Dental arch asymmetry in the mixed dentition

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The lack of perfect symmetry of the dentofacial complex is well docu mented.[1,2] Anteroposterior cephalometric radiographs show underlying skeletal asymmetries in children[3] and adults[4] whose faces are considered esthetically pleasing. Dental arch asymmetry is present in most populations, although those with malocclusions tend to have more asymmetry. For example, populations with intact permanent dentitions that have not had orthodontic treatment usually average less than 1.0 mm of transverse or anteroposterior dental arch asymmetry, whereas subjects with untreated Class II subdivision malocclusions have more.[6-11] Adults with missing teeth tend to be more asymmetric than adults with intact dentitions;[12] however, little is known about dental arch asymmetries in children with mixed dentition. Early diagnosis and treatment of dental arch asymmetries could minimize the need for complex treatment mechanics or asymmetric extractions.

Many factors, (i.e., congenital malformations, digital habits, interproximal caries, extractions) can influence dental arch asymmetry.[1,2] However, Angle[13] believed that teeth that were erupting in a somewhat aberrant position could be guided by the cuspal inclines of opposing teeth into a more ideal position. Vig and Hewitt[3] suggested that the dentoalveolar region is more adaptive and shows a greater degree of symmetry than the remainder of the face, probably because of the compensatory growth of the alveolus. However, if the maxillary and mandibular teeth do not coincide in rest position, then asymmetric functional activity can occur

Abstract

Many orthodontists evaluate dental asymmetry clinically by comparing landmarks on the occlusal surfaces of dental casts. The purpose of this study was to quantify and describe maxillary and mandibular intra-arch asymmetry in 52 Caucasian children in the mixed dentition, and to determine if a relationship exists between intra-arch and interarch asymmetry. The median palatal plane (MPP) was used as a reference for transverse measurements. A computer-constructed transverse palatal plane (TPP) was the reference for anteroposterior measurements. Asymmetry greater than 2.0 mm was present at any one landmark in 25% of the sample. Transverse asymmetries exceeded anteroposterior asymmetries in magnitude and prevalence. The high association (Pearson's correlation) between the positions of anteroposterior and transverse interarch landmarks indicated that the arches had similar dimensions. Many children in the mixed dentition have intra-arch asymmetries that are more severe and prevalent in the transverse plane than in the anteroposterior plane.

Key Words

Dental arch • Asymmetry • Children • Mixed dentition

Submitted: November 1995 **Revised and accepted:** May 1996 Angle Orthod 1998;68(1):37-44.

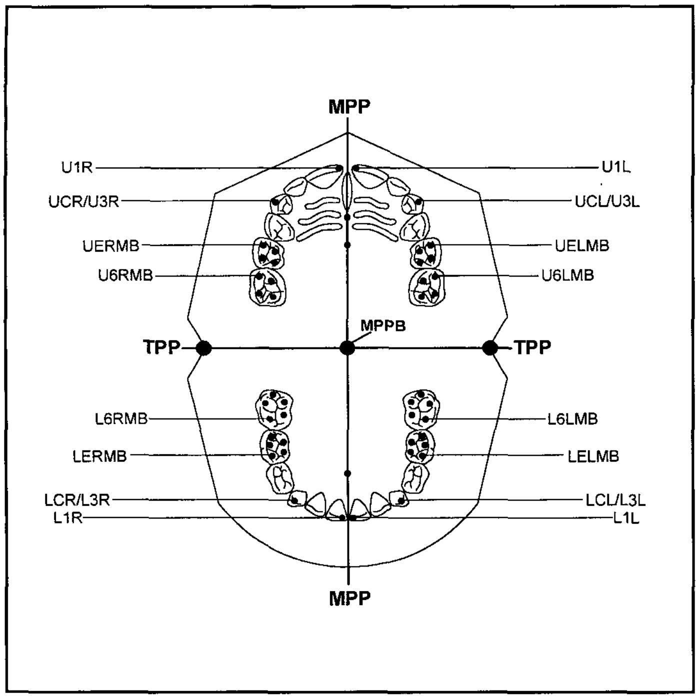

Figure 1

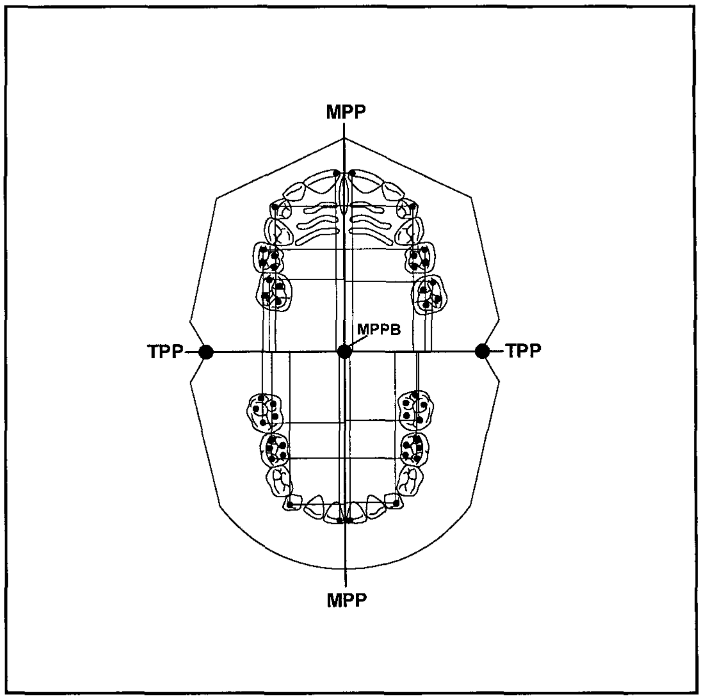

Figure 2

Figure 1
Intra-arch landmarks and reference planes.

Figure 2
Anteroposterior and transverse measurements.

and this can lead to deviated structural growth or to dysfunction of temporomandibular joint structures.[14] However, there is a paucity of data in the literature that addresses the issue of intra-arch dimensions versus interarch relationships of the dental arches.

Accordingly, the purpose of this study was to describe the degree and distribution of dental arch asymmetry in a sample of Caucasian children with relatively intact mixed dentition. At the same time, this study evaluated the relationship between intra-arch and interarch asymmetry in that same group.

Materials and methods

The sample consisted of 52 Caucasian children in the mixed dentition, none of whom were seeking orthodontic care at the time records were taken. A Caucasian sample was chosen to minimize variability from racial differences. The sample included 30 males and 22 females, with a mean age of 9 years 0 months (range, 7 years 3 months to 11 years 1 month). Over a period of 1.5 years, the parents of more than 800 children from pediatric dentistry clinics at the university, two public health clinics, and a private school were contacted personally or by letter requesting the opportunity to examine their children and take dental records if the children met study criteria. The families were reimbursed $10 for their time and expenses if records were taken. This sample represents the patients who met the inclusion criteria and for whom full records could be obtained.

The inclusion criteria required that subjects have all permanent first molars and central incisors and primary second molars erupted. The following exclusion criteria were chosen to minimize variables influencing asymmetry: history of orthodontic treatment or space maintenance, visually apparent interproximal caries, history of primary molar or canine extractions, history of dental trauma, restorations or fractures that included the incisal edges of the permanent central incisors, digit habits past the age of 3 years, ectopically erupting first molars, evidence of a syndrome or craniofacial malformation, or obvious facial asymmetry.

A power analysis was performed to derive the required sample size. We chose an alpha of 0.01 and power of 0.80, assuming that a clinical asymmetry of 2.0 mm with an expected standard deviation of 2.5 mm was to be detected. Since the actual sample size was greater than the required sample size of 32, and the largest actual standard deviation (1.72 mm) was much less than the expected standard deviation, sufficient power was available to detect a true difference of 2.0 mm.

The parents completed health and dental histories and gave informed consent for study. One investigator performed all clinical examinations and collected all data. Alginate (Jeltrate Plus, Caulk Division, Dentsply International Inc, Milford, Del) impressions were poured in orthodontic plaster within 6 hours. Bite registrations in centric occlusion (CO) were recorded in polyvinylsiloxane impression material (Kerr Stat BR, Kerr Corp, Romulus, Mich). Casts were trimmed in CO by one investigator with the backs 90° to the median palatal raphe.

Although 43 landmarks were marked on the casts using a 0.5 mm lead pencil, only 19 landmarks (cusps of central incisors, canines, primary second molars, and permanent first molars) and the reference planes from which measurements were taken are shown in Figure 1. The other landmarks were used for establishing the reference planes, for orientation of the casts for digitization, or as part of another study. Table 1 defines the acronyms of each of the landmarks or reference planes from which measurements were taken in this study. These landmarks were chosen because they can be evaluated clinically for symmetry and identified easily on a cast, and they have been used in previous studies.[8-10] Occlusal and buccal grooves were not used because of the presence of sealants in children of this age. The occlusal surfaces of the casts were photographed with the backs of maxillary and mandibular casts aligned as shown in Figure 1. Photography was standardized using a Nikon F-2 (Nikon Inc, Tokyo, Japan) body with a 55 mm f3.5 Micro Nikkor lens (Nikon Inc, Tokyo Japan) mounted on a Polaroid MP4 column (Polaroid Corporation, Cambridge, Mass) and centering on casts placed on a flat elevated glass surface to diminish shadows. The distance between two reference dots placed on each cast was measured (Sylvac Ultra-Cal Mark III digital calipers, Fred F. Fowler Co Inc, Newton, Mass) and used to print 1:1 photographs.

The median palatal plane (MPP, Figure 2) was drawn on the photograph through two landmarks identified along the median palatal raphe. One landmark was identified as the point on the median palatal raphe adjacent to the second ruga. The other point was identified on the median palatal raphe 1 cm distal to the first point. The angle between the maxillary MPP and the back of the cast was measured. The mirror image of that angle was transferred to the mandibular cast to establish the mandibular MPP.

A computer program (UNC DIGIT program, UNC-CH Department of Orthodontics, Chapel Hill, NC) was used to construct maxillary and mandibular transverse palatal planes (TPPs) 90° to the corresponding MPP through a common landmark (MPPB) at the distal edges of the maxillary and mandibular MPPs.

One investigator digitized all photographs three times. Eight maxillary and eight mandibular transverse linear measurements were taken of lines constructed by the computer 90° from the MPP to the dental landmark (Figure 2). Similarly, eight maxillary and eight mandibular anteroposterior linear measurements were taken of lines constructed 90° from the TPP to the dental landmarks.

Table 1
Definitions of acronyms for cast landmarks or 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

The arithmetic mean for the sample was calculated by averaging the arithmetic differences (right measurement subtracted from left measurement) for all subjects (three digitizations each). A negative arithmetic mean indicated the right side measurement was larger than the left, while a positive arithmetic mean indicated the left side measurement was larger than the right.

The 99% confidence intervals (99% probability that the true population mean was within the interval) were used to describe both the degree of asymmetry and the one-sidedness of any asymmetry.

The mean absolute difference for each landmark was calculated by averaging the absolute differences for all subjects (three digitizations each). Absolute differences demonstrated the true magnitude of asymmetry, whereas arithmetic differences masked the magnitude of differences. The frequency of differences that exceeded 2.0 mm was calculated.

The degree of asymmetry considered to be clinically important was arbitrarily set at 2.0 mm. A one-tailed median sign test was used to determine whether the mean of the absolute differences was significantly different from the difference (2.0 mm) that was considered clini-

Table 2
Transverse intra-arch mean differences (mm) of children in the mixed dentition

Landmark measure	N#	Arithmetic mean* ± S.D. (mm)	Absolute mean ± S.D. (mm)	99% confidence intervals Lower	Upper	Asymmetry >2mm Percentage (N)
UI-MPP	52	0.40 ± 1.36	1.23 ± 0.70	-0.11	0.90	15.4%(8)
UC-MPP	49	0.77 ± 0.96	1.00 ± 0.71	0.40	1.14	12.2% (6)
UEMB-MPP	52	0.75 ± 1.23	1.14 ± 0.88	0.30	1.21	15.4% (8)
U6MB-MPP	52	0.86 ± 1.36	1.31 ± 0.94	0.36	1.37	15.4% (8)
LI-MPP	52	-0.52 ± 1.18	1.11 ± 0.63	-0.96	-0.08	9.6% (5)
LC-MPP+	44	0.32 ± 1.72	1.48 ± 0.92	-0.38	1.02	25.0% (11)
LEMB-MPP	52	0.19 ± 1.56	1.35 ± 0.79	-0.39	0.77	17.3% (9)
L6MB-MPP	52	0.27 ± 1.54	1.26 ± 0.91	-0.30	0.84	19.3% (10)

N = Sample number
* Differences were calculated as right/MPP from left/MPP
+ Statistically significant differences (median sign test; $p \leq 0.01$)

cally important, H_0:m=1 mm. Although paired *t*-tests indicated that all differences between bilateral landmarks were significantly different ($p \leq 0.005$) from 0.0 mm, the one-tailed median sign test was used because the median is the descriptive statistic least affected by a skewed distribution.

Scattergrams of the relationship between opposing landmarks in the transverse and anteroposterior dimensions were developed. A Pearson's correlation coefficient was calculated for each set of opposing landmarks to determine if there was a similar tendency for asymmetry between the dental arches. Significance was accepted at $p \leq 0.01$.

Three alginate impressions were made of each of three dentoforms. The resulting nine trimmed casts were photographed and the photographs were digitized as previously described. Intrainvestigator reliability was evaluated using the intraclass correlation. The intraclass correlations for the 32 measurements ranged from 0.32 to 0.99. Only one measurement (LIL-MPP) had a correlation less than 0.73 (0.32).

Results

Small transverse and anteroposterior dental arch asymmetries were found in both arches (Tables 2 and 3). Although the values were low, the left sides were larger (both upper and lower confidence intervals positive) for three transverse measurements (UC-MPP, UEMB-MPP and U6MB-MPP); the right sides were larger (both upper and lower confidence intervals negative) for one measurement (LI-MPP) (Table 2). There was no tendency toward one-sidedness in the anteroposterior dimension (Table 3).

The mean absolute differences (Tables 2 and 3) were slightly greater in the transverse dimension (1.00 mm to 1.48 mm) as compared with the anteroposterior dimension (0.42 mm to 1.14 mm). The only statistically significant difference ($p<0.01$) occurred in the transverse dimension at the mandibular canine region (Table 2).

Transverse asymmetry greater than 2.0 mm was present at any one landmark (Table 2) in as many as 25% (n=11) of the subjects, whereas anteroposterior asymmetry was present in as many as 11.5% (n=6) (Table 3). The prevalence of anteroposterior asymmetries increased in the posterior part of the arches and the percentage and the magnitude of anteroposterior asymmetry was slightly greater in the maxillary arch (Table 2). These trends were not apparent in the transverse dimension (Table 1).

All opposing interarch dental landmarks were significantly correlated ($p \leq 0.0001$) in the transverse and anteroposterior dimensions (Table 3), except the left incisors (transverse dimension). Examples of scattergrams for the anteroposterior and transverse relationships between maxillary and mandibular landmarks are shown in Figures 2 and 3. There appeared to be a linear relationship in both planes of space between each of the opposing landmarks, but the strength of association or the explanation of variability of one arch

Table 3
Anteroposterior intra-arch mean differences (mm) of children in the mixed dentition

Landmark measure	N#	Arithmetic mean* ± S.D. (mm)	Absolute mean ± S.D. (mm)	99% confidence intervals Lower	Upper	Asymmetry >2mm Percentage (N)
UI-TPP	52	-0.05 ± 0.55	0.42 ± 0.91	-0.26	0.16	0.0% (0)
UC-TPP	49	-0.39 ± 1.10	0.91 ± 0.72	-0.81	0.04	6.1% (3)
UEMB-TPP	52	-0.26 ± 1.30	1.07 ± 0.77	-0.74	0.23	7.7% (4)
U6MB-TPP	52	-0.19 ± 1.30	1.14 ± 0.80	-0.70	0.33	11.5% (6)
LI-TPP	52	0.03 ± 0.72	0.52 ± 0.50	-0.24	0.29	1.9% (1)
LC-TPP	44	0.13 ± 0.79	0.61 ± 0.51	-0.20	0.45	4.2% (2)
LEMB-TPP	52	-0.22 ± 1.08	0.83 ± 0.72	-0.62	0.18	7.7% (4)
L6MB-TPP	52	-0.19 ± 1.16	0.95 ± 0.68	-0.62	0.24	7.7% (4)

N = Sample number
* Differences were calculated as right/TPP from left/TPP
+ No statistically significant differences ($p>0.01$)

by the other value was higher in the anteroposterior plane than in the transverse. In the transverse plane, the strength of association between the position of the opposing landmarks was higher in the posterior region than the anterior.

Subjects with multiple tooth crossbites were identified on each scattergram. As noted by the symbol for multiple tooth crossbites in the scattergrams, none of the visual representations of the dimensional relationships between the arches indicated that multiple tooth crossbites clustered or failed to follow the linear trend. The scatter of data for transverse relationships between some molar landmarks appeared slightly greater in subjects with crossbites as compared with those having no crossbites (Figure 3).

Table 4
Correlation between maxillary and mandibular dental landmarks of children in the mixed dentition

Landmarks	N#	Anteroposterior (r)	Transverse (r)
LIR-UIR	52	0.79*	0.38+
LCR-UCR	45	0.84*	0.47*
LERMB-UERMB	52	0.86*	0.50*
L6RMB-U6RMB	52	0.89*	0.65*
LIL-UIL	52	0.81*	0.33ns
LCL-UCL	47	0.83*	0.65*
LELMB-UELMB	52	0.88*	0.77*
L6LMB-U6LMB	52	0.90*	0.85*

N = Sample number
* Pearson correlation coefficient (r); $p < 0.0001$
+ $p = 0.006$
ns Not significant (p=0.017)

Discussion

As many as 25% of the children in the mixed dentition had transverse asymmetries greater than 2.0 mm at any one landmark, although the mean differences were not large (Table 2). Fewer children (11.5%) had anteroposterior asymmetries greater than 2.0 mm (Table 3). The small mean transverse and anteroposterior intra-arch asymmetries in these children in the mixed dentition (Tables 2 and 3) corroborates previous investigations[7-9,14-15] of subjects in the permanent dentition. The significant transverse difference at the mandibular canines (Table 2) could be related to erupting incisors asymmetrically pushing primary canines buccally, or to permanent canines erupting asymmetrically out of the line of the arch. The canine asymmetry could be a transitional problem that would be resolved as the primary teeth exfoliate or a long-term problem of a buccally displaced permanent canine.

Similar to adults,[6,8,12] the prevalence of anteroposterior asymmetry in the mixed dentition increases (Table 3) the more posterior the landmarks, and this could contribute to asymmetric molar relationships. Interestingly, the asymmetry in the anteroposterior dimension is

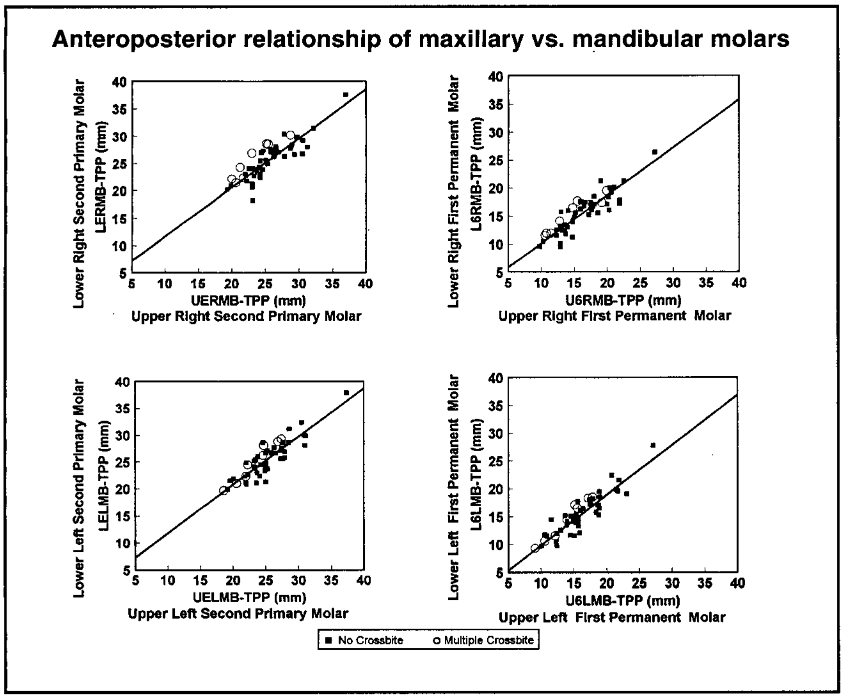

Figure 3

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

not as severe or prevalent as in the transverse dimension in this population. This finding does not support the findings of other studies[8,14] that report larger anteroposterior than transverse asymmetries. There may be age-related differences in dental arch asymmetry because at least one longitudinal study[16] of skeletal asymmetry found that the mandible was longer on the left side at age 6 and on the right side at age 16. Sample differences also may account for some of these differences because Ferrario et al.[15] eliminated all subjects with posterior crossbites, while these subjects were included in our study. Our study sample shows, however, a prevalence (15%) of multiple tooth posterior crossbites similar to that of a population of 1005 noninstitutionalized children aged 8 to 11 years (8.5%).[17] A small amount of asymmetry in the mandibular canine region could contribute to crossbites causing occlusal interferences and a functional shift. However, the maxilla contributes substantially to asymmetry in both transverse and anteroposterior dimensions (Tables 2 and 3) in children; thus, functional or structural deviations of the mandible are not the sole reason for dental arch asymmetry.

Reports[3-6,18-20] of skeletal and dental arch asymmetry do not consistently favor the left versus the right side as larger. Although some landmarks in our study show one-sidedness, the mean arithmetic differences are small and inconsistent and probably are not important clinically.

The high degree of interarch association between the spatial positions of opposing dental landmarks in both the transverse and anteroposterior directions indicates that the dental arches had similar dimensions. In other words, the data suggest that asymmetry found in one arch was also found in the other. The high association between the anteroposterior maxillary and mandibular landmark positions is not unexpected, considering the low prevalence of anteroposterior asymmetries greater than 2.0 mm in either arch. Although opposing cuspal inclines of teeth may guide erupting molars with slightly aberrant positions into good relationships, dental guidance may be difficult with larger differences.[13] Thus, the lower transverse associations between interarch landmarks, particularly in the anterior region, may be related to the greater number of children with transverse asymmetry greater than 2.0 mm or to skeletal relationships of the jaws. Many of these patients (53.8%) had Class II molar relationships; therefore, guiding contacts in the anterior portion of the jaws would be minimal. Although incomplete eruption of the permanent molars could contribute to lower correlations in the transverse dimension compared with the anteroposterior, the fully erupted second primary molars had lower correlations than the permanent molars.

Vig and Hewitt[3] suggested that dentoalveolar structures compensate for cephalometrically evident skeletal asymmetries in children showing no pronounced facial asymmetries. It is tempting to hypothesize that dentoalveolar compensation is responsible for the high degree of association between the distances of opposing landmarks to the reference planes in both the transverse and anteroposterior dimensions. This is particularly tempting because the arches of patients with multiple tooth crossbites appear to have a linearly dimensional relationship between opposing landmarks. However, causal factors in asymmetry, for example, asymmetric chewing,[1] could have affected both arches similarly. Longitudinal studies are needed to determine the extent to which growth and development of the alveolus compensates for asymmetry of children's dental arches.

Many orthodontists evaluating dental arch asymmetry visually analyze the occlusal surfaces of dental casts.[14] Although there is some question as to whether the median palatal raphe is an ideal reference plane in all patients,[6] it is the standard reference plane against which researchers make transverse comparisons of the positions of bilateral dental landmarks.[5-10] The anteroposterior positions of bilateral dental landmarks are usually compared with a transverse palatal plane (TPP) established 90° to the median palatal raphe.[9,10] Researchers have measured casts either directly, using a stereograph,[7] reflex metrograph[21] or a ruled grid,[9,10] or indirectly, by digitizing life-size photographs of oriented casts.[8] There are problems with most of these methods, particularly during the transfer of a median plane to the mandibular cast (i.e., ruled grid placed on the occlusal surfaces of aligned casts). Imprecise trimming of the backs of the casts so that they are not exactly 90° to the median palatal plane can contribute to error in bilateral anteroposterior measurements. For example, the reflex metrograph, a computerized laser beam, uses a swing arm to establish the transverse palatal plane parallel to the backs of the casts even if the backs of the casts are not trimmed 90° to the median palatal plane. Error in our study was minimized by trimming and aligning the backs and heels of the casts relative to each other and the correction of the TPP plane to the MPP planes by the computer. Furthermore, our intraclass correlations for all parameters except mandibular incisors to MPP were very good. The poor intraclass correlation for the incisors could be explained by the small distance of the incisors to the MPP, although the total difference in measurement during the reliability study was similar for the other parameters.

Conclusions

This study quantifies and describes dental arch asymmetry for Caucasian children in the mixed dentition who meet the inclusion criteria of this study and sets the stage for future studies to determine the influence of various factors in dental arch asymmetry.

Small amounts of transverse and anteroposterior asymmetries are common in Caucasian children in the mixed dentition. Statistically significant transverse asymmetry was present at the mandibular canine region. Asymmetries greater than 2.0 mm were more prevalent in the transverse plane than in the anteroposterior. The high degree of interarch association between the spatial positions of opposing dental landmarks in both the transverse and the anteroposterior directions indicates that the dental arches had similar dimensions. Thus, the data suggest that asymmetry found in one arch was also found in the other.

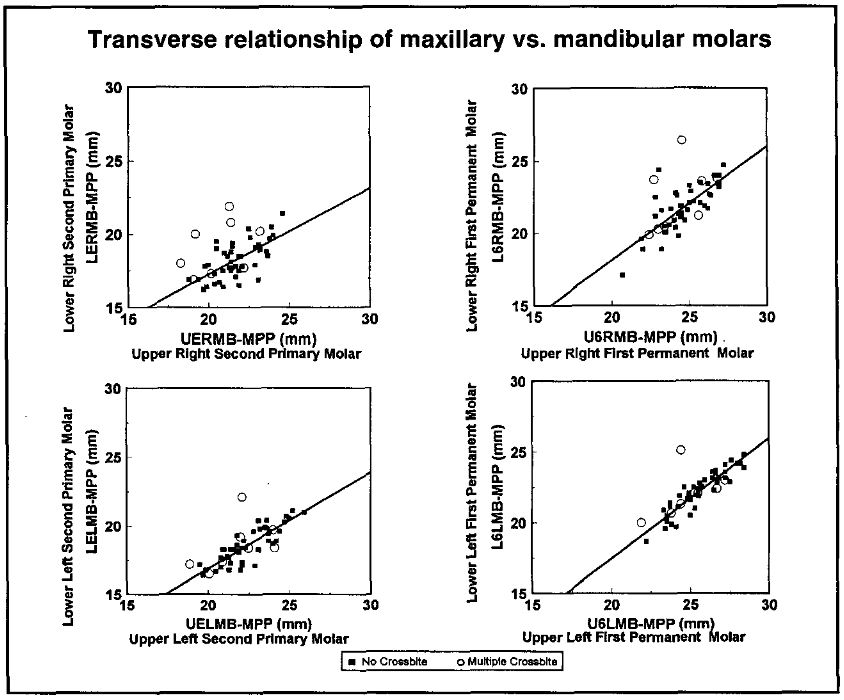

Figure 4

Figure 4
Scattergrams showing the transverse relationships of maxillary vs. mandibular molar landmarks.

Acknowledgments

Gratitude is expressed to Kerr Co. for their donation of materials and to the Pediatric Dentistry Alumni, University of North Carolina Dental School, for their partial financial support of this project. Appreciation is also expressed to Ceib Phillips and Debbie Price for their statistical and computer support. This work was supported by a grant from the USPHS Bureau of Maternal and Child Health (#MCJ-379494).

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