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Skeletal and Dental Contributions to Posterior Crossbites

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ABSTRACT

The objective of this retrospective study was to compare skeletal and dental arch morphology of children with posterior crossbites with a control group of children without posterior crossbites. The study included 93 patients with a posterior crossbite (33 boys and 60 girls) and 97 patients without a posterior crossbite (50 boys and 47 girls). Skeletal and dental characteristics between the two groups were compared using measurements of dental casts, and lateral and posteroanterior cephalograms. Univariate analyses revealed that seven characteristics were significantly different between the crossbite and noncrossbite groups: mandibular plane angle, lower face height, skeletal maxillary to mandibular width ratio, maxillary intermolar width, mandibular intermolar width, maxillary to mandibular intermolar width ratio, and mandibular unit length. Using maxillary to madibular intermolar width ratio as the outcome measure, a stepwise variable selection technique, analyzed all 190 patients and found only two variables significantly associated with this measure: skeletal maxillary to mandibular width ratio and lower face height. The coefficient of multiple determination for this model was only 13%, indicating that these two variables accounted for only a small portion in the variation of the ratio between the maxillary and mandibular intermolar widths.

KEY WORDS: Posteroanterior cephalometry, Vertical dimension, Mouth breathing, Craniofacial growth, Transverse dimension.

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INTRODUCTION Return to TOC

Posterior crossbites are a relatively common malocclusion. Kutin and Hawes[1] as well as Clinch[2] have examined posterior crossbites in the deciduous and mixed dentitions. From the results obtained from children in nursery school and second grade, Kutin and Hawes[1] found that one in every 13 children showed posterior crossbite, an overall prevalence of 7.7%. The prevalence of crossbite was not greatly different between boys and girls in this sample. The study also showed that in untreated crossbites, the permanent dentition erupted into the same crossbite relationships as in the deciduous molars. In addition, it was documented that the permanent premolars and molars erupted into a normal position when the crossbite was corrected in the deciduous and mixed dentition.

Possible etiologies of crossbites include prolonged retention or premature loss of deciduous teeth, crowding, palatal cleft, genetic control, arch deficiencies, abnormalities in tooth anatomy or eruption sequence, oral digit habits, oral respiration during critical growth periods, and malfunctioning temporomandibular joints.[1–3]

Betts et al[4] stated that the posterior crossbite does not confine itself to dental dysplasias but is more often related to an underlying skeletal problem. Skeletal crossbite can result from one of the following maxillomandibular combinations:

1. Narrow maxilla, normal mandible.
2. Normal maxilla, wide mandible.
3. Narrow maxilla, wide mandible.

For radiographic identification and evaluation of transverse skeletal discrepancies, the posteroanterior (PA) cephalogram is the most readily available and reliable diagnostic tool. Betts et al[4] and Vanarsdall and White[5] stressed the importance of a three-dimensional analysis for diagnosing posterior crossbites. Traditionally, orthodontists have focused on two-dimensional lateral cephalograms; yet, treatment is in three planes of space. Unless the PA cephalogram is analyzed, a differential evaluation of the transverse plane of space cannot be made. Typically, standard PA cephalograms have not been used as part of routine diagnostic records. The 1990 Journal of Clinical Orthodontics study of orthodontic diagnosis and pretreatment procedures reported that only 13.3% of orthodontists take PA cephalograms for initial records.[6] Most importantly, PA cephalograms must be evaluated because growth in the transverse plane is completed earliest. Therefore, fixed appliance or functional therapy must be started at an early age or the skeletal problem may only be resolved using orthognathic surgery. Except when associated with facial asymmetry, the skeletal evaluation of the transverse plane typically has been noted only on dental casts. According to Vanarsdall and White[5], the dental arches are not an accurate means of assessing the transverse skeletal dimension. Only the maxillary intermolar width correlates with the maxillary skeletal base dimension. The mandibular dental width measurements do not correlate with mandibular skeletal dimension.[6]

To determine the treatment plan for a case involving posterior crossbite, it must be decided whether the posterior crossbite is a true skeletal dysplasia or a problem involving only the dentoalveolar structures. In addition, any means of identifying the morphologic characteristics of a posterior crossbite may be helpful in the possible prevention or early treatment of this condition and also be a guide in assuring that the treatment mechanics used are appropriate.

The purpose of this study was to determine if any skeletal and dental differences exist between patients with and without posterior crossbites. An additional aim was to develop a set of standard measurements of PA cephalograms for children in the mixed dentition group. The null hypothesis tested in this study was that there are no differences in skeletal and dental morphologic traits between children with posterior crossbites and children without posterior crossbites.

MATERIALS AND METHODS Return to TOC

Subjects for this retrospective study were recruited from an orthodontic training clinic. Patients with mixed dentition and posterior crossbite who had dental casts made during 1994–2000 were identified. Patients in the mixed dentition group without posterior crossbites were identified from the same pool and served as the comparison group. Posterior crossbite was defined as a minimum of two teeth in unilateral or bilateral posterior lingual crossbite. This comparison group consisted of patients who presented initially for orthodontic consultation with malocclusions other than posterior crossbite.

From an initial number of 100 in each group, exclusion criteria (lack of consent for research and Class III malocclusion) reduced the size of the groups to 93 patients in the crossbite group and 97 patients in the comparison group.

The orthodontically evaluated nonposterior crossbite patients were chosen as controls rather than subjects with “ideal” occlusion to provide the clinician with a more accurate understanding of the crossbite and nonposterior crossbite patients than would present to a typical orthodontic practice.

Data collected included variables describing dental arch morphology, Angle Classification, and lateral and posteroanterior cephalograms.

Measurements of dental casts

Using the dental casts, the following measurements were recorded.

- Maxillary intermolar width (Mx6-Mx6), the linear measurement between the mesiolingual cusp tips of the right and left maxillary first molars.
- Mandibular intermolar width (Md6-Md6), the linear measurement between the mesiobuccal cusp tips of the right and left mandibular first molars.

All intermolar widths were measured in millimeters using Fowler Ultra-Cal III digital calipers (Fred Fowler Co. Inc., Newton, Mass).

The maxillary to mandibular intermolar ratio was calculated by dividing the maxillary intermolar width (Mx6-Mx6) by the mandibular intermolar width (Md6-Md6). Each subject was classified on the basis of molar relationship as either Angle Class I, Class II, or Class III.[7] Only subjects with Angle Class I or II relationship were included in this investigation. The Angle Class molar relationship was defined by the distance in millimeters between perpendicular projections on the mesial surfaces of permanent first molars.[8] (see Figure 1).

Measurements of radiographs

Ricketts suggested and chose specific radiographic landmarks and measurements to assess transverse discrepancies between the maxilla and the mandible.[9–11] The following landmarks from the Ricketts PA cephalometric analysis were used: JR, JL, AG, and GA (see Figure 2). Measurements were made directly on the PA cephalogram using a ruler and were recorded in millimeters.

Using these landmarks, the following measurements were recorded.

- Effective maxillary width (JL-JR): the linear measurement between points JL and JR (bilateral points located at the depth of concavity of the lateral maxillary contour, at the junction of the maxilla and zygomatic buttress).
- Effective mandibular width (AG-GA): the linear measurement between the points AG and GA (bilateral points at the inferior margin of the antegonial protuberance).

Lateral cephalograms were hand traced on acetate paper. These tracings were then measured using a millimeter ruler and protractor to compare skeletal and dental characteristics between crossbite and noncrossbite children. The following variables in the sagittal dimension were recorded (Figure 3).

1. Upper incisor inclination: the angle between the sella-nasion line and a line connecting the upper incisor root apex to the upper incisor tip.
2. Lower incisor inclination: the angle between a line formed by gonion and gnathion and a line connecting the lower incisor root apex to the lower incisor tip.
3. Mandibular plane angle: the angle between a line formed by gonion and gnathion and the sella-nasion line.
4. ANB angle: the angle between the A point-nasion line and the nasion-B point line.
5. Lower face height: the linear distance from the anterior nasal spine of the maxilla to menton.
6. Maxillary unit length: the linear distance from condylion to anterior nasal spine.
7. Mandibular unit length: the linear distance from condylion to gnathion.

Statistical methods

Patient's sex, age, Angle Class, and the skeletal and dental arch morphology measurements were summarized separately for the two groups of patients using frequencies and percentages, means and standard deviations (SD). The correlations between the morphology measurements were estimated both overall and by group using the Pearson correlation coefficient. “Moderate” correlations were considered to have r values of at least 0.40. Logistic regression models with the binary endpoint of posterior crossbite (yes, no) were fit to evaluate the association between presence of a posterior crossbite and each of the variables. First, univariate models were fit to examine the association between presence of a posterior crossbite and sex, age, and Angle Class, respectively. Next, additional models were fit to evaluate the association between presence of a posterior crossbite and each of the morphology measurements with and without adjusting for age, sex, and Angle Class in the models. Finally, a multivariable logistic regression model was fit using a stepwise variable selection method to identify a set of measurements that were independently associated with presence of a posterior crossbite, after adjusting for age, sex, and Angle Class.

Using the data from all the patients included in this study, multiple linear regression models were fit to identify radiographic measurements that were associated with the ratio of the maxillary to mandibular intermolar width obtained from the dental casts. Models were fit using stepwise and backward variable selection techniques, after adjusting for age, sex, and Angle Class.

All calculated P values were two-sided, and P values less than .05 were considered statistically significant.

Ten cases were randomly selected at the end of the study using a table of random numbers, and tracings and measurements were redone by the same investigator to test for reliability of the method. Measurement errors were determined using the Dahlberg formula:

$$\sqrt{\left(\sum D^2/2N\right)}$$

where D is the difference between remeasured values, and N is the number of double measurements (N = 10). Method error scores can be found in Table 1.

A sample size of nearly 100 per group was selected to provide sufficient power to detect a difference of 0.4 standard deviations between group means. These calculations were based on assuming equal group variances, a two-sided alternative hypothesis, and type-I error level of 5%.

RESULTS Return to TOC

The study included 93 patients with a posterior crossbite and 97 patients without a posterior crossbite. The demographics and Angle Class of these patients are summarized in Table 2. Girls were more likely to have a posterior crossbite (P = .026). Although a minority of the patients was Angle Class I, these patients were more likely to have a posterior crossbite (P = .012). Also, patients presenting with a posterior crossbite tended to be slightly younger (P = .065).

The correlations (r) between the skeletal measurements made from the radiographs and the dental arch morphology measurements obtained from dental casts are summarized in Tables 3 through 5 overall and by patient group.

A summary of each measurement within the two patient groups is shown in Table 1. In univariate analyses (after adjusting for age, sex, and Angle Class), patients with a larger mandibular plane angle, longer lower face height, longer mandibular unit length, smaller effective maxillary to mandibular skeletal width ratio (JL-JR:AG-GA), smaller maxillary intermolar dental width (Mx6-Mx6), larger mandibular intermolar dental width (Md6-Md6), and smaller maxillary to mandibular intermolar dental width ratio (Mx6-Mx6:Md6-Md6) were significantly more likely to have a posterior crossbite (all P < .05).

On the basis of a stepwise multivariable analysis after adjusting for age, sex, and Angle Class, patients with a smaller maxillary to mandibular intermolar dental width ratio (Mx6-Mx6:Md6-Md6) and longer lower face height were more likely to have a posterior crossbite (P < .001 and P = .003, respectively). The adjusted generalized coefficient of determination (R^2 value) for this model was 69.0%. A smaller Mx6-Mx6:Md6-Md6 is in essence another way to define a posterior crossbite. It was, therefore, not surprising to see the coefficient of determination (R^2 value) to be rather high at 69.0%.

In a second analysis, using the data from all the patients included in this study, multiple linear regression models were fit to identify radiographic measurements that were associated with the Mx6-Mx6:Md6-Md6 instead of posterior crossbite. Models were fit using stepwise and backward variable selection techniques, after adjusting for age, sex, and Angle Class. Using a stepwise variable selection technique, the ratio of the effective maxillary to mandibular skeletal width (JL-JR:AG-GA) followed by lower face height were identified as the characteristics most associated with the Mx6-Mx6:Md6-Md6. The same results were obtained when the model was fit using a backward variable selection technique. Both models were adjusted for age, sex, and Angle Class. The coefficient of multiple determination (R^2) for this final model was only 13.0%, indicating that these characteristics only explain a small portion of the variation in the Mx6-Mx6:Md6-Md6.

The Partial R^2 values listed in Table 6 indicate the amount of the variation in the Mx6-Mx6:Md6-Md6, which can be explained by each variable in the model after controlling for the other variables in the model. In the final model, the skeletal width ratio (JL-JR:AG-GA) accounted for only 4% of the variation in the intermolar width ratio (Mx6-Mx6:Md6-Md6).

DISCUSSION Return to TOC

The measurement used in this study to compare maxillary and mandibular skeletal width in children was different from Betts' measurement in adults. Rather than measuring the difference between maxillary and mandibular skeletal width, ie (AG-GA) minus (JL-JR), the ratio equaling (JL-JR) divided by (AG-GA) was used. This ratio was used because the subjects of this study were children, whereas the norms by Betts et al[4] were based on adults. The investigators believed that the maxillo-mandibular skeletal width ratio was more appropriate to use with children because of their greater variability in physical size for subjects of similar age, as compared with adults. This variability is because of the large difference in skeletal ages and physical maturity found in children of similar chronological age.

The groups were chosen based on the presence or absence of a clinically apparent posterior crossbite. The principal outcome variable tested for its association with posterior crossbite was the maxillo-mandibular skeletal width ratio (JL-JR:AG-GA) ie, did the group with crossbites have a smaller ratio than the group without crossbite. Another way the study could have been designed would have been to choose two groups, one that would fit a category of "smaller," and one with a category of "larger" JL-JR:AG-GA. The principal outcome variable that might have then been tested would be the presence or absence of posterior crossbite in these groups.

Although the prevalence of posterior crossbite in the population has been reported to be as high as 7.7%,[1] this is still a relatively low number. It was decided when originally designing the study, that the selection of groups based on a JL-JR:AG-GA criteria might result in too few patients with posterior crossbites in these groups to be able to obtain a meaningful statistical analysis. It was, therefore, decided to select the groups on the basis of the presence or absence of posterior crossbite.

The results of the statistical analysis showed the following findings: patients with a larger mandibular plane angle, longer lower face height, longer mandibular unit length, smaller JL-JR:AG-GA, smaller Mx6-Mx6, larger Md6-Md6, and smaller Mx6-Mx6:Md6-Md6 were significantly more likely to have a posterior crossbite. Thus the evidence does not support the null hypothesis that there is no difference between the two groups.

Only two of the seven variables ended up in the final multivariable analysis model, because of the fact that many of the variables were related or tended to measure the same features (eg, lower face height and mandibular plane angle are both measurements of the vertical dimension). The remaining five variables did not contribute significantly to the multivariable analysis model and were therefore eliminated.

The low R^2 value indicates that there are many other variables at play with regard to the intermolar dental width ratio. In fact, in the final model, the JL-JR:AG-GA alone accounted for only 4% of the variation in the Mx6-Mx6:Md6-Md6. Clinicians should therefore be cautious not to make assumptions regarding skeletal relationships (eg, JL-JR:AG-GA) solely on the basis of intermolar widths obtained from dental casts.

In this study, girls were more likely to have a posterior crossbite. Sixty patients (64.5%) in the posterior crossbite group were girls. These findings differ from those reported in 1969 by Kutin and Hawes[1] who found no sex difference associated with the prevalence of crossbite. In their study, Kutin and Hawes[1] visited classrooms and examined children in nursery school and second grade, whereas the current investigation studied children who were specifically referred to an orthodontic specialty practice. It is possible that the sex differences with regard to the prevalence of crossbite could be due to referral patterns. There is evidence to suggest that more girls are referred to an orthodontic practice and more girls pursue treatment after being referred to an orthodontic practice, but this does not explain the comparison group having fewer girls because the comparison group also received treatment, albeit for a problem other than crossbite.

Another possibility to account for the higher number of girls with posterior crossbite could be nonnutritive sucking habits. Most research supports the finding that girls demonstrate a higher level of nonnutritive sucking habits and more persistent habits than boys.[12] A study by Infante[13] revealed the prevalence of finger sucking between boys and girls. Of the 680 children studied, 23.5% of girls sucked a digit but only 13.7% of the boys did. It is also interesting to note that at five years of age, nine times more girls than boys sucked their thumbs. Nonnutritive sucking habits have also been implicated in decreased palatal arch width and increased incidence of posterior crossbite.[12] For these reasons, it is possible that more girls than boys require orthodontic treatment for dentofacial deformities caused by nonnutritive sucking habits. This fact may account for the higher number of girls with posterior crossbite in the current study. Although not directly assessed in this study, it would be interesting to evaluate the relationship between posterior crossbite and nonnutritive sucking habits in future studies.

The percentages of Angle Class II malocclusions in this study were significantly higher than would be expected in the general population. However, all the patients in this study were in the transitional dentition with the majority of them still retaining all the deciduous second molars; as such, many of the patients had an end-to-end molar relationship. By the definition used in this study, end-to-end molar relationships were classified as Angle Class II. According to Bishara et al,[8] it could be anticipated that about half of these patients would change into an Angle Class I on the exfoliation of the deciduous second molars.

Angle Class I patients were more likely to have a posterior crossbite in this study. In these patients, the mandibular molar is further mesial relative to the maxillary first molar than it would be in patients with Angle Class II, occluding with a narrower transverse portion of the maxillary arch, thereby increasing the likelihood of posterior crossbite. It would also be expected that a small percentage of the transitional Angle Class I patients may change into an Angle Class III relationship on exfoliation of the deciduous second molars.[8]

Clinical implications of this study confirm the importance of the posteroanterior cephalogram in determining the presence of skeletal transverse discrepancy. If a child clinically presents with a posterior crossbite, it may be beneficial to include a posteroanterior cephalogram as part of the complete orthodontic records. The presence of a small effective maxillary to mandibular skeletal width ratio, ie, JL-JR:AG-GA, would suggest a skeletal component to the crossbite. This would have implications regarding early vs late treatment. A skeletal component to the posterior crossbite would be a reason for early intervention with the objective of providing skeletal correction while the child is still growing. Once the patient reaches skeletal maturity the likelihood of obtaining true skeletal correction would be unlikely.

On the other hand, if the review of the records reveals a larger or normal JL-JR:AG-GA, the posterior crossbite would be considered more dental in nature.

This may possibly be a reason for postponing intervention to correct the posterior crossbite, because there is no skeletal component. This would save the expense as well as reduce treatment time by consolidating treatment into one phase, with correction of the crossbite at the time of full orthodontic appliance treatment. We currently do not have evidence of what would happen if we delay posterior crossbite treatment and this would be an area for future studies to explore.

So how will the clinician know if the width/ratio values are “small” or “large” based on a single posteroanterior cephalogram? Unlike the lateral cephalogram, little has been published regarding normal values of the transverse dimension obtained from posteroanterior cephalograms. Because normal values are lacking, clinicians may be making treatment decisions based on subjective judgment rather than on rigorous scientific data. Cortella et al[14] studied the transverse development of the jaws. They generated norms for the posteroanterior cephalometric analysis using data from the Bolton-Brush growth study. This provided age specific means and standard deviations of cephalometric measurements for the distances JL-JR, AG-GA, and the corresponding differences. The current study showed similarities to the Cortella et al[14] study with regard to transverse dimension values. In the current study, the mean age (SD) for the nonposterior crossbite group was 10.4 (2.0). The closest corresponding age group in the Cortella et al[14] study was nine years. Therefore, the nonposterior crossbite patients in the current study were compared with the nine-year-old group in the Cortella et al study.[14] For the Cortella et al[14] nine-year-old-age group, the following was found: mean (SD) effective maxillary width (JL-JR) = 60.6 (2.6), mean (SD) effective mandibular width (AG-GA) = 77.1 (3.4). In the current study, looking at these same variables (Table 1): mean (SD) effective maxillary width (JL-JR) = 60.4 (4.6), mean (SD) effective mandibular width (AG-GA) = 80.9 (4.9). When the clinician obtains a posteroanterior cephalogram, the values listed in Table 1 can be used as reference norms in determining if transverse width/ratio values are small or large. Clinically evaluating patients with posterior crossbite requires knowledge of skeletal and dental normal values to make proper decisions regarding treatment timing and treatment mechanics.

A review of the literature includes the following as potential etiologic factors for posterior crossbite: prolonged retention or premature loss of deciduous teeth, crowding, palatal cleft, genetic control, arch deficiencies, abnormalities in tooth anatomy or eruption sequence, oral digit habits, oral respiration during critical growth periods, and malfunctioning temporomandibular joints.[1–3] Although this study did not explore each of these items specifically, it is obvious that multiple factors contribute to the presence of a posterior crossbite. The role that each potential etiologic factor plays in the presence or absence of a posterior crossbite is unknown. It would be desirable to investigate further the extent to which the various etiologic factors contribute to posterior crossbite. This information would increase the clinician's ability to make rational decisions regarding the prevention and treatment of posterior crossbites.

Bresolin et al[15] investigated the possible differences in facial growth between children with allergy who appeared to breathe predominately through the mouth and children without allergy who appeared to breathe predominately through the nose. All subjects received an intraoral clinical examination and lateral cephalometric radiograph analysis. Findings for the children who breathed through the mouth were as follows: (1) they had longer faces, (2) their faces were more retrognathic, (3) their mandibles had more obtuse gonial angles, (4) their palates were higher and maxillary intermolar dental width was narrower, and (5) they were more likely to have posterior dental crossbites than children who breathed through the nose. Although the current study did not differentiate between patients who breathe through the mouth vs through the nose, some comparisons between these studies can be made. In the Bresolin et al[15] study, the children who breathed through the mouth tended to have longer faces and smaller maxillary intermolar dental width. Similarly, in the current study, children with posterior crossbite had longer lower facial heights and smaller maxillary intermolar width as well. Because both studies showed longer face heights in combination with smaller maxillary intermolar width, this would suggest a possible connection between the vertical and transverse dimensions. It seems that in children with posterior crossbite and in children who breathe through their mouth, excessive vertical dimension is associated with deficient transverse dimension. The Bresolin et al[15] study found seven posterior crossbites in 30 children who breathed through the mouth and no posterior crossbites in 15 children who breathed through the nose. The true relationship between mouth breathing and posterior crossbite is still in question. It would be interesting to know what number of children with posterior crossbite are mouth breathers. In that way, a better understanding of mouth breathing in association with posterior crossbite could be obtained.

Linder-Aronson[16] also explored the relationship between airway obstruction and malocclusion by conducting airflow tests in 162 subjects six years to 12 years of age. Eighty-one were clinically determined to need adenoidectomies, and 81 were controls. The effect between adenoid size, nasal airflow, and a number of conditions, including low tongue position, mouth breathing, narrow maxillary arch, posterior crossbite, and elongation of the lower anterior vertical face height, and steep mandibular plane angle were investigated. He reported results demonstrating a relationship between obstructing adenoid tissue and elongation of the lower anterior vertical face height, open bite, retrognathia, obtuse gonial angle, steep mandibular plane angle, narrowing or elevation of the palate, and posterior crossbite. Subsequent studies demonstrated that the direction of mandibular growth normalized in a more horizontal or less vertical manner after adenoidectomy and change to nasal respiration.[17–20] This resulted in diminished lower anterior vertical face height and improvement of the retrognathia. There are numerous similarities between Linder-Aronson's[16] adenoidectomy group and the current study's posterior crossbite group. Both groups showed increased lower anterior vertical face height, steeper mandibular plane angles, and posterior crossbite. Once again, both studies showed a deficient transverse relationship along with increased vertical dimension.

The issue of upper airway obstruction and its impact on craniofacial development and facial pattern is controversial. Craniofacial morphology and occlusal patterns are influenced by a variety of factors. Clearly, further investigation into the exact role that upper airway obstruction has on craniofacial development would benefit both medical and dental practitioners. In an attempt to better comprehend the role of the various factors, a follow up of the children in this study is currently underway. Thus far, the follow up has consisted of a survey sent to the parents of the children in this study. The survey includes questions with regard to the child's history of mouth breathing, nasal breathing, snoring, allergies, adenoids, tonsils, medications, and oral digit habits. Analysis of these data is presently underway, and the findings will be decribed in a future report.

CONCLUSIONS Return to TOC

On the basis of the results of this study, the following conclusions can be made:

1. The ratio of the effective maxillary to mandibular skeletal width obtained from the radiographs, ie (JL-JR):(AG-GA), followed by lower face height were identified as the characteristics most correlated with the ratio of the maxillary to mandibular intermolar dental width obtained from the dental casts. The coefficient of multiple determination (R^2) for this model was low indicating that these characteristics only explain a small portion of the variation in the ratio of the intermolar dental width obtained from the dental casts.

2. Our finding of a low partial R^2 value JL-JR:AG-GA in explaining the variation of Mx6-Mx6:Md6-Md6 supports Vanarsdall and White's[5] premise that dental arches are poor predictors of the transverse skeletal dimension.

3. Patients with a larger mandibular plane angle, longer lower face height, longer mandibular unit length, smaller effective maxillary to mandibular skeletal width ratio (JL-JR:AG-GA), smaller maxillary intermolar dental width, larger mandibular intermolar dental width, and smaller maxillary to mandibular intermolar dental width ratio were significantly more likely to have a posterior crossbite. However, the clinical significance of these findings remains questionable.
4. Smaller maxillary to mandibular intermolar dental width ratio and longer lower face height were the two variables most associated with a patient's likelihood of having a posterial crossbite.
5. Values from this study can be used by clinicians as reference norms in posteroanterior cephalometric analysis.
6. Furthermore, well-controlled studies are needed to investigate upper airway obstruction and its impact on craniofacial development and occlusal patterns.

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TABLES Return to TOC

TABLE 1. Summary of the Distributions Within Each Group and the Results of the Univariate and Multivariable Logistic Regression Analyses

Measurement	Method Error[a]	Posterior Crossbite: Yes (n = 93) Mean (SD)	Median	No (n = 97) Mean (SD)	Median	Univariate Analysis, P-Value[b] Unadjusted	Adjusted	Multivariable Analysis, P-Value*
Upper incisor inclination (°)	2.5	102.3 (7.8)	103	103.2 (8.0)	103	.427	.349	NS
Lower incisor inclination (°)	2.3	91.1 (6.1)	92	93.6 (8.5)	93	.019	.062	NS
Mandibular plane angle (°)	2.5	36.3 (5.8)	36	33.4 (6.3)	33	.001	.002	NS
ANB angle (°)	1.2	4.0 (2.2)	4	3.8 (2.5)	4	.673	.524	NS
Lower face height (mm)	0.7	64.5 (5.6)	63	62.8 (4.4)	62	.027	<.001	.003
Maxillary unit length (mm)	2.0	88.8 (6.3)	89	89.6 (5.2)	90	.303	.688	NS
Mandibular unit length (mm)	0.8	109.1 (7.3)	109	108.3 (8.0)	108	.467	.014	NS
Effective maxillary width (JL-JR) (mm)	0.8	58.5 (5.7)	58	60.4 (4.6)	60	.009	.058	NS
Effective mandibular width (AG-GA) (mm)	1.2	80.5 (5.3)	80.00	80.9 (4.9)	80	.547	.348	NS
JL-JR:AG-GA (%)	NA[c]	72.7 (6.1)	72.5	74.8 (5.1)	75	.012	.009	NS
Maxillary intermolar width (mm)	0.5	36.0 (3.6)	36.4	39.3 (3.1)	38.9	<.001	<.001	NS
Mandibular intermolar width (mm)	0.6	44.7 (3.1)	44.6	43.6 (2.7)	43.5	.007	.002	NS
Maxillary:Mandibular intermolar width ratio (%)	NA	80.6 (7.2)	80.8	90.2 (4.7)	90.7	<.001	<.001	<.001

[a] The method error for each measurement was determined using the Dahlberg formula based on a random sample of 10 cases.

[b] Each measurement was evaluated univariately for an association with posterior crossbite with and without adjusting for age, sex, and Angle Class, in separate logistic regression models.

[c] NA indicates not applicable; NS, not significant.

* Based on a multivariable logistic regression model using a stepwise variable selection method, after adjusting for age, sex, and Angle Class.

TABLE 2. Summary of Patient Demographics and Angle Class

Characteristic	Posterior Crossbite: Yes (n = 93)	No (n = 97)	P-Value[a]
Female sex, n (%)	60 (64.5)	47 (48.5)	.026
Male sex, n (%)	33 (35.5)	50 (51.5)	
Age at time of dental cast (years)			
Mean (SD)	9.9 (2.0)	10.4 (2.0)	.065
Range	6.6–15.0	6.9–16.9	
Angle Class, n (%)			
I	12 (12.9)	3 (3.1)	.012
II	81 (87.1)	94 (96.9)	

[a] P-values based on fitting univariate logistic regression models to examine the association with the presence of a posterior crossbite.

TABLE 3. Correlation Between Skeletal and Dental Arch Morphology Measurements Based on all 190 Patients[a]

	Upper Incisor Inclination	Lower Incisor Inclination	Mandibular Plane Angle	ANB Angle	Lower Face Height	Maxillary Unit Length	Mandibular Unit Length	Effective Maxillary width (JL-JR)	Effective Mandibular Width (AG-GA)
Upper incisor inclination		0.26	−0.28	−0.14	−0.10	0.01	0.01	0.19	0
Lower incisor inclination			−0.44	0.18	−0.16	0.21	0	0.12	−0.06
Mandibular plane angle				0.21	0.42	−0.30	−0.17	−0.29	−0.15
ANB angle					0.16	0.20	−0.11	−0.07	−0.14
Lower face height						0.25	0.48	0.21	0.33
Maxillary unit length							0.64	0.31	0.45
Mandibular unit length								0.36	0.59
Effective maxillary width (JL-JR)									0.51
Effective mandibular width (AG-GA)									
(JL-JR)/(AG-GA)									
Maxillary intermolar width									
Mandibular intermolar width									
Maxillary/Mandibular intermolar width									

[a] The tabled values are Pearson correlation coefficients. Based on a sample of 190 patients, a Pearson correlation coefficient >.15 is significantly different from zero ($P < .05$).

TABLE 3. Continued

	(JL-JR)/(AG-GA)	Maxillary Intermolar Width	Mandibular Intermolar Width	Maxillary/Mandibular Intermolar Width
Upper incisor inclination	0.22	0.19	0.21	0.05
Lower incisor inclination	0.19	0.24	0.20	0.12
Mandibular plane angle	−0.21	−0.40	−0.31	−0.21
ANB angle	0.03	−0.17	−0.16	−0.07
Lower face height	−0.03	−0.12	−0.01	−0.12
Maxillary unit length	0	0.21	0.19	0.08
Mandibular unit length	−0.06	0.20	0.21	0.06
Effective maxillary width (JL-JR)	0.72	0.43	0.31	0.26
Effective mandibular width (AG-GA)	−0.23	0.26	0.27	0.08
(JL-JR)/(AG-GA)		0.29	0.14	0.23
Maxillary intermolar width			0.45	0.75
Mandibular intermolar width				−0.25
Maxillary/Mandibular intermolar width				

TABLE 4. Correlation Between Skeletal and Dental Arch Morphology Measurements Based on 93 Patients with a Posterior Crossbite[a]

	Upper Incisor Inclination	Lower Incisor Inclination	Mandibular Plane Angle	ANB Angle	Lower Face Height	Maxillary Unit Length	Mandibular Unit Length	Effective Maxillary Width (JL-JR)	Effective Mandibular Width (AG-GA)
Upper incisor inclination		0.20	−0.31	−0.19	−0.18	0.03	0	0.15	0
Lower incisor inclination			−0.43	0.25	−0.10	0.14	−0.08	−0.01	−0.07
Mandibular plane angle				0.19	0.48	−0.21	−0.04	−0.03	−0.01
ANB angle					0.22	0.21	−0.05	−0.03	−0.04
Lower face height						0.37	0.54	0.36	0.41
Maxillary unit length							0.69	0.24	0.46
Mandibular unit length								0.32	0.65
Effective Maxillary width (JL-JR)									0.50
Effective Mandibular width (AG-GA)									
(JL-JR)/(AG-GA)									
Maxillary intermolar width									
Mandibular intermolar width									
Maxillary/Mandibular intermolar width									

[a] The tabled values are Pearson correlation coefficients. Based on a sample of 93 patients, a Pearson correlation coefficient >.20 is significantly different from zero ($P < .05$).

TABLE 4. Continued

(JL-JR)/(AG-GA)	Maxillary Intermolar Width	Mandibular Intermolar width	Maxillary/ Mandibular Intermolar Width
0.17	0.15	0.28	−0.06
0.05	0.11	0.25	−0.08
−0.04	−0.23	−0.36	0.03
0	−0.06	−0.15	0.05
0.09	−0.20	−0.14	−0.10
−0.05	0.06	0.16	−0.05
−0.13	0.07	0.10	0
0.75	0.34	0.37	0.10
−0.19	0.13	0.20	0
	0.30	0.28	0.12
		0.50	0.72
			−0.24

TABLE 5. Correlation Between Skeletal and Dental Arch Morphology Measurements Based on 97 Patients without a Posterior Crossbite[a]

	Upper Incisor Inclination	Lower Incisor Inclination	Mandibular Plane Angle	ANB Angle	Lower Face Height	Maxillary Unit Length	Mandibular Unit Length	Effective Maxillary Width (JL-JR)	Effective Mandibular Width (AG-GA)
Upper incisor inclination		0.30	−0.25	−0.09	0.02	−0.03	0.02	0.23	−0.01
Lower incisor inclination			−0.43	0.15	−0.17	0.27	0.07	0.19	−0.06
Mandibular plane angle				0.22	0.31	−0.39	−0.30	−0.50	−0.26
ANB angle					0.10	0.20	−0.15	−0.12	−0.24
Lower face height						0.11	0.42	0.09	0.26
Maxillary unit length							0.61	0.38	0.43
Mandibular unit length								0.44	0.54
Effective Maxillary width (JL-JR)									0.52
Effective Mandibular width (AG-GA)									
(JL-JR)/(AG-GA)									
Maxillary intermolar width									
Mandibular intermolar width									
Maxillary/Mandibular intermolar width									

[a] The tabled values are Pearson correlation coefficients. Based on a sample of 97 patients, a Pearson correlation coefficient >.20 is significantly different from zero ($P < .05$).

TABLE 5. Continued

(JL-JR)/(AG-GA)	Maxillary Intermolar Width	Mandibular Intermolar Width	Maxillary Mandibular Intermolar Width
0.26	0.23	0.18	0.13
0.27	0.25	0.24	0.11
−0.33	−0.45	−0.38	−0.23
0.08	−0.30	−0.19	−0.24
−0.13	0.14	0.09	0.11
0.05	0.37	0.28	0.23
0.02	0.43	0.30	0.29
0.66	0.47	0.34	0.32
−0.30	0.42	0.37	0.20
	0.16	0.05	0.19
		0.76	0.62
			−0.04

TABLE 6. Summary of Partial R^2 Values

Variable	Partial R^2 (%)[a]
Age	6.2
Sex	0.5
Angle Class	0.04
JL-JR/AG-GA	4.0
Lower face height	3.8

[a] The partial R^2 values indicate the amount of the total variation in the Mx6-Mx6:Md6-Md6 ratio that can be explained by each variable in the model after controlling for the other variables, as estimated from a multiple linear regression model.

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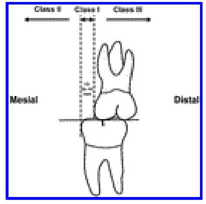

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FIGURE 1. Angle classification

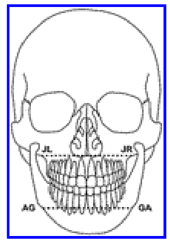

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FIGURE 2. Posteroanterior cephalogram

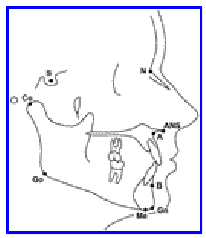

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FIGURE 3. Lateral cephalogram

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