Original Article

Anteroposterior Dental Arch and Jaw-Base Relationships in a Population Sample

Lei Zhou; Chung-Wai Mok; Urban Hägg; Colman McGrath; Margareta Bendeus; John Wu

ABSTRACT

Objective: To determine the association between the anteroposterior relationship of the dental arch and the anteroposterior relationship of the jaw-base in a Chinese population sample.

Materials and Methods: Orthodontic casts and lateral cephalograms were obtained from a random sample of 405 twelve-year-old Chinese children from a population survey in Hong Kong. Angle’s classification was used to assess the dental arch relationship from orthodontic casts. The jaw-base relationship was assessed from the lateral cephalograms using angular (ANB angle) and linear (Wits analysis) measurements. The correlation between the anteroposterior dental arch and jaw-base relationships was assessed.

Results: The anteroposterior dental arch did coincide with the jaw-base relationships, as expressed by the ANB angle in 61%, the Wits analysis in 67%, and with both in 53%. The jaw-base relationship assessed with the Wits analysis was more significantly associated with the dental arch relationship \( (P < .001) \) than that assessed with the ANB angle \( (P < .01) \). The correlation coefficient between the ANB angle and the Wits appraisal was .65 for the combined sample, and .60, .64, and .67 for Class I, II, and III dental arch relationships.

Conclusion: In this population, the anteroposterior relationship of the dental arch and jaw-base fail to match in at least one out of every three individuals. Linear measurement of anteroposterior jaw-base relationships is a more valid reflection of the dental arch relationship than angular measurements.

KEY WORDS: Cephalometrics; Orthodontics; Malocclusion

INTRODUCTION

Angle’s classification of malocclusion is based on the mesiodistal relationship between the upper and lower dental arches. Subsequent studies revealed that the dental arch relationship is largely affected by the facial skeleton upon which the teeth are invested. Björk pointed out that local changes confined to the teeth can exercise a limited effect on the discrepancy in the relationship between the upper and lower dental arches, whereas facial or cranial configurations may produce marked effects. Thus, the relationships between craniofacial morphology and malocclusion have long been of interest to orthodontists. Studies have primarily investigated the relationship between the type of malocclusion and cranial base angle, vertical facial dimensions, and size of both jaws. However, few studies have investigated the relationship between the anteroposterior dental arch and jaw-base relationships.

An area of extensive debate within orthodontics is whether the anteroposterior dental arch correlates with the jaw-base relationship, and thus whether both need to be assessed in orthodontic diagnosis and treatment planning. Because assessments of both the anteroposterior dental arch and jaw-base relationships are made in the sagittal plane, it is plausible that they are highly correlated, though some have suggested that there is poor relationship between them. A popula-
tion-based study is required to strengthen the evidence as to whether the anteroposterior dental arch relationship is correlated with the jaw-base relationship.

Haavikko and Hele\textsuperscript{12} studied 1017 Finnish children aged from 2.5 to 19 years and concluded “among Finnish children every Angle class includes a large proportion of atypical facial types”. However, the age range of subjects within that study varied considerably and thus the sample had varying degrees of dental arch and jaw-base development. They also reported that in Angle Class III the frequency of skeletal Class III (38\%) was smaller than that of skeletal Class I (62\%).\textsuperscript{12} In contrast, Milacic and Markovic\textsuperscript{14} reported that 85\% of Angle Class III individuals had identical dental and skeletal relationships in a study of 585 Swiss orthodontic patients. The conflicting evidence is likely to be related to the samples that have been studied, which for the most part have been convenient clinical samples as opposed to random samples drawn from a population. From a large sample of 8- to 16-year-old Caucasian orthodontic patients, a moderate association was reported between the first permanent molar relationship and four different methods of assessing jaw-base relationship\textsuperscript{13} ie, r = .50 for ANB and r = .64 for Wits appraisal. However, the proportion of Class II patients was more than 70\%, far above that of a population sample.\textsuperscript{16}

It is generally accepted that Angle’s classification is valuable when assessing the anteroposterior dental arch relationship. Both angular and linear measurements have been proposed in the assessment of anteroposterior jaw-base relationship.\textsuperscript{13,17–19} However, each of the methods described exhibits its own inherent weakness, based on the variability of factors other than the jaw relationship itself.\textsuperscript{13,17} The correlation between anteroposterior dental arch relationship and anteroposterior jaw-base relationship assessed by angular and linear measurements has not been undertaken in a population study.

This study aims to investigate the association between anteroposterior dental arch and jaw-base relationships in a population sample of Chinese children. In addition, the study aims to compare angular vs linear measurements of the association between anteroposterior dental arch and jaw-base relationships.

**MATERIALS AND METHODS**

**Sample**

The data for this study were derived from the records of 12-year-old Chinese children from Hong Kong who participated in a large population survey. Orthodontic casts and lateral cephalometric radiographs were obtained at random from 405 of the children,\textsuperscript{20} and this sample formed the present study group. Orthodontic casts were taken in centric occlusion and trimmed with symmetrical bases.\textsuperscript{16} Lateral cephalometric radiographs were taken in natural head posture.\textsuperscript{21} Of the orthodontic casts and lateral cephalometric radiographs obtained in the population study, the records of 306 (75\%; study sample) of 405 subjects were amenable for analysis; only lateral cephalograms were available for the remaining 99 subjects. There were no statistically significant gender differences for molar and skeletal classifications; subsequently, data for both genders was combined for analysis. Ethical approval had been obtained for this study from the Ethics Committee, Faculty of Dentistry, The University of Hong Kong.

**Data Collection**

**Study cast measurement.** Two trained and calibrated examiners assessed the molar relationship of the 306 orthodontic casts (anteroposterior dental arch relationship) on the basis of Angle’s definition using dividers and standard rulers. The upper first molar mesiobuccal cusp width of each subject was measured and was regarded as one cusp width. Molar Class I was defined as occurring where the mesiobuccal cusp of the upper first molar occluded with the mesiobuccal groove of the lower first molar within the range of less than half a cusp width anteriorly or posteriorly. Molar Class II was defined as occurring where the mesiobuccal cusp of the upper first molar occluded anterior to the Class I position. Molar Class III was defined as occurring where the mesiobuccal cusp of the upper first molar occluded posterior to the Class I position. Twenty-five percent of the casts were reassessed for inter- and intraexaminer reliability. The study sample of 306 subjects was distributed into three different classes based on the molar relationship (Figure 1).

**Cephalometric analysis.** The 405 lateral cephalometric radiographs were digitized twice and analyzed by an independent examiner using the program CAS-SOS (Computer-Assisted Simulation System for Orthognathic Surgery; Soft Enable Technology Limited, Hong Kong, PRC). The cephalometric reference values of anteroposterior jaw-base relationship were assessed using angular measurement by the ANB angle\textsuperscript{18} and linear measurement by the Wits analysis\textsuperscript{19} of the 405 lateral cephalograms (Figure 2), and the jaw-base relationships were categorized into three groups (skeletal Class I, II, III). Skeletal Class I was defined as values within the range of mean value of the sample ± one standard deviation. Class II was defined as greater than mean value plus one standard deviation. Class III was defined as less than mean value minus one standard deviation (Table 1). Thereafter, the study...
sample of 306 subjects was allocated to the three different skeletal classes based on the ANB angle and Wits appraisal, respectively (Figure 1).

Data analysis. In assessing inter- and intraexaminer reliability, method errors (M.E.) were calculated by Dahlberg’s formula, \[ \text{M.E.} = \sqrt{\frac{\sum d^2}{2n}}, \] where \( d \) is the registrations differences between the two registrations, and \( n \) is the number of double registrations. The M.E. for the intra- and interexaminer’s measurements of molar relationships were not statistically significant \((P > .05)\). The M.E. for linear and angular measurements of the cephalometric radiographs did not exceed 0.5 mm and 0.7°, respectively \((P > .05)\).

Frequency tables were produced to determine the distribution of the children with different anteroposterior dental arch relationships (Angle’s definition of molar relationship) and different jaw-base relationships (ANB angle and Wits analysis). The percentage of concordance between the dental arch and jaw-base relationships was assessed. Variations in ANB angle \(^\circ\) and Wits appraisal (mm) with respect to molar classification were assessed using Kruskal-Wallis tests (a nonparametric equivalent to analysis of variance). Association between molar classes and skeletal classes was assessed through cross-tabulation using Fisher’s exact test. Correlation analysis was used to investigate the association between ANB angle and Wits appraisal.

RESULTS

The distribution of the study sample of 306 children into the molar and skeletal classes is given in Figure 2. The dento-skeletal morphology assessed from the lateral cephalograms did not differ between those included in this study and those with missing orthodontic study casts. Class I molar relationship was most common (73.2%), followed by Class II (19.9%) and Class III (6.9%). The jaw-base relationship (skeletal classes) assessed by the ANB angle and Wits analysis differed significantly among the three molar classes (Figure 3).

Significant association between molar classes and skeletal classes was found when the jaw-base relationship was assessed by the ANB angle \((P < .01)\), and a stronger significant association was found when jaw-base relationship was assessed by the Wits analysis \((P < .001)\) (Table 2). Sixty-one percent of the subjects had identical anterior-posterior classes in dental arch and jaw-base relationships determined by ANB angle, 67% of subjects had identical classes determined by Wits analysis, and 53% with both the ANB angle and Wits analysis (Table 3).

Among the molar Class I group, 72.8% were cate-
Figure 3. (A) Mean values ± standard deviation for ANB angle (°) in various molar classes. (B) Mean values ± standard deviation for Wits appraisal (mm) in various molar classes. The lines represent the range of the skeletal parameters.

**Table 2.** Distribution of 306 Children With Identical Anteroposterior Dental Arch and Jaw-Base Relationships

<table>
<thead>
<tr>
<th>Molar Class</th>
<th>ANB, °</th>
<th>Wits, mm</th>
<th>ANB &amp; Wits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class III</td>
<td>7 (2.3)</td>
<td>8 (2.6)</td>
<td>5 (1.6)</td>
</tr>
<tr>
<td>Class I</td>
<td>163 (53.3)</td>
<td>175 (57.2)</td>
<td>134 (43.5)</td>
</tr>
<tr>
<td>Class II</td>
<td>18 (5.9)</td>
<td>23 (7.5)</td>
<td>14 (4.6)</td>
</tr>
<tr>
<td>Total</td>
<td>188 (61.4)</td>
<td>206 (67.3)</td>
<td>163 (53.3)</td>
</tr>
</tbody>
</table>

* p < 0.05; ** p < 0.01; *** p < 0.001

**Table 3.** Distributions of 306 Children With Various Dental Arch (Molar Classes) and Jaw-Base Relationships (Skeletal Classes) Assessed by ANB (°) and Wits Analysis (Mm) on the Basis of Molar Classes

<table>
<thead>
<tr>
<th>Molar Class</th>
<th>ANB**</th>
<th>Wits***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>III</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>n %</td>
</tr>
<tr>
<td>Class III</td>
<td>21</td>
<td>7 (33.3)</td>
</tr>
<tr>
<td>Class I</td>
<td>224</td>
<td>35 (15.6)</td>
</tr>
<tr>
<td>Class II</td>
<td>61</td>
<td>8 (13.1)</td>
</tr>
<tr>
<td>Total</td>
<td>306</td>
<td>50 (16.3)</td>
</tr>
</tbody>
</table>

** P < .01; *** P < .001.
Table 4. Distributions of 306 Children With Various Dental Arch (Molar Classes) and Jaw-Base Relationships (Skeletal Classes) Assessed by ANB (°) and Wits Analysis (mm) on the Basis of Skeletal Classes

<table>
<thead>
<tr>
<th>Skeletal Class</th>
<th>III</th>
<th>I</th>
<th>II</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANB, °</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>50</td>
<td>7 (14.0)</td>
<td>35 (70.0)</td>
<td>8 (16.0)</td>
</tr>
<tr>
<td>Wits, mm</td>
<td>40</td>
<td>8 (20.0)</td>
<td>31 (77.5)</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Wits, mm</td>
<td>212</td>
<td>14 (6.6)</td>
<td>163 (76.9)</td>
<td>35 (16.5)</td>
</tr>
<tr>
<td>Wits, mm</td>
<td>44</td>
<td>13 (5.8)</td>
<td>175 (77.8)</td>
<td>37 (16.4)</td>
</tr>
<tr>
<td>Wits, mm</td>
<td>44</td>
<td>0 (0.0)</td>
<td>26 (59.1)</td>
<td>18 (40.9)</td>
</tr>
<tr>
<td>Wits, mm</td>
<td>44</td>
<td>0 (0.0)</td>
<td>18 (43.9)</td>
<td>23 (56.1)</td>
</tr>
</tbody>
</table>

Figure 4. Regression between ANB angle and Wits appraisal for (A) reference sample, (B) the study sample, (C) molar Class III group, (D) molar Class I group, and (E) molar Class II group.

classification,¹ and the two most commonly used cephalometric methods, ANB angle¹⁸ and Wits appraisal,¹⁹ were investigated in a comprehensive population sample for the first time in the orthodontic literature. The present sample comprised study models and lateral cephalograms obtained from a large proportion of a randomized sample of 12-year-olds included in an oral and health survey in the mid-1980s.²⁰ Almost 20 years...
later, all cephalograms were available, but only three out of four orthodontic study models. Some orthodontic study models were missing, and others were partly damaged and thus not amenable to analysis.

The dento-skeletal morphology assessed from the lateral cephalograms did not differ between those included in this study and those with missing orthodontic study casts, which might indicate that the “dropout” or “loss” was at random. The present sample’s prevalence of molar classes was in general agreement with a large population study of Chinese children. The mean values of ANB and Wits are also in general agreement with previous studies. Consequently, the results of this study could be considered as representative of its original population.

The choice of a 12-year-old cohort for the oral health survey was mainly due to the following reasons: (1) the severity and the type of malocclusion that can be detected from a child at this age is representative of his/her problem in the future; (2) a better assessment of the original crown diameter of the permanent teeth can be made because little or no enamel attrition has altered the mesiodistal or buccolingual dimensions of the teeth; and (3) a child at this age would tend to have fewer carious, restored, or extracted teeth due to the recent emergence of the permanent teeth, and so would be ready for orthodontic treatment. The cephalometric values obtained from 12-year-olds seem to be valid for a larger age range because it has been reported that there is no statistically significant difference for cephalometric parameters in 7- to 13-year-olds.

This study showed that only half of the subjects had an agreement with dental arch relationship and jaw base relationship assessed by angular and linear measurements (Table 3). However, there was an agreement between dental arch and jaw-base relationship in two out of three subjects when assessed with one method only. Consequently, the “facial type” did not match the type of occlusion in about 30% of the subjects. It is thus evident that the Angle classification of occlusion, based on the dental arch relationship alone, will not reveal the full picture of dento-facial deformity, not even in the sagittal plane. This was in accordance with other studies. It is obvious that orthodontic patient samples can be heavily biased, eg, it was reported from a study using orthodontic patient samples that dental arch and skeletal Class III individuals coincide in 85% of patients, whereas results from this study and another population study demonstrate that the unbiased figure is far less (Table 2).

This study showed that Wits appraisal based on linear measurement along the occlusal plane seems to reflect the dental arch relationship and the underlying jaw-base relationship better than angular measurement (ANB angle) using the same landmarks on the maxilla (A-point) and mandible (B-point), respectively. Consequently, the method errors for locating those two cephalometric landmarks were identical for both ANB angle and Wits appraisal. To assess the ANB angle, the nasion (N-point) was located. It has been pointed out the clinical experience has revealed that the cephalometric landmark nasion (N) is difficult to identify on Southern Chinese patients. As point N is not involved in Wits appraisal, all errors associated with its identification, as well as the inconsistencies in the angle ANB due to varying horizontal and vertical positions of N, are irrelevant. Another plausible reason as to why Wits analysis proved superior might be that when defining the functional occlusal plane in Wits analysis, two landmarks are used, the midpoints of overlap of the mesiobuccal cusps of the first molars and the buccal cusps of the first premolars. The anteroposterior dental arch relationship using Angle’s classification is based on the first permanent molars, which were assessed close to the functional occlusal plane.

The regression between the ANB angle and the Wits appraisal was statistically significant. The association between the variables of ANB angle and Wits appraisal did not differ among the various classes of dental arch relationship (Figure 4C–E)

CONCLUSIONS

• The anteroposterior dental arch and jaw-base relationships did not match in one of three individuals.
• Linear measurement of anteroposterior jaw-base relationship is a more valid reflection of the dental arch relationship than the angular measurement.
• The prediction between the variables of ANB angle and Wits appraisal is moderately independent of the dental arch relationship.

ACKNOWLEDGMENT

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REFERENCE