Dental arch asymmetry in children with large overjets

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Angle[1] recognized that asymmetry was a distinct component of malocclusion; in fact, he designated it as a separate subdivision. Malocclusions involving asymmetries are found in a large proportion of 6-to-11-year-old children in the United States, and especially in Class II children.[2]

Approximately two-thirds of the patients who complain of muscular pain and have 3 mm or more asymmetric mandibular deficiency are more Class II on the side with the deficiency.[3] However, dental asymmetry contributes more to Class II subdivision malocclusion than does mandibular skeletal asymmetry when landmarks are measured on submental vertex radiographs.[4,5] Anteroposterior mandibular molar asymmetry is the variable that most differentiates patients with Class II subdivision malocclusion from patients with normal occlusion. The mean difference in the anteroposterior position of the mandibular molars in Class II subdivision is six-fold that of Class I malocclusion. Thus, skeletal asymmetry appears to contribute less to Class II subdivision malocclusion than does mandibular dental asymmetry.

The maxillary arch also contributes significantly to asymmetries in both anteroposterior and transverse dimensions.[4,6-10] In fact, maxillary molar asymmetry contributes almost as much as mandibular skeletal asymmetry to Class II subdivision malocclusion.[4]

Dentoalveolar compensation may modify un-

Abstract

Little is known about asymmetry of children's dental arches. The purposes of this study were to quantify and describe dental arch asymmetry of 151 children with large overjets, and to determine if a spatial relationship exists between dental landmarks in opposing arches. The median palatal plane (MPP) was the reference for transverse measurements. A computer-constructed transverse palatal plane (TPP) was the reference for anteroposterior measurements. More than 30% of the children had transverse asymmetries ≥2 mm at the maxillary first permanent molar (paired *t*-test; $p=0.0001$). The highest mean transverse asymmetry (1.59±1.24 mm) and anteroposterior asymmetry (1.51±1.23 mm) were at the maxillary first permanent molars. A higher proportion of children with large overjets had clinically significant intra-arch asymmetries (≥2 mm) at several bilateral landmarks than norms (99% confidence intervals). Only 3% of these children exhibited interarch molar asymmetries ≥4 mm. The position of the landmarks in one arch varied with the landmarks in the opposing arch (Pearson's correlation; $p=0.0001$). Although many children with large overjets have significant intra-arch asymmetries, few exhibit asymmetric interarch asymmetries.

Key Words

Asymmetry • Children • Dental arch • Overjets

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Table 1
Definitions of acronyms for cast landmarks and planes

Acronym	Definition
U1(L/R)	Upper incisor mesioincisal line angle (left/right)
UC(L/R)	Upper canine cusp tip (left/right)
UEMB(L/R)	Upper second primary molar mesiobuccal cusp tip (left/right)
U6MB(L/R)	Upper first permanent molar mesiobuccal cusp tip (left/right)
L1(L/R)	Lower incisor mesioincisal line angle (left/right)
LC(L/R)	Lower canine cusp tip (left/right)
LEMB(L/R)	Lower second primary molar mesiobuccal cusp tip (left/right)
L6MB(L/R)	Lower first permanent molar mesiobuccal cusp tip (left/right)
MPP	Median palatal plane
TPP	Transpalatal plane
MPPB	Common point at the intersection of the maxillary MPP and the mandibular MPP

derlying skeletal or dental asymmetry.[1,11] Cuspal inclines of opposing teeth can act as guides to correct slightly aberrant eruption patterns. Therefore, asymmetry in one arch could potentially be compensated by the opposing arch. Conversely, asymmetric eruption patterns might be reflected in the opposing arch, depending on the severity of the aberration. However, there is a paucity of information concerning the spatial relationship between dental landmarks in opposing arches of children.[10]

Therefore, the purposes of this project were to quantify and describe dental arch asymmetry in a carefully selected group of Caucasian children with large overjets, and to determine the spatial relationship between interarch landmarks.

Materials and methods

Subjects

Pretreatment dental casts of 151 Caucasian children with overjets of 7 mm or more were drawn from a randomized clinical trial. The sample included 85 males and 66 females whose ages ranged from 7 to 11 years. All subjects had four permanent first molars and central incisors erupted and no evidence of any syndrome, craniofacial malformation, or obvious facial asymmetry.[12]

Landmark identification and digitization

All casts were trimmed using a wax bite in centric occlusion (CO) with the backs perpendicular to the median palatal raphe. Landmarks (cusps of central incisors, canines, primary second molars, and permanent first molars, and two points on the median palatal raphe) as defined by Maurice and Kula[10] were marked with a 0.5 mm lead pencil (Figure 1). The landmarks and reference planes used in this study are presented in Table 1. Photographs of the occlusal surfaces of the casts with the backs of the maxillary and mandibular casts aligned (Figure 1) were printed at 1:1 magnification using measurements taken between two dots placed on each cast distal to the molars.[10] The median palatal plane (MPP) was drawn on the photograph through two landmarks on the median palatal raphe, one adjacent to the second rugae and the other approximately one centimeter distal to the first. An additional landmark was established at the intersection (MPPB) of the MPP and the heels of the casts. One investigator digitized all photographs using the UNC DIGIT program (University of North Carolina, Chapel Hill, Department of Orthodontics, Chapel Hill, NC). The computer program constructed the maxillary and mandibular transverse palatal planes (TPP) 90° to the corresponding MPP through the common landmark (MPPB) at the distal edge of the maxillary and mandibular MPPs. Transverse measurements were taken 90° from MPP to the bilateral landmarks (Figure 2). Similarly, anteroposterior measurements were taken 90° from TPP to the bilateral landmarks.[10] Not all dental landmarks were present, accounting for missing data. The transverse values for mandibular landmarks were not reported because of the uncertainty in horizontal alignment of the maxillary and mandibular casts.

Data analysis

The mean absolute difference in measures between each set of bilateral landmarks to MPP or TPP was calculated for all subjects. Absolute differences indicated the true severity of asymmetry as compared with arithmetic differences, which indicate one-sidedness of asymmetry. The severity of asymmetry considered clinically important was set at 2.0 mm, to compare with values established by Maurice and Kula.[10] The frequency of differences ≥2.0 mm was calculated. Paired t-tests were used to determine whether the differences between each set of bilateral measurements was significantly different from zero. A Bonferroni's procedure to set the level of significance was considered too stringent because of the multiple analyses within the study—a true significant difference might be missed; therefore, the level of significance was set at $\alpha=0.01$.

To determine the amount of asymmetry in molar relationships between sides of the arches, the difference between the anteroposterior distances

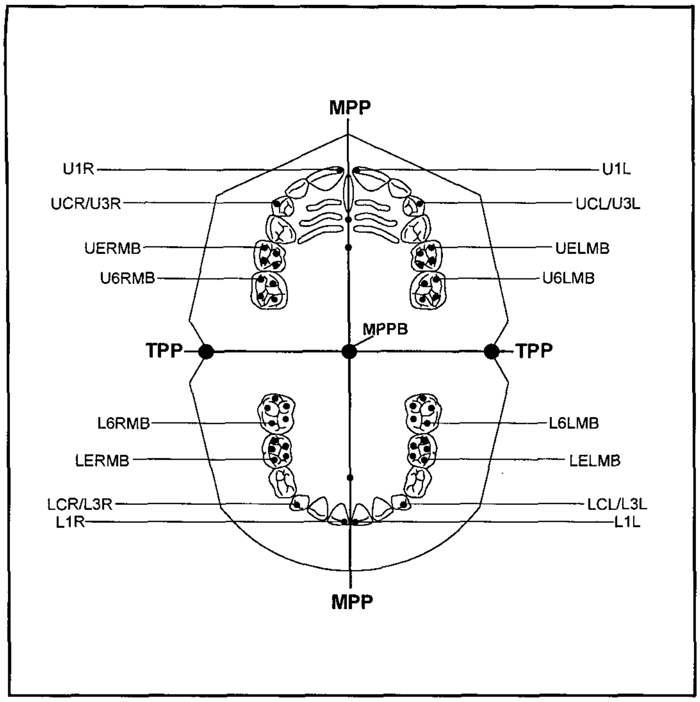

Figure 1

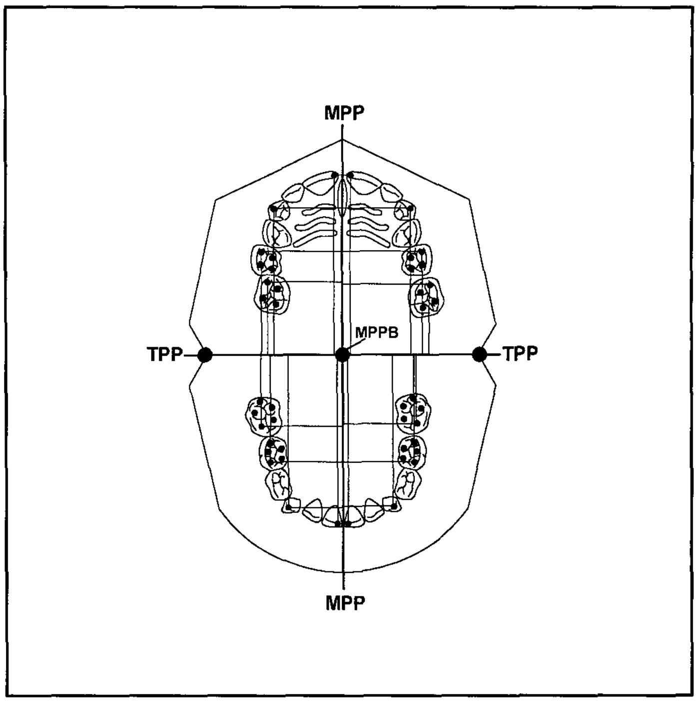

Figure 2

Figure 1
Intra-arch landmark location

Figure 2
Measures from dental landmarks to reference planes

from the maxillary and mandibular mesiobuccal cusps tips of the first permanent molars to the TPP was calculated for each side of the casts. A discrepancy of 2 mm in molar relationships between sides was considered clinically significant, and a difference of 4 mm was considered adequate to produce a subdivision classification. The frequency of subjects with molar relation asymmetries was determined.

Confidence intervals (99%) for absolute anteroposterior and transverse mean differences were used to determine the likelihood that the mean absolute differences of the large overjet group were different from the mean differences of the norms. Confidence intervals for proportions (99%) were used to determine the likelihood that the percentage of children with large overjets and ≥2 mm differences between landmark measures and the percentage of norms having ≥2 mm differences were different from each other.

The relationship between opposing landmark measures in the anteroposterior dimensions was depicted visually using scattergrams. A Pearson's correlation coefficient was calculated for each set of opposing landmark measures to determine if there was a similar tendency for spatial position between the dental arches. The level of significance was set at p=0.01.

Reliability study

Ten casts were marked, photographed, and digitized three times on separate days, as previously described. The intraclass correlation was used to determine intra-investigator reliability between the three sets of digitizations. Intraclass correlations for the 24 measurements of the landmarks to the particular reference plane (MPP or TPP) ranged from 0.91 to 0.99.

In an additional study to determine the method error, three alginate impressions taken of three different dentoforms were poured and trimmed in centric occlusion so that the heels were parallel. The casts were marked, photographed three times, and digitized as previously described. Intraclass correlations for the measurements of the three sets of photographs for each cast ranged from 0.92 to 0.99.

Results

Intra-arch asymmetry

Statistically significant transverse and anteroposterior asymmetries (p=0.0001) were found for all bilateral measures in the large overjet group (Tables 2 and 3). Asymmetry tended to be greatest and most variable at the maxillary first permanent molar in both the tranverse and anteroposterior dimensions. Mean differences for any measure did not exceed 1.59±1.24 mm. The incisors exhibited the smallest mean differences anteroposteriorly in both the maxilla (0.56±0.50 mm) and the mandible (0.51±0.47 mm). The likelihood that the mean anteroposterior asymmetry at the mandibular canines and second molars or the mean transverse asymmetry at the maxillary incisors in the children with large overjets were the same as the mean asymmetry of the norms (Tables 2 and 3) was low (99% confidence

Table 2
Absolute mean differences (mm) between anteroposterior measures of bilateral dental landmarks in children with large overjets

Landmark measure	N	Mean ± SD (mm) Large overjet	Norms# n=52^	Asymmetry >2mm Percentage (number) Large overjet	Norms# n=52^	99% confidence intervals for proportions Lower	Upper
U1-TPP	151	0.56±0.50 +	0.42±0.91	2.0% (3)	0.0% (0)	-0.06	0.02
UC-TPP	137	1.16±0.89 +	0.91±0.72	19.0% (26)	6.1% (3)	-0.27	0.01
UEMB-TPP	130	1.35±1.22 +	1.07±0.77	24.6% (32)$	7.7% (4)	-0.32	-0.02
U6MB-TPP	151	1.51±1.23 +	1.14±0.80	26.4% (40)	11.5% (6)	-0.31	0.01
L1-TPP	146	0.51±0.47 +	0.52±0.50	0.7% (1)	1.9% (1)	-0.05	0.08
LC-TPP	117	1.37+1.12 +	0.61+0.51 @	23.9% (28)$	4.2% (2)	-0.34	-0.05
LEMB-TPP	135	1.29±1.09 *	0.83±0.72 @	22.2% (30)	7.7% (4)	-0.29	0.00
L6MB-TPP	150	1.33±1.14 +	0.95±0.68	25.3% (38)$	7.7% (4)	-0.22	-0.03

Maurice T, Kula K. Angle Orthod 1998;68(1):37-44.
^ Except maxillary canines (n=49) and mandibular canines (n=44)
+ Statistically significant differences between sides (paired *t*-test; *p*=0.0001)
@ Populations not likely to be the same (99% confidence intervals)
$ Populations not likely to be the same (99% confidence intervals for proportions)

Table 3
Absolute mean differences (mm) between transverse measures of bilateral dental landmarks in children with large overjets

Landmark measure	N	Mean + SD (mm) Large overjet	Norms# n=52^	Asymmetry >2mm Percentage (number) Large overjet	Norms# n=52^	99% confidence intervals for proportions Lower	Upper
U1-MPP	151	0.91±0.74+	1.23±0.70@	0	0	0	0
UC-MPP	137	0.94±0.71+	1.00±0.71	8.8% (12)$	12.2% (6)	-0.91	-0.60
UEMB-MPP	130	1.29±1.06+	1.14±0.88	18.4% (24)	15.4% (8)	-0.20	0.14
U6MB-MPP	151	1.59±1.24+	1.31±0.94	31.1% (47)	15.4% (8)	-0.33	0.02

Maurice T, Kula K. Angle Orthod 1998;68(1):37-44.
^ Except maxillary canines (n=49)
+ Statistically significant differences between sides (paired *t*-test; p=0.0001)
@ Populations likely not to be the same (99% confidence intervals)
$ Populations likely not to be the same (99% confidence intervals for proportions)

intervals).

Approximately 30% of the subjects had clinically significant transverse maxillary asymmetry at the first permanent molars, and 25% exhibited maxillary anteroposterior asymmetry at the second primary molars or at the first permanent molars (Tables 2 and 3). Mandibular anteroposterior asymmetry ≥2.0 mm was present in approximately 25% of the subjects. The prevalence and magnitude of anteroposterior asymmetry was similar in the maxillary and mandibular arches (Table 2).

Four of the confidence intervals for proportions (UEMB-TPP, LC-TPP, L6MB-TPP and UEMB-MPP, Tables 2 and 3) did not include zero as a possibility of the difference between the two groups. Therefore, we are 99% confident that the difference in proportions of asymmetric patients in the overjet group was greater than in the norms for those parameters.

Table 4
Correlation between maxillary and mandibular dental landmark measures in children with large overjets

Landmarks	N	Anteroposterior* (r) Large overjets	Norms# n=52^
LIR-UIR	150	0.72	0.79
LCR-UCR	123	0.74	0.84
LERMB-UERMB	122	0.78	0.86
L6RMB-U6RMB	151	0.81	0.89
LIL-UIL	147	0.71	0.81
LCL-UCL	119	0.72	0.83
LELMB-UELMB	133	0.78	0.88
L6LMB-U6LMB	150	0.80	0.90

* Significant correlations (Pearson correlation coefficient; $p = 0.0001$)
# Maurice and Kula. Angle Orthod 1998;68(1):37-44.
^ Except maxillary canines (n=49) and mandibular canines (n=44)

Anteroposterior relationship of maxillary vs. mandibular molars

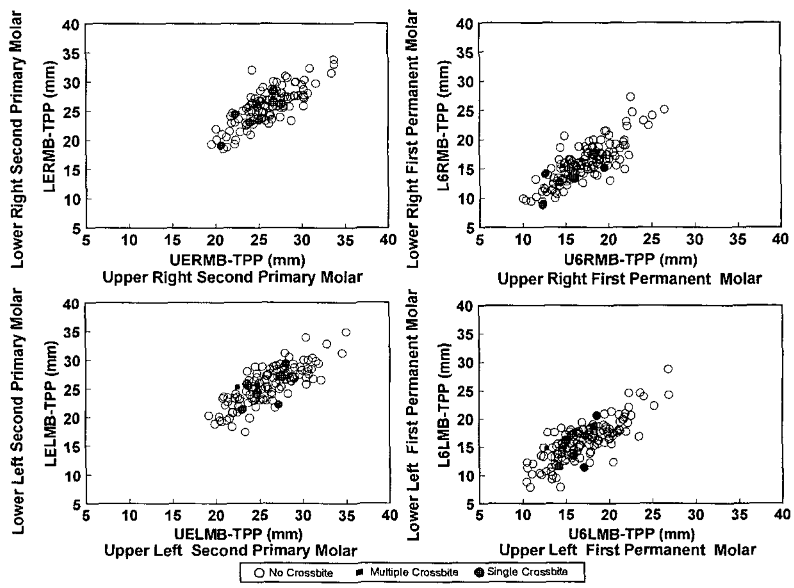

Figure 3

Figure 3
Scattergrams showing the anteroposterior relationships of maxillary vs. mandibular molar landmarks.

Interarch molar asymmetry

A total of 14 (9.3%) patients had 2 mm or more molar asymmetry when the right and left sides were compared; only 4 (2.6%) had 4 mm or more asymmetry.

Correlation between opposing dental landmarks

Strong linear associations existed between all landmark measures in one arch and the landmark measures in the opposing arch and were statistically significant (p=0.0001) (Table 4). Examples of scattergrams depicting the relations between maxillary and mandibular landmark measures are shown in Figure 3.

Subjects with single- and multiple-tooth crossbites were identified on the scattergram (Figure 3). Multiple-tooth crossbites did not appear to cluster nor did they follow a nonlinear trend.

Discussion

Intra-arch asymmetry

Few studies[10] have quantified dental arch asymmetry in children, although asymmetry is reported frequently in adults. Understanding the influence of dental asymmetry on the development of malocclusion and the timing of occurrence is paramount to the successful prevention or treatment of malocclusion. Our study shows that children with large overjets have statistically significant transverse and anteroposterior dental asymmetries. However, few of these absolute values appeared to be from a different population than the norms.[10]

Our data support other reports[4,6,10] that the maxilla contributes substantially to asymmetry in children, although these findings are not supported by de Araujo et al.[9] Clinically significant transverse and anteroposterior maxillary asymmetries occur twice as often in children with large overjets compared with norms.[10] The prevalence of asymmetry in the large overjet group appeared to be dissimilar to norms for only a few landmark measures. The permanent molars account for the greatest prevalence (31%) of clinical asymmetries. Thus, it appears that structural or functional deviations of the mandible are not the sole reason for dental asymmetry.

The prevalence of clinically significant mandibular anteroposterior asymmetries is three times that reported by Maurice and Kula,[10] and this was supported by the confidence intervals for several landmarks. Like other authors,[4,9] we found considerable asymmetry in the transverse dimension of the mandible, but since we were unsure of the orientation of the mandibular casts in the horizontal direction, we did not include this element in our report. Greater maxillary and mandibular asymmetries are also reported in Class II subdivision adults as compared with adults who have normal occlusion.[4] Similar to our sample, children in the permanent dentition with Class II subdivision occlusion exhibited dental asymmetry without accompanying frontal skeletal asymmetry.[8]

Interarch molar asymmetry

Our findings do not support a report[2] that 40% of children 6 to 11 years old with Class II malocclusion had asymmetric molar relationships. Only 10% of our children had a 2 mm difference in the anteroposterior relationship of the bilateral permanent molars. Even fewer (3%) had interarch asymmetries that could be considered severe enough to be classified as subdivision. These results confirm a report that more than 90% of children with large overjet had bilateral Class II molar occlusion.[12]

Smith and Bailit[13] indicated that the anteroposterior molar relationship was the most asymmetric variable in two groups of adults studied. However, fewer than 4% to 6% of a group from a primitive culture had molar asymmetries greater than 2.5 mm, whereas 27% of orthodontic patients studied had asymmetries greater than 2.5 mm. The difference in the degree of asymmetry between the groups was believed to be related to premature tooth loss in the orthodontic patients. Premature loss of primary molars in our subjects was difficult to determine if the subjects were in the late mixed or early permanent dentition. However, few patients in early mixed dentition exhibited premature loss of primary molars.

Correlation between opposing landmarks

The difference in the prevalence of intra-arch asymmetry and interarch molar asymmetry suggests that at least minor asymmetry can be modified during growth. Cuspal inclines of erupting teeth could guide aberrantly placed teeth into acceptable occlusion if the position is not excessively aberrant.[1] Vig and Hewitt[11] suggested that dentoalveolar growth could compensate for skeletal asymmetry. The high degree of interarch association between all maxillary and mandibular dental landmark measures in the anteroposterior dimension indicates that as a tooth in one arch varies in position, the matching tooth in the opposing arch varies as well. Thus, if one landmark is asymmetric in the anteroposterior dimension, the opposing landmark also tends to be asymmetric in the same direction. It appears that asymmetry in both arches tends to be similar.

In the transverse dimension, it appears that compensation also occurs. For example, most of the crossbites were single tooth crossbites (n=8), primarily at the primary second molars. The permanent molars were involved in only three crossbites, two of which involved multiple teeth. Therefore, it appears that even though 30% of this group had clinically significant transverse maxillary asymmetries, few actually presented with either lingual or buccal posterior crossbites, suggesting some mode of compensation.

As expected, correlations between anteroposterior landmark measures of the large overjet subjects are somewhat lower, in general, than those of the norms.[10] Severe anteroposterior arch discrepancies could occur in patients with large overjets because of small or retropositioned mandibles.

A small amount of transverse asymmetry in either the maxillary or mandibular arch could contribute to crossbites by causing occlusal interferences and a functional shift. The mean asymmetry of approximately 1.5 mm in the transverse dimension of the maxillary first permanent molars in our subjects could be adequate to produce a mandibular shift into maximal intercuspation. In addition, subjects with narrow or small mandibles, as might occur in children with large overjet, could also shift laterally into maximal cuspation. A shift could help explain the anteroposterior difference at several of the mandibular posterior landmarks if it caused a mandibular rotation producing an apparent anteroposterior asymmetry. Since the casts were trimmed in centric occlusion, this could explain some of the mandibular asymmetry. However, Rose et al.[5] noted no unusual skeletal positioning in Class II subdivision patients.

Other factors can also contribute to dental asymmetry. Rotation of teeth can contribute to dental asymmetry measurements because of the change in position of the cusp tip. The mesiolingual rotation of first permanent molars, for example, could contribute to transverse asymmetries. Additional studies concerning the relation of molar rotation and asymmetry are required. In addition, the change from late mixed to permanent dentition with the attending loss of primary molars and permanent molar shift could contribute to some of the anteroposterior asymmetries in this group of 7- to 11-year-olds.

Diagnosis of the location of a dental asymmetry is necessary to appropriate treatment of the malocclusion. Treatment mechanics to produce desired molar occlusion applied to the wrong jaw can produce dental midlines noncoincident with the facial midline or slow treatment. Thus, accurate diagnosis of asymmetry is necessary in the treatment of children.

Conclusions

Many children with large overjets have clinically significant asymmetry in each arch, but few children have significant asymmetric molar relationships. Our findings suggest that dentoalveolar compensation helps to modify asymmetries in the dental arches.

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