A Cephalometric Evaluation Of Craniofacial Landmarks And Their Relationship To Intermolar (Mandibular) Dimensions*

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Introduction

The determination of ideal arch width is one of the cardinal problems confronting orthodontic case analysis. Howes[1] stated that "in our studies of anteroposterior proportions of the face, we should not lose sight of the fact that our biggest problem is still arch width . . ." Numerous investigators have inferred that a correlation may exist between growth in width of the cranial base and growth in width of the mandible through the medium of the mandibular condyles in the glenoid fossae of the temporal bones. If such a relationship should exist, it would permit determination of arch width on an individual basis rather than depend upon an evaluation of arch width according to an age norm for the population.

This study was undertaken in order to determine the variability of certain dental and cranial breadth measurements in individuals with normal occlusion and in individuals with malocclusion. Another objective of this investigation was to determine the correlation between cranial base width and mandibular denture breadth in children with normal and malocclusion. Possible clinical applications were also considered.

*From a thesis in partial fulfillment of the requirements for the degree of Master of Dental Science, Tufts Univ. School of Dental Medicine.

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Materials and Methods

Normal Occlusion Group

Cephalometric records of twenty-four North American Caucasian children with normal occlusion were chosen from the files of the Philadelphia Institute for Research in Child Growth. Selection was made from dental casts and P-A cephalograms on the basis of:

1. Dental age ranging from eruption of the mandibular first permanent molar to the beginning of eruption of the mandibular second permanent molar. This corresponded to Hellman's stages III-A through III-C.
2. Class I molar and cuspid relationship.
3. Overjet of less than one mm.
4. Minimal overbite.
5. Minimal loss of arch length (not more than three mm).
6. Clear definition of the foramina rotunda on the P-A cephalogram.

The P-A cephalograms were obtained on a Broadbent-Bolton cephalometer with a five-foot tube-transporionic distance. A typical tracing of a P-A cephalogram of a normal child is shown in Figure 1.

Tracings were made from the P-A cephalograms on matte acetate tracing film with a 4H lead pencil. The following linear measurements, to the nearest 1.0 mm, were made:

1. Bicondylar breadth (Cd-Cd) — the distance between the most lateral

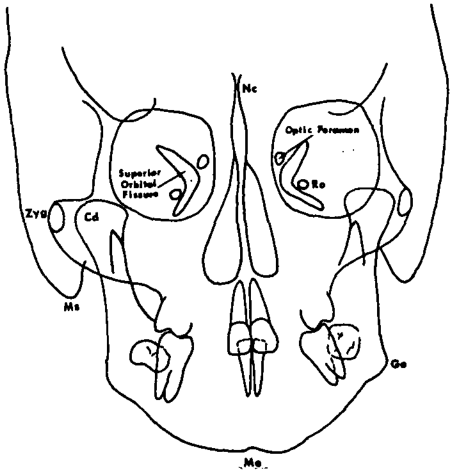

Fig. 1 Typical tracing of a posterior-anterior cephalogram of a normal child.

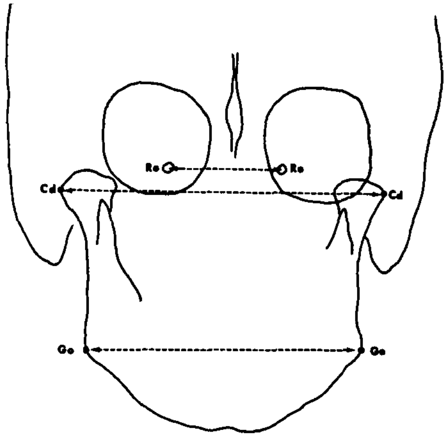

Fig. 2 Tracing of a posterior-anterior cephalogram illustrating the transverse measurements used in this study.

projections of the shadow of the mandibular condyles as determined by inspection.

2. Bigonial breadth (Go-Go) — the greatest distance between the shadows of the two gonial angles as determined by inspection.

Measurement of birotundal width (Ro-Ro) was obtained directly from the P-A cephalograms. Pinholes were placed in the geometric center of each foramen rotundum and the distance between them was measured to the nearest 1.0 mm. A tracing of the P-A cephalogram illustrating the transverse measurements used in this study is shown in Figure 2.

The dental arch widths were obtained directly from plaster casts of the dentition. The following measurements, to the nearest 1.0 mm, were made with a Korkhaus tri-dimensional millimeter caliper:

1. Mandibular first permanent molar breadth (6-6) — the distance between the respective central fossae.
2. Maxillary first permanent molar breadth (6-6) — the distance between the centers of the mesial marginal ridges.

Malocclusion Group

The pretreatment records of forty-eight patients were obtained from the files of the post-graduate orthodontic Department of the Tufts University School of Dental Medicine. The criteria for selection were:

1. Dental age corresponding to Hellman's stages III-A through III-C.
2. No crossbite in the buccal segments.
3. Clear definition of the foramina rotunda on the P-A cephalogram.

These P-A cephalograms were taken with a Margolis cephalostat.

The following measurements were recorded in the same manner as the normal occlusion group:

1. Birotundal breadth (Ro-Ro)
2. Mandibular first permanent molar breadth $(\overline{6}\text{-}\overline{6})$.

Findings

Normal Occlusion Group

The data compiled from the normal occlusion group consisting of three skeletal breadths and maxillary and mandibular denture breadths are shown in Table I. Specific correlation coefficients were also determined. It was found that

TABLE I

STATISTICAL ANALYSIS — NORMAL OCCLUSION GROUP

	Width (mm)				
	$\overline{6}$-$\overline{6}$	$\underline{6}$-$\underline{6}$	Ro-Ro	Cd-Cd	Go-Go
Range	37-42	38-47	35-41	106-124	77-102
Mean	39.21	42.38	38.38	111.88	88.33
Standard Deviation	1.53	1.95	1.60	5.21	9.86

Correlation Coefficients

	$\overline{6}$-Ro	$\underline{6}$-Ro	$\overline{6}$-Go	$\overline{6}$-Cd
r =	0.5471	0.4623	0.2489	0.5036

TABLE II

STATISTICAL ANALYSIS

MALOCCLUSION GROUP

	Width (mm)	
	$\overline{6}$-$\overline{6}$	Ro-Ro
Range	33-47	35-46
Mean	38.67	38.96
Standard Deviation	2.74	2.39

Correlation Coefficients

	$\overline{6}$-Ro
r =	0.8128
t =	5.4

a moderate positive correlation existed in all with the single exception of $\overline{6}$-bigonial breadth ($r = 0.2489$).

Malocclusion Group

The data for the malocclusion group are shown in Table II. The correlation coefficient between $\overline{6}$ and Ro breadth ($r = 0.8128$) is highly significant, as is the "t" value (<1% level of confidence).

Discussion

Many investigations of the correlation between cranial and facial breadths with denture widths have been conducted. The results of these past studies have been inconclusive. The current study indicated that there was a low positive correlation between bigonial and mandibular molar breadth. This is in agreement with the findings of others.[2-4]

The correlations in breadth between bicondylar and $\overline{6}$, birotundal and $\overline{6}$, and birotundal and $\underline{6}$ have not been reported previously. Lateral expansion of the cranial base, resulting in a lateral movement of the glenoid fossa, may influence the growth in width of the mandible through the mandibular condyles.[5-16] It should be noted that in this study the bicondylar — $\overline{6}$ breadth relationship showed a moderate positive correlation in the normal group.

Growth in width of the cranial base has been shown to be nearly complete by seven to ten years of age. Subtelny[17] demonstrated that birotundal breadth was stabilized at an early age. Growth of the mandible has been shown to be primarily dependent upon condylar increments and apposition in localized regions, particularly after eruption of the mandibular first permanent molars. It has also been established that mandibular molar breadth is fairly constant after the eruption of these teeth.[18-22]

Based upon the prior studies, it may be assumed that growth in the cranial base width exerts a definite influence over growth in the width of the mandible. The lack of a significant correlation between bigonial and $\overline{6}$ breadth may be the result of the predominance of appositional growth occurring at the gonial angle. Since growth in the width of the cranial base occurs by lateral expansion, the lateral displacement of the temporal bones results in coordinated lateral movement of the mandibular condyles. It may be assumed that the cranial base exerts control over growth in width of the mandible by this same mechanism.

Previous investigations[23-29] indicate that these growth patterns are established as early as prenatal life and that, once established, growth occurs in parallel increments. This lends credence to the hypothesis that the correlation found in this study should exist at any age. It also permits the determination of the ideal molar arch width for the individual based upon individual skeletal variability rather than upon a "norm" established for an average population. Hixon[30] stated that it was appropriate to describe the patient in terms of the norm, but that the norm was abused when used alone for diagnostic evaluation or as an average objective in treatment. Sassouni[31] stated that, "we have to admit that there is no universal normality; there is no norm which can be applied indiscriminately to everybody."

Although it is apparent from the data that the relationship between $\overline{6}$ breadth and foramen rotundum breadth ($r = 0.8128$) in the malocclusion group is highly significant, the same data from the normal group resulted in only a moderate correlation. This difference can be accounted for by the variability in the two ranges. Kelley[32] referred to the early work of Pearson in 1908 on this problem. McNemar[33] stated:

> "The magnitude of the correlation coefficient varies with the degree of heterogeneity (with respect to the traits being correlated) of the sample. If we are drawing a sample from a group which is restricted in range with regard to either or both variables, the correlation will be relatively low."

The range of $\overline{6}$ breadth in the normal group was only 5 mm while the range for the same measurement in the malocclusion group was 14 mm or almost three times the range of the normal. The range of Ro breadth in the normal was 6 mm while the same measurement in the malocclusion group had a range of 11 mm.

The differences between the means of foramen rotundum breadth and $\overline{6}$ breadth in the normal and malocclusion groups respectively, were computed. The "t" value for Ro breadth measurements was 1.06, and the "t" value for $\overline{6}$ breadth measurements was 0.89. Both of these values indicated that the differences between the means are not significant and, therefore, the difference between the correlation coefficients in question is due to the variability of the range of the data.

To test this reasoning further, the range of the malocclusion group was substituted for the range of the normal group, and the correlation coefficient was calculated proceeding on the assumption that the difference in correlations was due to a difference in range. An "r" value of 0.973 indicated that if the range in the normal group were increased to that found in the malocclusion group, the correlation coefficient between $\overline{6}$ and Ro breadth would be significant at a high level of confidence.

By changing both variables ($\overline{6}$ breadth and Ro breadth), in order to test the hypothesis from the opposite approach, an "r" value of 0.5938 was obtained. This approximated the value obtained for the normal group and reconfirmed the fact that the difference in correlation coefficients between the normal and malocclusion groups was due to the difference in the range.

The possibility that the correlation coefficient of $\overline{6}$-Ro breadth obtained in the malocclusion group could have occurred by chance alone was determined by calculating the "t" value, with the assumption that $r = 0$. The value obtained (5.45) was highly significant

(< 1% level of confidence), and indicates that the calculated "r" value could not have occurred by chance alone.

Salzmann[34] stated that crossbite may be confined to the teeth alone or it may also be due to factors which lie outside of the dental arches, as in mandibular or muscular development. The findings of this present study may guide the determination of correct arch width in the mandibular permanent first molar area in malocclusions, particularly those involving bilateral buccal crossbites. To test this hypothesis, two individuals with malocclusions demonstrating bilateral buccal crossbite were chosen. In the first patient, the $\overline{6}$ breadth was 43 mm, the $\underline{6}$ breadth was 36 mm, and the Ro breadth was 35 mm. Similar measurements of the second individual were $\overline{6}$ breadth 43 mm, $\underline{6}$ breadth — 39 mm, and Ro breadth — 37 mm. Correction of the crossbite relationship was attained with the use of crossbite elastics and contraction archwires on the mandibular arch in order to reduce $\overline{6}$ breadth to approximate Ro breadth. Attainment of this breadth resulted in correction of the crossbite relationship in both cases.

It can be stated that birotundal breadth may be an accurate index in determining correct mandibular first permanent molar breadth in malocclusion cases. Also, it can be useful in determining the correct position of the mandibular first permanent molar (i.e., whether maxillary expansion or mandibular contraction is necessary in malocclusions exhibiting bilateral crossbites).

There is still need for further study in order to determine the validity of the proposed hypothesis, that mandibular arch width in the first permanent molar area is governed by growth in the width of the cranial base.

Summary

Posterior-anterior cephalograms and dental casts of twenty-four children with normal occlusion and of forty-eight children exhibiting a malocclusion were used to study arch width and lateral development of the skull. Statistical analysis of the data indicated various significant relationships which led to the following conclusions:

1. Birotundal and mandibular first permanent molar breadths are more variable in individuals with malocclusion than in individuals with normal occlusion.
2. A moderate positive correlation exists in children with normal occlusion between mandibular first permanent bimolar and birotundal breadth, maxillary first permanent bimolar and birotundal breadth, and mandibular first permanent bimolar and bicondylar breadth. A low positive correlation exists between mandibular first permanent bimolar and bigonial breadth in the age group studied.
3. A highly significant correlation exists between mandibular first permanent bimolar and birotundal breadth in individuals with malocclusions.
4. A significant relationship exists between the width of the cranial base and the width of the mandible.

Evaluation of the clinical application of the birotundal mandibular first permanent bimolar breadth relationship led to the following conclusion: The birotundal-mandibular first permanent bimolar breadth relationship may be useful as a guide in the diagnosis and determination of mechanotherapy for malocclusions demonstrating bilateral buccal crossbites.

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