Robert E. Barsley,[1] *D.D.S. and Diana M. Lancaster,*[2] *Ph.D.*

Measurement of Arch Widths in a Human Population: Relation of Anticipated Bite Marks

REFERENCE: Barsley, R. E. and Lancaster, D. M., **"Measurement of Arch Widths in a Human Population: Relation of Anticipated Bite Marks,"** *Journal of Forensic Sciences,* JFSCA, Vol. 32, No. 4, July 1987, pp. 975-982.

ABSTRACT: The authors compared arch width measurements of diagnostic dental models obtained from dental school patients. Arch width measurements were taken in the canine area on each dental cast in an effort to assist forensic dental investigators in matching certain classes of subjects to the bites they might possibly inflict. If any canine teeth were absent, the measurements were taken using other specified adjacent teeth which the investigators felt would be interpreted as the arch width determiners in a bite mark injury. The ages of the subjects varied from 14 to 87 years. Statistical comparison of the maxillary arch width, mandibular arch width, and the mean difference between maxillary and mandibular arch width were performed. Significant differences between the arch width measurements were found to exist between several classes of subjects based on race and sex.

KEYWORDS: odontology, bite marks, dentition

Many studies have focused on the measurement of various parameters of normal jaw and tooth relationships [*1-3*]. Most, if not all, of these studies have determined from various measurements the dimensions of the ideal or stylized maxilla or mandible and the accepted normals for their associated teeth. This study focuses on the actual arch width as found in a sample of dental school clinic patients. The question central to this study is:

Are there statistically significant differences in arch width measurements based on sex or race?

A secondary question explored by the study is:

What percentage of arches will measure less than 3.5 cm or less than 3.0 cm?

Method

Every patient accepted for dental treatment in the dental school student clinic is obligated to have a set of dental diagnostic casts fabricated. The students accomplish this procedure on their assigned patients before any dental treatment. Rigid plastic disposable impression

Presented at the 37th Annual Meeting of the Academy of Forensic Sciences, Las Vegas, NV, 12-16 Feb. 1985. Received for publication 19 May 1986; revised manuscript received 27 Oct. 1986; accepted for publication 29 Oct. 1986.

[1]Associate professor of oral diagnosis, Medicine and Radiology, Louisiana State University School of Dentistry, New Orleans, LA.

[2]Associate professor, Instructional Services, Louisiana State University School of Dentistry, New Orleans, LA.

trays and prepackaged, premeasured irreversible hydrocolloid (alginate) material are used. These impressions are then poured with dental stone in the recommended water-powder ratio by the students. The resulting casts must then be approved by the student's assigned clinic instructor before the appointment can proceed. At the conclusion of the diagnostic and treatment planning appointment, the diagnostic casts are retained by the clinical faculty. A notation of the patient's name, chart number, age, sex, and race is made by the student on the base of each cast before its surrender.

At a weekly session one of the authors (REB) measured the distance between the cusp tips of specified teeth on each cast. The demographic data were also copied from the base of the casts. All measurements were made by the author using the same dental Boley gauge—a vernier, direct reading type. The following criteria were used to standardize the arch width measurements between each case.

1. All measurements were recorded to the nearest 1/10 mm (0.01 cm).
2. As shown in Fig. 1, teeth with sharp cusp tips were measured from tip to tip.
3. As shown in Fig. 2, on those teeth with attrition of the incisal edge, the measurement was taken from the most faciodistal point angle to the corresponding tooth.
4. All measurements are straight line with no attempt to correct for or to allow for any type of arch curvature in any axis.
5. As shown in Figs. 3 and 4, in those cases without one or both canine teeth, the measurement was taken from the next most posterior tooth present. If no posterior teeth were present then the measurement was taken from the next most anterior tooth in the arch. All other criteria as mentioned above were applied in these measurements. All such cases were positively identified as to the number and arch position of missing teeth to allow for proper statistical treatment.

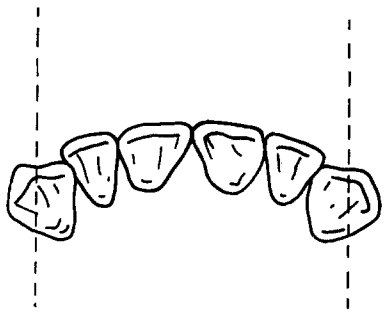

FIG. 1—*Direct measurement across the arch was used for teeth with sharp, clearly defined cusp tips.*

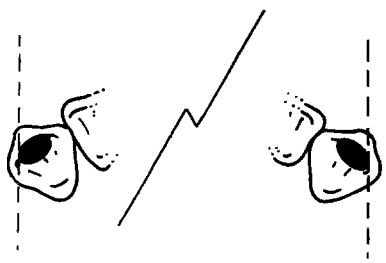

FIG. 2—*Direct measurement across the arch from the most faciodistal point angles of abraded cusp tips was used when required.*

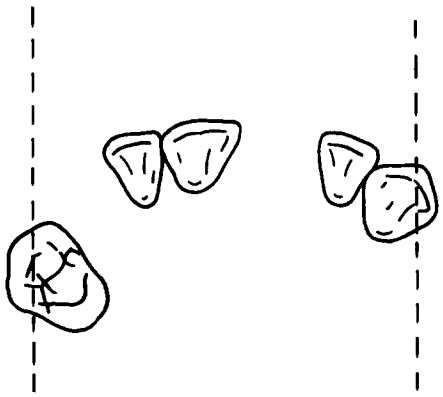

FIG. 3—*In cases where one or both canines were missing the measurement was taken from the labial cusp tip of the next most posterior tooth present.*

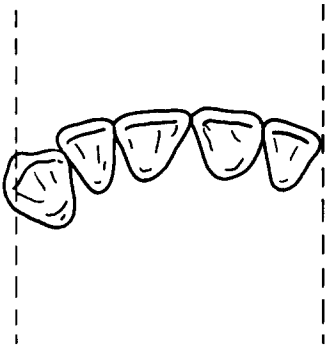

FIG. 4—*In cases where one or both canines were missing and no posterior teeth were present the measurements were taken from the most faciodistal point angle of the next most anterior tooth still present.*

The major goal was to obtain an arch width measurement from each dental diagnostic cast. The authors chose to use teeth judged most likely to have been interpreted (rightly or wrongly) in a bite injury as the canines. If all six anterior teeth were not present, then the remaining tooth or teeth felt most likely to be judged the arch width determiner in a bite injury were used. An example would be in a maxillary cast exhibiting bilateral absence of the lateral incisors with the canines having migrated mesially to replace the missing incisors; in such a case the first bicuspids (if present) would be measured as the arch width determiners.

In the course of the academic year, 1400 usable dental diagnostic casts were produced by the students as outlined above. Each was fully processed by the author. Of these 1198 had full sexual and racial data available. For each class of subjects, the mean arch width was determined as was the mean difference between maxillary and mandibular arch widths. A *t* test of the overall means for race and sex separately was used to determine significance at a 95% confidence level. Analysis of variance was used to determine overall significance among the 4 classes of subjects, white males, black males, white females, and black females on arch width measurements. A separate analysis was performed for each arch width measurement, maxillary, mandibular, and the difference between maxillary and mandibular measure-

ments. Followup t test comparison using the Duncan Multiple Range technique provided data on significant differences between pairs of the four groups. In addition, each class was ranked in increasing arch width size yielding a percentage of subjects exhibiting an arch width greater or less than a particular measurement.

Each class of subjects was divided into subclasses based upon which of the mandibular or maxillary teeth were present for measurement. An additional class consisted only of those subjects who presented with all six anterior teeth intact and measurable in either or both arches. Although the age of all subjects was not recorded, none were younger than 14 years old. The oldest individual was 87 and at least 20 subjects were seen for each age between 23 and 41 inclusive. Age per se was not used as a variable in this study.

Results

Tables 1, 2, and 3 contain the mean arch widths for the maxilla, mandible, and the maxillary and mandibular difference for all subjects according to sex. Tables 4, 5, and 6 contain the results according to race. Values which were found to be significantly different are indicated.

Tables 7 and 8 give the mean mandibular and maxillary arch width expressed in centimetres. The mean differences between these measurements in the same individual has also been calculated and is presented in Table 9. The subjects were classified according to sex and race. For the mandibular width, all groups are significantly different from each other based on the mean values. This was true when all available subjects were tabulated and remained significant when only those subjects with all six mandibular anterior teeth from canine to canine intact were studied.

Tabulations for the maxillary arch were quite similar in results with one exception. The groups white males and black females were not significantly different from each other; however, they were significantly different from every other group. Again, when only maxillae

TABLE 1—*Comparison of mandibular arch width by sex.*[a]

Sex	Mandibular Mean, cm	Standard Deviation	No. of Cases
Female	2.78	0.27	760
Male	2.84	0.31	438

[a] $t = 3.40$
df = 1196
$p = 0.001$

TABLE 2—*Comparison of maxillary arch width by sex.*[a]

Sex	Maxillary Mean, cm	Standard Deviation	No. of Cases
Female	3.55	0.31	703
Male	3.68	0.35	406

[a] $t = 6.26$
df = 1107
$p = 0.001$

TABLE 3—*Comparison of mean maxillary and mandibular arch width differences by sex.*[a]

Sex	Mean Difference	Standard Deviation	No. of Cases
Female	0.77	0.30	701
Male	0.83	0.35	406

[a] $t = 3.08$
df = 1105
$p = 0.01$

Note: The mean difference is not directly arithmetically calculable as a result of the incidence of edentulism isolated to a single arch in some subjects.

TABLE 4—*Comparison of mandibular arch width by race.*[a]

Race	Mandibular Mean, cm	Standard Deviation	No. of Cases
White	2.72	0.27	673
Black	2.91	0.28	525

[a] $t = 11.83$
df = 1196
$p = 0.001$

TABLE 5—*Comparison of maxillary arch width by race.*[a]

Race	Mandibular Mean, cm	Standard Deviation	No. of Cases
White	3.51	0.30	630
Black	3.70	0.34	479

[a] $t = 9.82$
df = 1107
$p = 0.001$

TABLE 6—*Comparison of mean maxillary and mandibular arch width difference by race.*[a]

Race	Mandibular Mean, cm	Standard Deviation	No. of Cases
White	0.79	0.31	629
Black	0.80	0.34	478

[a]Note: The mean difference is not directly arithmetically calculable as a result of the incidence of edentulism isolated to a single arch in some subjects.

TABLE 7—*Mandibular arch width by sex and race.*[a]

Group	Mean, cm	Code	No. of Cases
All cases	2.81		1198
White males	2.78	A	297
Black males	2.98	B	141
White females	2.68	C	376
Black females	2.87	D	384
	$F = 59.33$	df = 3,1194	p 0.001

[a]For comparison between individual groups, means with different letter codes are significantly different at p 0.05.

Note: All mandibular arch width measurements remain significantly different between groups when only the cases (1177) with all six mandibular anterior teeth present are studied.

TABLE 8—*Maxillary arch width by sex and race.*[a]

Group	Mean, cm	Code	No. of Cases
All cases	3.59		1109
White males	3.60	A	277
Black males	3.83	B	129
White females	3.44	C	353
Black females	3.66	A	350
	$F = 58.47$	df = 3,1105	p 0.001

[a]For comparison between individual groups, means with different letter codes are significantly different at p 0.05.

Note: The same significant differences between groups are found when only the cases (1033) with all six maxillary anterior teeth present are studied.

TABLE 9—*Difference between the maxillary and mandibular arch widths by sex and race.*[a]

Group	Mean, cm	Code	No. of Cases
All cases	0.79		1107
White males	0.82	A,B[b]	277
Black males	0.86	A	129
White females	0.76	B	352
Black females	0.78	B	349
	$F = 3.63$	df = 3,1103	p 0.05

[a]For comparison between individual groups, means with different letter codes are significantly different at p 0.05.

Note: Studies utilizing only cases (1031) with all six anterior mandibular teeth present show only the following group to exhibit significant difference—black males and white females.

Note: Studies utilizing only cases (1074) with all six anterior maxillary teeth present show the following groups to exhibit significant difference—white males and black males, black males and black females, black males and white females, white males and white females.

Note: Studies utilizing only those cases (999) with all six maxillary and mandibular teeth present show the following groups to exhibit significant difference—black males and black females, black males and white females, white males and white females.

[b]This group is not significantly different from any other group.

with all six anterior teeth from canine to canine intact and present were studied the same statistical significance was found.

In comparing the difference between the two arch measurements in an individual, the mean value obtained showed fewer statistically significant differences than either arch alone. In a study of all subjects, the group of white males was not significantly different from any other group. The other groups were all significantly different. When maxillae and mandibles exhibiting all six anterior teeth in place were studied only certain groups retained any statistically significant differences as can be seen from the notes on Table 9.

Table 10 reports the number of cases in each group which had an arch width measurement of 3.5 cm or less. Nearly 100% of the mandibles exhibited this trait. For the maxillary arch, this figure varied from a high of 61% of white females to slightly less than 15% of black males. In addition, figures are given for those arches measuring less than 3.0 cm. The range of measurements in the maxilla was 5.82 to 2.09 cm, each of which occurred a single time. In the mandibles, the range was 3.98 to 1.88 cm, again each of these being a single occurrence. In 24 cases (2.2%) the measurement of the mandibular width exceeded or equalled the maxillary measurement, in one case by as much as 0.94 cm.

Table 11 reports the incidence of isolated maxillary complete edentulism in the subjects studied. Many of these patients reported no prosthetic replacement and were in fact seeking their first maxillary denture to oppose their remaining natural mandibular dentition.

Discussion and Conclusions

The authors were able to survey 1198 diagnostic casts of patients accepted for treatment in a dental school clinic. The arch width of each maxillary and mandibular cast was measured

TABLE 10—*Percentage of cases at specified arch widths.*

Group	Arch	Percent Measuring	
		3.50 cm or Less	3.00 cm or Less
All cases	mandibular	98.7	78.0
	maxillary	38.8	3.4
White males	mandibular	98.3	81.1
	maxillary	33.6	3.6
Black males	mandibular	96.5	54.6
	maxillary	14.7	2.3
White females	mandibular	99.7	91.8
	maxillary	60.9	5.7
Black females	mandibular	97.7	70.1
	maxillary	31.1	1.7
Incomplete demographics	mandibular	99.0	79.4
	maxillary	35.8	2.7

TABLE 11—*Percentage of cases with maxillary edentulism.*

Group	Percent	No. of Cases
All cases	7.7	107/1397
White males	6.7	20/297
Black males	8.5	12/141
White females	6.6	25/376
Black females	9.4	36/384
Incomplete demographics	7.0	14/199

at the cuspid area and demographic information was gathered. The mean arch width was calculated by sex and by race. Significant differences were observed between the groups of subjects in many cases. The mean difference between the maxillary and mandibular measures was calculated and significant differences between groups reported. The measurements disclosed that the arch width was less than 3.5 cm in a majority of cases. A large number of mandibular arches exhibited a width of less than 3.0 cm also. It was pointed out that a small percentage of subjects exhibited mandibular measurements equal to or in excess of their maxillary measurements. The incidence of subjects exhibiting maxillary complete edentulism against natural mandibular teeth was reported.

The values provided by this study may be of assistance in the examination and classification of bite marks. However, the variance between groups is small, on the order of 0.01 or 0.02 cm, and is unlikely to be readily noticeable by observation of a bite mark on skin. Bite marks in inelastic material may be suitable for comparison with this data. The great majority of all mandibular measurements in this study fall below 3.0 cm. None of the subjects were children. The authors caution against attempting to draw conclusions about the race, sex, or age of the suspected biter based solely on the measurement of bite marks alone.

Acknowledgments

The authors wish to thank: LSU Medical Center Computer Services, LSU School of Dentistry Learning Resources, and LSU School of Dentistry Word Processing.

References

[1] Duguid, R. and McKay, G. S., "Bite Length Measurements and Tooth-to-Arch Relationships Obtained from Dental Casts Using an *X, Y*-Digitiser and Computer," *Journal of the Forensic Science Society,* Vol. 21, No. 3, July 1981, pp. 211-223.

[2] Moorees, C. F. A., *The Dentition of the Growing Child,* Harvard University Press, Cambridge, MA, 1959, pp. 87-110.

[3] Moyers, R. E., Van Der Linden, F. P. G. M., Riolo, M. L., and McNamara, J. A., *Standards of Human Occlusion Development,* University of Michigan Center for Human Growth and Development, Ann Arbor, MI, 1976, pp. 49-180.

Address requests for reprints or additional information to
Dr. Robert Barsley
1100 Florida Ave., Box 140
New Orleans, LA 70119-2799