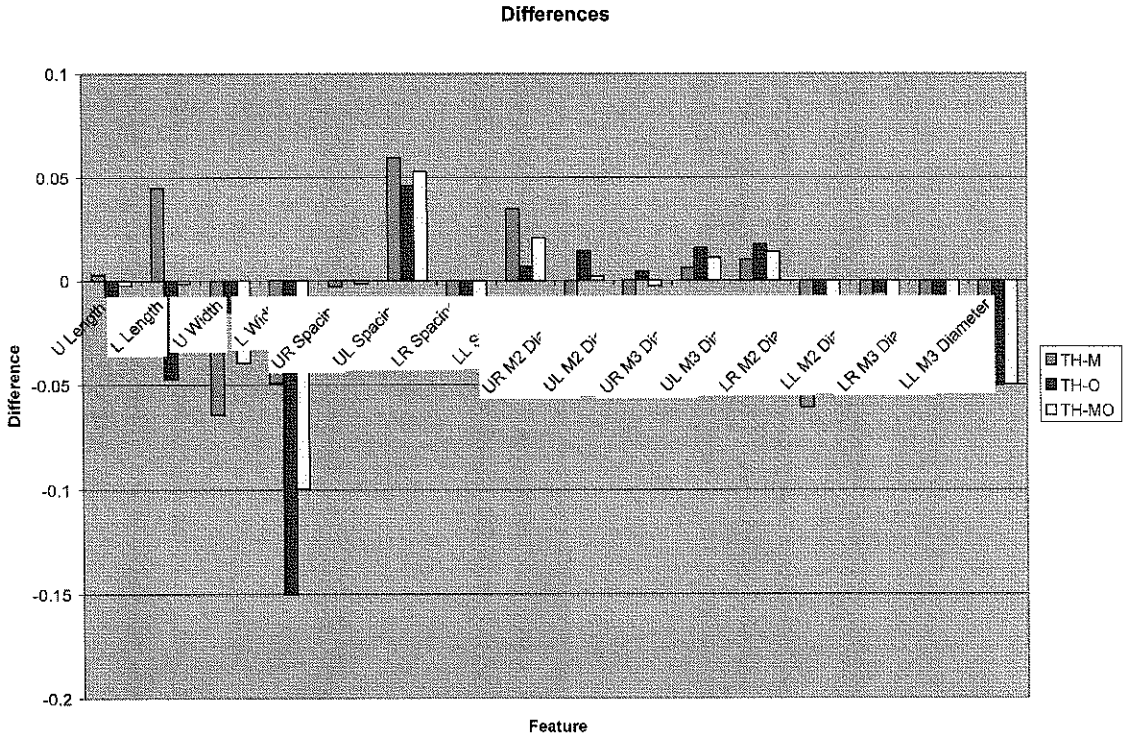


Figure A-3: Original Differences



Bibliography

Byers, Steven N. Introduction to Forensic Anthropology. 2nd ed. New York: Pearson, 2005.

Gold, Dr. Ronen. "Oral Surgery - Westfield NJ - Referring Doctors." Referring Doctors. 2007. Oral & Maxillofacial Surgery of Westfield, NJ. 4 May 2007 <http://www.ronengold.com/referring-doctors.html>.

Edwards, Michelle J., Mark R. Brickley, Rebecca D. Goodey, and Jonathan P. Shepherd. "The Cost, Effectiveness and Cost Effectiveness of Removal and Retention of Asymptomatic, Disease Free Third Molars." British Dental Journal 167 (1999): 380-384. 20 Mar. 2007.

Guerrisoli, Danilo M., Rusiel A. Souza, Manoel D. Sousa Neto, Ricardo G. Silva, and Jesus D. Pecora. "External and Internal Anatomy of Third Molars." Brazilian Dental Journal 9 (1998): 91-94. 18 Mar. 2007 <http://www.forp.usp.br/bdj/Bdj9(2)/t0492/t0492.html>.

Hicks, E P. "Third Molar Management: a Case Against Routine Removal in Adolescent and Young Adult Orthodontic Patients." Journal of Oral Maxillofacial Surgery 57 (1999): 831-836.

The Shelby White-Leon Levy Program for Archaeological Publications. 9 June 2006. Harvard University. 4 May 2007 <http://www.fas.harvard.edu/~semitic/wl/digsites/Iran/TepeHissar_02/index.htm>.

Silvestri, Anthony R., and Iqbal Singh. "The Unresolved Problem of the Third Molar." The Journal of the American Dental Association 134 (2003): 450-455.

Teaford, Mark F., Moya M. Smith, and Mark Ferguson, eds. Development, Function and Evolution of Teeth. Cambridge: Cambridge UP, 2000.