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The Correlation of Dental Arch Width and Ethnicity

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Technical Note

The Correlation of Dental Arch Width and Ethnicity

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Abstract: This study sought to demonstrate a correlation between arch width, ethnic background, individual height, weight, and whether orthodontic treatment had been rendered. Conclusions revealed that arch widths were significantly larger ($p = 0.002$ for the mandible and $p = 0.008$ for the maxilla) in non-Whites than in Whites. In addition, arch widths of the mandible were significantly larger in individuals who had had orthodontic treatment compared to those who had not ($p=0.005$). This did not carry through to those arch widths in the maxilla of orthodontic versus nonorthodontic care ($p=0.258$).

Introduction

Often, patterned injuries in criminal cases can be either exculpatory or incriminating [1, 2]. Patterned injuries left by the dentition of an assailant in the victims of violent crimes have been shown to demonstrate such evidence [3]. The testimonies of forensic odontologists have been challenged by defense attorneys as only being opinions, with no research to support them. These challenges stemmed from several Supreme Court rulings, most notably the Daubert decision. However, McFarland completed a basic study using subjective observations without statistical analysis [4]. Rawson completed a study of all the possible positions each anterior tooth could occupy [5]. An additional study characterized arch width analysis [2]. Recent studies have quantified the individual characteristics of the six anterior teeth in the human dentition [6, 7]. In a recent study, exemplars were gathered from males between the ages of 18 and 44 years [6].

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In that analysis, arch width was defined as the distance from the center point of one cuspid imprint to the center point of the opposite cuspid. The line connecting these points was measured using both an automated process of the placement of a marker and the measuring tool found in Adobe Photoshop CS2.

A database on the frequency distribution of commonly observed characteristics in the human dentition has begun to emerge. It may be possible over several years to eventually expand the individual dental characteristics study, as previously reported [6], and to replicate a database similar in size to that of mtDNA. This study is an effort to link a specific arch width to an ethnic group. This project provides the forensic odontologist and the criminal justice system with a valuable tool to either include or exclude a suspect on the basis of a pattern of an injury associated with a crime. It also provides for developing a specific profile to an as yet unidentified suspect. This would allow investigators to first focus valuable resources by profiling the most likely of a victim's associates when DNA is not recovered from the scene.

Materials and Methods

Five hundred exemplars were gathered from males between the ages of 18 and 44 from patients seeking care at Marquette University's School of Dentistry, two military reserve units, and participants of the Wisconsin Dental Association's May 2006 conference. Seventy-nine exemplars were discarded because they were distorted. Another seven were discarded because no ethnic origin was indicated on the survey form. Of the remaining samples, 360 were listed as White or Caucasian, 18 were Black or African American, 20 were Hispanic, 8 were Asian, and 8 were other non-White. For the purposes of statistical analysis, the non-Whites were grouped and compared to Whites because there were not enough examples to consider each ethnic group separately. The ethnic background of the individuals included in the research mimicked the U.S. census bureau statistics for the State of Wisconsin (Table 1). Each participant filled out an informed consent and a brief anonymous medical history, which included questions regarding age, gender, height, weight, ethnic origin, history of facial trauma, and whether orthodontic treatment had been rendered. Exemplars were identified by alphanumeric designation and were not associated with a specific individual's identification.

Ethnicity	Study Total	Percentage	Wisconsin Census Data
White	360	86.9	88.9
Black	18	4.3	5.7
Hispanic	20	4.8	3.6
Asian	8	1.9	1.7
Other non-White	8	1.9	2.5

Table 1

Current study compared with census data.

Arch widths were measured from the midpoint of the left and right cuspid imprint equidistant from the mesial and distal registration of the outline of the tooth margins. A one-pixel marker from a palette of ten, dubbed Tom's Toolbox[1], was placed at this center point. Measurements were carried out using the measure tool in Adobe Photoshop CS2 and an automated program. This automated program utilizes the palette of ten pixels, each having a different green color intensity value from 1 to 250. They were inserted at an enlargement of 300 percent. A comparison of the manual measurements recorded in Adobe Photoshop with those calculated by the automated program, Tom's Toolbox, was used to validate the accuracy and reliability of the measurements in each method as cited in a previous publication by the authors [6]. The values of the arch width were incorporated into a spread sheet, with the operator tasked to answer the questions regarding height, weight, ethnicity, and orthodontic treatment by utilizing a drop-down menu. All original histories were archived on the Marquette University server, with the data recorded on a spreadsheet for statistical analysis.

Pearson Product Moment Correlations were calculated using Statistical Analysis Software (SAS Institute, Carey, NC) for arch width, weight, and height as well as for the ethnic background of each subject and orthodontic history (Tables 2 and 3). Because the sample size for ethnic groups other than White was small, all non-White backgrounds were grouped for statistical analysis. There were enough subjects to separate those who had from those who had not had orthodontic treatment. Likewise, those with a history of facial fracture did not constitute a large enough group to be studied independently.

[1] An automated software program under development at Marquette University that has been adapted for bitemark analysis [6].

Arch Widths	Whites	Non-Whites	p-value	Orthodontic Treatment	No Orthodontic Treatment	p-value
Mandible	26.4 ± 0.10 (64)	27.2 ± 0.22 (351)	0.002	26.8 ± 0.13 (157)	26.3 ± 0.12 (256)	0.005
Maxillary	33.1 ± 0.10 (63)	33.9 ± 0.27 (346)	0.008	33.3 ± 0.14 (156)	33.1 ± 0.13 (251)	0.258

(n): Sample size within each category
± represents 1 standard deviation
On average, the mandibular and maxillary arch width is significantly larger in non-Whites compared to whites. Similarly, the mandibular arch width is significantly larger in individuals with orthodonic treatment compared to those without.
The significance correlation is between the maxillary arch width and weight (r=0.101 p-value=0.040). The correlation seems to be driven by individuals without orthodontic treatment. Within those people, the correlation between weight and maxillary arch width is a little stronger (r=0.141 p-value= 0.024).

Table 2

Arch widths.

Overall	N	Height (inches)	Weight (lbs)
Mandible	415	-0.034 (0.491)	0.025 (0.607)
Maxillary	409	0.026 (0.595)	0.101 (0.040)
Whites			
Mandible	351	-0.011 (0.833)	0.046 (0.388)
Maxillary	346	0.054 (0.317)	0.097 (0.070)
Non-Whites			
Mandible	64	0.041 (0.749)	0.070 (0.584)
Maxillary	63	0.073 (0.567)	0.112 (0.350)
Orthodontic Treatment			
Mandible	157	-0.053 (0.513)	0.053 (0.511)
Maxillary	159	-0.036 (0.652)	0.044 (0.583)
No Orthodontic Treatment			
Mandible	256	-0.050 (0.423)	0.038 (0.543)
Maxillary	251	0.047 (0.456)	0.141 (0.025)

( ):p-value testing whether r = 0
25.8% (17/66) of non-Whites and 40.5% (143/353) of Whites had had orthodontic treatment. The proportion of individuals with orthodontic treatment is significantly higher in Whites (p-value=0.024).

Table 3

Pearson correlations between arch width, weight, and height.

Results and Discussion

The sample size for comparison of arch width with height and weight showed that there was little to no correlation (Table 2). Using a Pearson Product Moment Correlation with regard to these factors, the only significant association was between the maxillary arch width and weight ($r=0.101$; p value = 0.040). This correlation seems to be driven by individuals without orthodontic treatment. Within this group, the correlation between weight and maxillary arch width was somewhat stronger ($r=0.141$; p-value=0.025). One hundred forty-three Whites out of three hundred fifty-three in the sample had had orthodontic treatment. Seventeen out of sixty-six non-Whites had had orthodontic treatment. The proportion of individuals with orthodontic treatment was significantly higher in Whites (p-value= 0.024).

Table 3 shows the comparison of the width in the maxilla between those individuals who had not had orthodontic care to those who had had orthodontic care. Here, the mean difference in arch widths of 33.3 mm ± 0.14 mm compared to the means of nonorthodontic arch widths in the maxilla of 33.1 mm ± 0.13 mm resulted in a p-value of 0.258. This could be interpreted as the difference in crowding of the mandible being a skeletal phenomenon compared to the maxilla as being dental in origin. When taken together with the data for height and weight as it correlates to arch width, the p values for height comparisons and maxillary arch widths in the orthodontic versus the nonorthodontic patient were p=0.652 versus p=0.456, respectively. This could be further indication that skeletal differences did not have a significant effect on maxillary arch widths alone. The strength of tooth characteristics cannot be discarded when evaluating maxillary arch widths with respect to orthodontic treatment in this population.

On average, the mandibular and maxillary arch width is significantly larger in non-Whites compared to Whites (Table 2). Similarly, the mandibular arch width is significantly larger in individuals with orthodontic treatment compared to those without such treatment. Given a patterned injury, it seems relevant to state that an extremely wide arch in the maxilla is more likely to belong to a member of the group studied who is male and non-White. This study contained males who were between the ages of 18 and 44 years residing in the State of Wisconsin. Larger data sets would be necessary to subdivide

non-Whites into individual ethnic groups. In addition, the data does not include females, which could alter the results for these subgroups. In addition to lifting the restrictions of age and gender, the data set needs to be expanded to increase the minority representation that is more in line with U.S. census. This heterogeneous population mandates a much larger sample size.

Conclusion

Because the sample size was limited to four hundred individuals, a distinction between ethnic groups as far as arch width could not be determined along individual racial lines. The study did show a significant difference when grouping all non-Whites with those arch widths of Whites. Additional exemplars need to be gathered from a cross-section of the population to individualize results by race. Extrapolating to the United States population should proceed based on the pilot study presented.

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