Transverse skeletal and dental asymmetry in adults with unilateral lingual posterior crossbite

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Background: Posterior unilateral lingual crossbite (PUXB) is a common malocclusion in children. However, the extent to which PUXB affects the dentition and craniofacial structures in adults has not been fully defined. We investigated dental and skeletal asymmetry in adults with PUXB. **Methods:** We randomly selected 15 crossbite subjects (mean age, 26.2 years) and 15 matched controls (mean age, 30.6 years) from 3000 records. Mounted pretreatment dental casts were measured to assess dentoalveolar asymmetry, and posteroanterior radiographs were used to evaluate left–right skeletal asymmetry and positional deviations of the mandible. **Results:** A statistically significant difference in mandibular transverse dental asymmetry was observed between adults with PUXB and the control group. However, no significant differences were found in the right–left skeletal asymmetry, although the PUXB group showed more positional deviation of the mandible. Moreover, condylar position analysis indicated that the crossbite group did not show any greater functional shifts than the control group. **Conclusions:** We concluded that PUXB in adults is primarily due to dentoalveolar asymmetry and positional deviation of the mandible and not simply to right–left skeletal asymmetry of the mandible. These data suggest that untreated PUXB in children might lead to progressive asymmetric compensation of the condyle-fossa relationship and result in a positional deviation of the mandible, which, along with a distinct dentoalveolar asymmetry, maintains the crossbite occlusion in adults. (Am J Orthod Dentofacial Orthop 2005;127:6–16)

Posterior unilateral lingual crossbite (PUXB) occurs frequently in children, with a reported incidence of 8.7% to 23.3%.[1-3] It has previously been shown that correcting PUXB by maxillary expansion in children eliminates skeletal and dental asymmetries.[4-6] However, the extent to which PUXB affects the dentition and craniofacial structures in adults has not been fully defined. This study investigated skeletal and dental asymmetry in adults with PUXB.

Ahlgren and Posselt[7] noted a significantly greater number of cuspal interferences in patients with crossbite compared with patients with normal transverse occlusion. When an occlusal interference exists as the mandible closes into the maximal intercuspal position (MIP), a mandibular displacement from the original position, called a *functional shift*, occurs. This displacement continues until there is accommodation to the new MIP, resulting in a functional posterior crossbite. A lateral functional shift of the mandible occurs in approximately 80% of children with PUXB.[8,9] Thus, the mandibular midline deviates toward the crossbite side relative to the maxillary midline, and a subdivision malocclusion results on the crossbite side.[10] Additionally, an asymmetric condylar position occurs, with the crossbite-side condyle being forced superiorly and posteriorly, whereas the noncrossbite-side condyle is distracted inferiorly and anteriorly relative to the glenoid fossa.[4,5]

Uncorrected PUXB in children has been shown to be associated with increased asymmetry in the temporomandibular joints.[11] A mandibular displacement causes a change in the pattern and intensity of functional forces applied to the mandible and the temporomandibular joints. It has been hypothesized that, in a growing person, a displacement can change the modeling process of the mandible and gradually lead to permanent structural asymmetry.[12] An adult patient would be left with a structural asymmetry, considered a functional adaptation to the displacement.[13] There is evidence in the literature to support condylar adaptation.[12-14] Schmid et al[13] found that the mandibular

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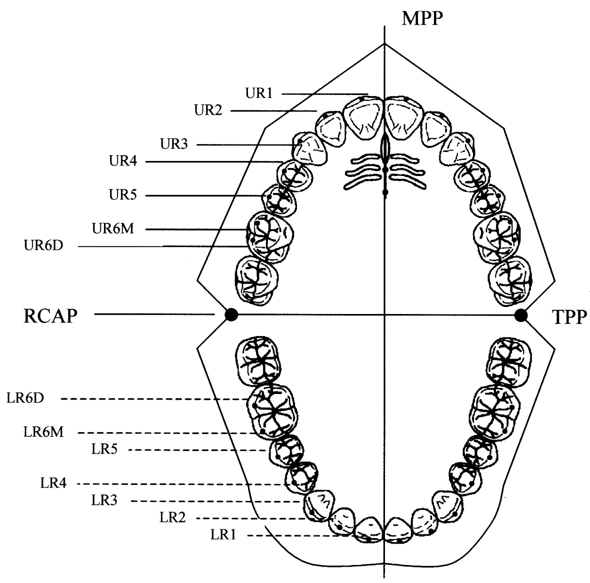

Fig 1. Intra-arch landmarks and reference planes for dental cast analysis. Same acronyms used for left side, except replace "R" with "L" (eg, *UL1*, midincisal point of maxillary left central incisor). *RCAP*, right cast aligning point to relate maxillary arch to mandibular arch; *MPP, TPP*, median palatal plane, transpalatal plane; *UR1*, midincisal point of maxillary right central incisor; *UR2*, midincisal point of maxillary right lateral incisor; *UR3*, cusp tip of maxillary right canine; *UR4*, buccal cusp tip of maxillary right first premolar; *UR5*, buccal cusp tip of maxillary right second premolar; *UR6M*, mesiobuccal cusp tip of maxillary right first molar; *UR6D*, distobuccal cusp tip of maxillary right first molar; *LR1*, midincisal point of mandibular right central incisor; *LR2*, midincisal point of mandibular right lateral incisor; *LR3*, cusp tip of mandibular right canine; *LR4*, buccal cusp tip of mandibular right first premolar; *LR5*, buccal cusp tip of mandibular right second premolar; *LR6M*, mesiobuccal cusp tip of mandibular right first molar; *LR6D*, distobuccal cusp tip of mandibular right first molar.

ramus height on the crossbite side remained relatively shorter during growth. They proposed that the lateral malocclusion leads to a change in the mandibular modeling process. The resulting growth restriction then progresses into mandibular and facial asymmetry.

Inferences from studies on the frequency of unilateral posterior crossbite in various groups[15] and follow-up studies of untreated subjects[16] indicate that PUXB develops early and has a low rate (0%-20%) of spontaneous correction.[3,15,17] The fact that a functional shift is rarely detected in adults with PUXB[18] might be an indication of adaptive remodeling changes in the temporomandibular joint with age, leading to a skeletal and positional asymmetry.[11,18,19]

However, studies that have documented the dentoalveolar, skeletal, and condylar positions of untreated adult patients with unilateral posterior crossbite are conflicting. Pirttiniemi et al[20] concluded that complete adaptation of the temporomandibular joint (TMJ) in adults with PUXB did not take place. In contrast, Cohlmia et al[21] and O'Byrn et al[18] showed that the TMJ complex adapted to displacements of the mandible by condylar growth or surface modeling of the fossa.

The extent to which PUXB affects dental arch asymmetries, skeletal asymmetries, jaw deviations, and temporomandibular positions in adults has not been fully established.[18] The purpose of this study was to quantify the amount of dental and skeletal asymmetry in adults with PUXB. In addition, this study determined the difference in condylar position between adult patients with PUXB and a control group.

MATERIAL AND METHODS

The sample for this retrospective study was collected from patients who sought orthodontic treatment at a private orthodontic office. From 3000 records, 15 subjects (7 women, 8 men) were selected for the crossbite group. A control group of 15 additional subjects (12 women, 3 men) was chosen from the same records. All patients selected for the study had no prior history of orthodontic treatment, and those in the crossbite group had at least 2 teeth in lingual crossbite. Patients with missing, unerupted, or impacted teeth, or extensive restorations, fractures, or defects resulting in dimensional tooth changes were excluded. The maxillary raphe line was readily detectable in all patients. A power analysis established that a sample size of 15 patients and 15 controls would give 80% power to detect a clinical asymmetry of 2 mm or more with a standard deviation of less than 2 mm at the $\alpha = .05$ level.

Dental casts were mounted on a Panadent articulator (Panadent, Grand Terrace, Calif) according to an estimated hinge axis facebow measurement. A centric relation bite registration was obtained with the Roth power centric relation registration technique.[22] The same operator took all records. Posteroanterior (PA) cephalometric radiographs were obtained before orthodontic treatment. Models and bite registration were duplicated for analysis with the backs of the models 90° to the midpalatal raphe.

Dental analysis

With a 0.5-mm lead pencil, 2 points were marked on the model along the midpalatal raphe to serve as the constructed maxillary midline. The first point was selected along the midline at the second palatal rugae,

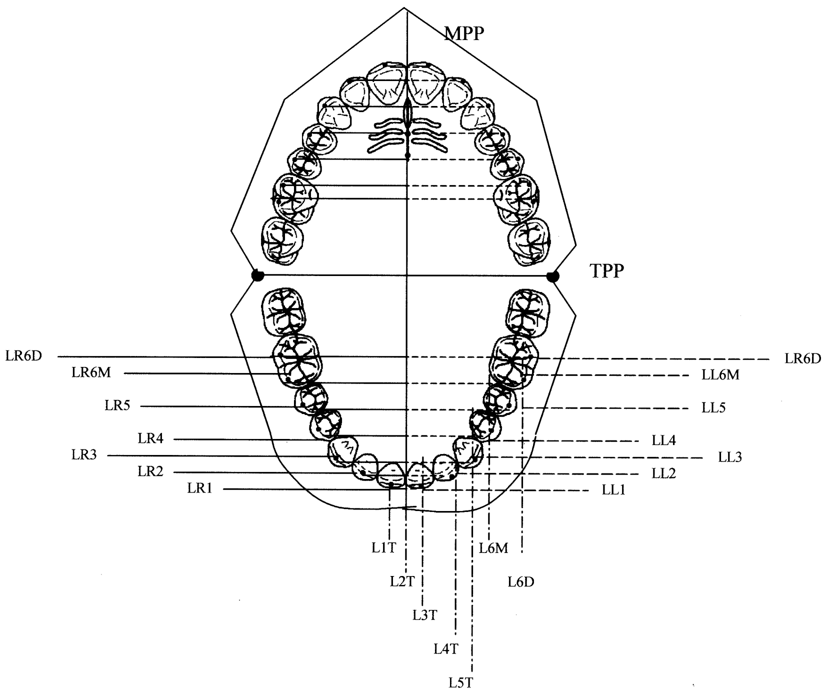

Fig 2. Examples of dental cast measurements in transverse plane for mandible. Similar measurements used for maxillary arch (eg, *U1T*, distance from UR1 to TPP minus distance from UL1 to TPP). *L1T*, distance from LR1 to MPP minus distance from LL1 to MPP; *L2T*, distance from LR2 to MPP minus distance from LL2 to MPP; *L3T*, distance from LR3 to MPP minus distance from LL3 to MPP; *L4T*, distance from LR4 to MPP minus distance from LL4 to MPP; *L5T*, distance from LR5 to MPP minus distance from LL5 to MPP; *L6MT*, distance from LR6M to MPP minus distance from LL6M to MPP; *L6DT*, distance from LR6D to MPP minus distance from LL6D to MPP.

and the second landmark was identified as the most visible posterior point along the midpalatal raphe. These points were chosen because of the stability and reproducibility of the rugae.[17] Pencil dots also identified the midpoints of the incisal edges, canine cusps, and buccal cusp tips of premolars and first molars on the maxillary and mandibular dental casts (Fig 1). A constructed mandibular dental midline was extrapolated from the maxilla, as has been done by others.[17] Left and right points were marked on the most visible posterior side of the maxillary base and transferred to the mandibular base (cast aligning points). In total, 18 landmarks were identified on the maxillary arch and 16 points on the mandibular arch.

Digital occlusal photographs were taken of all maxillary and mandibular casts according to a standardized technique and imported into Adobe Photoshop, version 5.0 (Adobe Systems, San Jose, Calif). Each photo was saved with a 5-mm grid box and then imported into Scion Image (Scion, Frederick, Md; a version of the Macintosh program, NIH Image, from the National Institutes of Health; it can be used to capture, display, analyze, enhance, measure, annotate, and output images; website: www.scioncorp.com/frames/fr_scion_products.htm). Each point in Scion was recorded to an x, y coordinate system with 18 maxillary coordinate points and 16 mandibular points. The points were imported into a Microsoft Excel (Microsoft, Redmond, Wash) program, Dental Cast Asymmetry Analysis, to orient the coordinates and align the maxillary and mandibular casts.

The Dental Cast Asymmetry Analysis program calculated transverse dental arch asymmetry for each tooth by subtracting the distances between the midincisal edges/cusp tip to median palatal plane (MPP) on the right side minus the distance from midincisal edges/cusp tip to MPP on the left side (Fig 2). Positive values indicate a right-sided asymmetry for each tooth. The mean absolute difference for each landmark was calculated by averaging the absolute differences for each group. Absolute differences demonstrate the true magnitude of asymmetry, whereas arithmetic differences mask the magnitude of the differences.

Table I. Asymmetry in crossbite group

Patient no.	*Crossbite side*	*ML dev (mm)*	*Mand dev (°)*	*Dent asym side*	*Mn asym > 2 mm*
1	Left	2 left	2 left	Left	Yes
2	Left	2 left	2 left	Right	Yes
3	Right	2 right	5 right	Right	Yes
4	Right	5 right	3 left	Right	Yes
5	Left	1 left	1 right	Left	Yes
6	Left	2 right	1.5 left	Right	Yes
7	Right	0	2 right	Right	Yes
8	Left	2 right	0.5 right	Left	Yes
9	Right	2 right	1 left	Right	No
10	Right	3 right	1 right	Right	Yes
11	Right	2 right	1 right	Right	Yes
12	Left	4 left	4 left	Left	Yes
13	Left	3 left	1 left	Left	Yes
14	Right	4 right	2.5 right	Right	Yes
15	Left	1 left	2.5 left	Left	Yes

Crossbite side, the side of the maxillary teeth in crossbite; *ML dev,* mandibular midline deviation; *Mand dev,* positional deviation of mandible relative to anterior cranial base; *Dent asym dev,* side that exhibited majority of dental asymmetry; *Mn asym > 2 mm,* whether patient had at least 1 tooth with asymmetry greater than 2 mm.

Table II. Asymmetry in control group

Patient no.	*ML dev (mm)*	*Mand dev (°)*	*Dent asym side*	*Mn asym > 2 mm*
1	3 left	0	Variable	No
2	3 right	1 right	Right	Yes
3	0	2 left	Left	Yes
4	0	2 right	Right	No
5	0	1 left	Variable	Yes
6	0	0	Variable	Yes
7	0	2 right	left	No
8	2 left	.5 right	Variable	No
9	0	3 left	Variable	No
10	0	.5 left	Right	Yes
11	2.5 left	2.5 left	left	Yes
12	2 right	0	Variable	Yes
13	1 left	0	Variable	No
14	0	0	Variable	No
15	1 right	3 left	0	Yes

Variable means that anterior teeth had asymmetry on 1 side and posterior teeth exhibited asymmetry on other side. *ML dev,* mandibular midline deviation; *Mand dev,* positional deviation of mandible relative to anterior cranial base; *Dent asym dev,* side that exhibited majority of dental asymmetry; *Mn asym > 2 mm,* whether patient had at least 1 tooth with asymmetry greater than 2 mm.

Skeletal asymmetry analysis

The PA radiograph provides the most direct assessment of transverse skeletal symmetry compared with other methods. Although rotations of the head can occur and cause errors, ear rods minimize rotation about the vertical and transverse axis.[23] The triangulation method was chosen because it can be used to study overall facial asymmetry by comparing the cranial base, maxilla, mandible, and dentoalveolar areas of the facial complex.[24,25]

Numerous PA cephalometric landmarks were located and recorded with a 0.5-mm lead pencil onto acetate tracing paper. The anatomic points used were defined according to Vig and Hewitt.[25] The landmarks were digitized and imported into Adobe Photoshop, version 5.0. The image file was imported into Scion Image to establish a Cartesian coordinate axes. The scale was set at 18 pixels per 5 mm, as determined from a grid scanned with the landmarks. Twenty skeletal points were recorded on the coordinate axes. These text files were imported into a Microsoft Excel program, Skeletal Asymmetry Analysis, which divided the left and right sides into various triangles, according to the work of Shah and Joshi.[24]

Table III. Transverse dental arch asymmetry (outlier excluded)

Transverse asymmetry	Control (n = 15) Absolute mean (mm)	Control (n = 15) SD (mm)	Crossbite (n = 14) Absolute mean (mm)	Crossbite (n = 14) SD (mm)	Difference	2-sided P value	Confidence interval
U1	1.38	1.02	1.86	1.42	−0.48	.30	−1.42, 0.45
U2	1.09	0.65	1.68	1.14	−0.59	.09	−1.29, 0.11
U3	1.03	0.85	1.74	1.12	−0.71	.07	−1.46, 0.05
U4	1.33	1.32	1.90	0.98	−0.57	.19	−1.46, 0.32
U5	2.00	1.81	2.04	1.06	−0.04	.95	−1.17, 1.11
U6M	2.12	2.09	2.73	1.78	−0.61	.41	−2.09, 0.88
U6D	2.56	2.26	2.97	1.74	−0.41	.59	−1.96, 1.13
UR6D-UL6D	55.51	3.36	56.43	4.03	−0.92	.51	−3.74, 1.89
L1	2.12	1.39	4.05	1.91	−1.93	.0041***	−3.20, −0.67
L2	1.60	1.12	4.98	3.06	−3.38	.0004***	−5.11, −1.64
L3	1.56	1.29	3.83	2.65	−2.27	.0064***	−3.84, −0.69
L4	1.13	0.86	4.21	2.43	−3.08	.0001***	−4.53, −1.76
L5	1.87	1.10	4.19	2.21	−2.32	.0012***	−3.63, −1.00
L6M	1.81	1.78	3.64	2.34	−1.83	.0244**	−3.41, −0.26
L6D	2.01	2.05	3.28	2.20	−1.27	.1192	−2.89, 0.35
LR6D-LL6D	48.96	3.92	52.92	4.12	−3.96	.0132**	−7.02, −0.89

**$P < .05$.
***$P < .01$; Student t test.

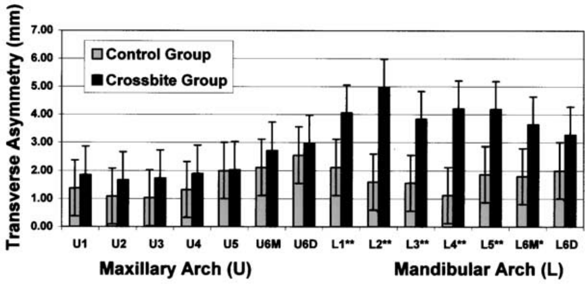

Fig 3. Amount of transverse dental asymmetry between patients with PUXB and control group of patients without crossbite, as measured from dental casts.

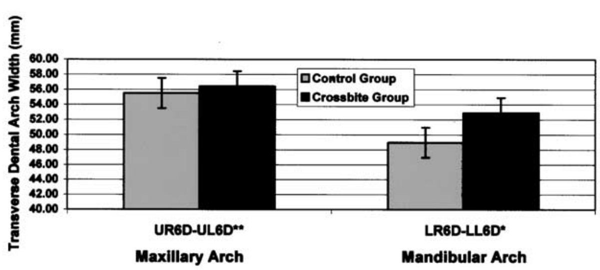

Fig 4. Amount of transverse dental-arch width between patients with PUXB and control group of patients without crossbite, as measured from dental casts.

The Skeletal Asymmetry Analysis program calculated the surface area of each triangle. Asymmetry was calculated for each patient by subtracting the area of the left side from the area of the right side and taking the absolute value. The absolute values identified true asymmetry. Seven variables for each patient were generated. Because of the superimposition of various anatomic structures in the PA radiograph, there is inaccuracy in selecting anatomic points.[21,22] To enhance valid identification, the same operator traced each PA cephalogram twice, at different times, and the mean was calculated for each measurement.

Skeletal midline analysis

The transverse positions of the maxillary and mandibular midlines and the transverse jaw relationships were determined with a method derived by Svanholt and Solow.[26] This method, hereafter referred to as the positional deviation method, was chosen because it is a direct and simple procedure for the analysis of transverse craniofacial development. Numerous PA cephalometric landmarks were located according to the work of Svanholt and Solow.[26] These points were plotted directly from the PA film onto acetate tracing paper, and 4 reference planes were constructed with the points selected to represent maxillary and mandibular skeletal midlines. The angles measured produced 3 variables to assess transverse jaw position.[26]

The transverse maxillary position calculated the deviation of the maxillary midline relative to the anterior cranial base. The transverse mandibular position was determined by the position of the mandibular

Table IV. Mean skeletal asymmetry (mm^2) of controls and cases

	Control (n = 15)		*Crossbite (n = 15)*				
Triangles	*Absolute mean (mm^2)*	*SD (mm^2)*	*Absolute mean (mm^2)*	*SD (mm^2)*	*Difference*	*2-sided* P *value*	*Confidence interval*
A	4.75	2.46	6.08	6.67	−1.33	.48	−5.08, 2.44
B	23.94	20.37	27.62	24.66	−3.68	.66	−20.59, 13.24
C	6.99	6.08	8.09	6.76	−1.10	.64	−5.91, 3.71
D	6.76	6.16	8.29	7.21	−1.53	.54	−6.54, 3.49
E	8.01	7.50	5.85	4.24	2.16	.34	−2.40, 6.71
F	0.98	1.05	0.55	0.65	0.43	.20	−0.23, 1.08
G	26.87	19.59	29.94	24.83	−3.07	.71	−19.79, 13.66

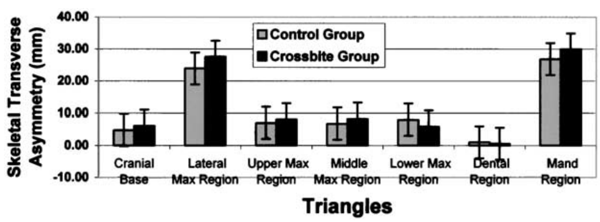

Fig 5. Amount of transverse skeletal asymmetry between patients with PUXB and control group of patients without crossbite, assessed from PA cephalometric measurements.

skeletal midline relative to the anterior cranial base, and the transverse jaw relationship was measured by the deviation of the mandibular dental midline in relation to the maxillary dental midline. If there were no midline discrepancy in either the maxillary or the mandibular midline, all 3 measures would be 0°. These three measurement angles would otherwise indicate a midline discrepancy.

Confirmation of condylar position

Recording asymmetry on either the dental models or the PA radiograph is incomplete without confirmation of the position of the condyle. The condylar position indicator (CPI) records the position of the condylar axis in 3 dimensions within the glenoid fossa on the Panadent articulator and measures the difference in millimeter increments between centric relation and in MIP. Centric relation on the CPI graph is always represented at the origin, and MIP is marked in red with pressure-sensitive ink paper. The CPI value is determined by calculating the distance of the red mark from the (0,0) point (centric relation). A larger absolute CPI value indicates that the condyle is not seated in the fossa.[27] A red mark displaced more than 2 mm from the origin indicates a clinically significant functional shift.[27] The same operator took all CPI recordings for the crossbite and control patients. The crossbite side in the crossbite group was compared with the right side in the noncrossbite group and the noncrossbite side with the left side.

Statistical analysis

To evaluate intraexaminer reliability for the novel method of determining dental arch asymmetry, various measurements were taken. Intraexaminer reliability for dental arch asymmetry has been previously reported.[28]

To determine reliability and reproducibility of PA cephalometric measurements, 10 radiographs were randomly selected, retraced, and remeasured by the same examiner 1 month after the original tracing. Intraclass correlations were calculated and reported.[28]

After the data were determined to have a normal distribution, parametric tests were performed. Two-sided Student *t* tests were used to compare absolute mean differences between the crossbite group and the noncrossbite group for all measures, with α set at .05. During the analysis of the transverse measurements, it was discovered that 1 patient in the crossbite group was an outlier. This patient was eliminated from the PUXB group, and the absolute mean and standard deviations were analyzed again comparing this group with the control group. Reanalysis of the data showed no change in our statistical results.

RESULTS

The PUXB group consisted of 15 subjects (7 women, 8 men) with an average age of 26.2 years. The control group consisted of 15 subjects (12 women, 3 men) with an average age of 30.6 years. Sixty-six percent of the patients in the both groups had Angle Class I malocclusions. In the crossbite group, 1 subject had a Class III malocclusion. The control group had a mean overbite of 2.9 mm and mean overjet of 5.9 mm. The PUXB group had a mean overbite of 1 mm and a mean overjet of 4.2 mm. Tables I and II show detailed descriptions of the groups, with the amount of dental asymmetry in the transverse plane, the mandibular

Table V. Assessment of transverse jaw positions

Variable	*Control (n = 15)*		*Crossbite (n = 15)*		*Difference*	*2-sided P value*	*Confidence interval*
	Absolute mean (°)	*SD (°)*	*Absolute mean (°)*	*SD (°)*			
Maxillary jaw position	0.80	0.73	1.10	1.04	−0.30	.37	−0.97, 0.37
Mandibular jaw position	1.07	1.00	2.00	1.25	−0.93	.032**	−1.78, −0.83
Transverse jaw relationship	1.17	1.14	2.60	2.35	−1.43	.043**	−2.80, −0.05

$^{**}P < .05$, $^{***}P < .01$; Student t test.

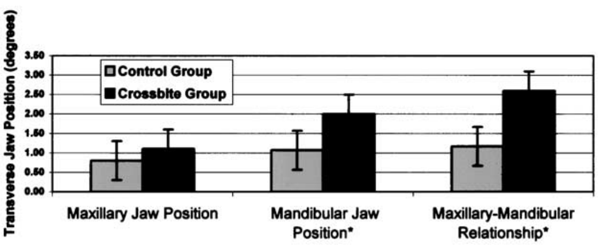

Fig 6. Amount of positional jaw deviation between patients with PUXB and control group of patients without crossbite, assessed from PA radiographs.

midline deviation, and the mandibular positional deviation.

The intraclass correlation test for reproducibility of identifying cusp tips for the dental cast method indicated that the variables were strongly reproducible except for the moderately reproducible results of the linear measures.[28]

Intraclass correlation for the triangulation measurements showed that skeletal asymmetries for triangles B, C, and D were strongly reproducible. However, measurements for triangles E, F, and G were moderately reproducible, and triangle A's measurements were weakly correlated.[28] This agrees with a report by Major et al[23] that addressed the difficulty of landmark identification. Therefore, the measurements were calculated on 2 separate occasions, and the means were calculated.

The reliability for the positional deviation measurements showed a strong correlation for the mandibular deviation and the jaw deviation measures.[28] However, the maxillary deviation measurement was only moderately correlated.

Dental asymmetry

Transverse dental-arch asymmetries (Table III, Fig 3) were found in both arches in both groups. No variable in the transverse plane of the maxilla in the crossbite group was statistically different from those in the control. However, relative to the constructed mandibular midline, the mandibular asymmetries in the crossbite group were statistically more significant than those of the controls. There was a significant difference in the widths of the mandibular arches (LR6D-LL6D). The mandibular arch of the crossbite group was approximately 4 mm wider than in the control group (Fig 4).

Skeletal asymmetry

With the triangulation method, no significant differences in skeletal asymmetry were noted between the groups (Table IV, Fig 5). Although the crossbite group showed slightly larger areas for triangles A, B, C, D, and G, it exhibited asymmetry in the maxillary and mandibular skeletal regions.

However, a significant difference was found between the mandibular jaw position and the transverse jaw relationship between the crossbite group and the control group when the positional deviation method was used (Table V, Fig 6). The mandibular jaw was positioned 1.4° from the maxillary midline in the crossbite group compared with controls. No significant differences were found in the maxillary jaw position.

Condylar position

No statistically significant differences were found in condylar position within the fossa between the 2 groups in the inferior-superior and transverse planes of space (Table VI, Fig 7). These results indicate that adults with unilateral crossbites do not exhibit any more functional shift deviations than a control group.

DISCUSSION

Dental asymmetry

This study corroborates previous investigations showing that dental-arch asymmetry is present in most populations, even without crossbite.[17,29] We found that adults with PUXB malocclusions display more transverse dental-arch asymmetry in both arches. Significant transverse deviation of the mandibular dentition in a crossbite group compared with a noncrossbite group can be due to a mandibular functional shift, dentoalveolar or skeletal asymmetry, or a combination of these factors. PA cephalometric radiographs showed no differences between the skeletal asymmetry of the PUXB

Table VI. Statistics of differences between sides for CPI values

	Control (n = 15)		Crossbite (n = 15)				
Variable	Mean (mm)	SD (mm)	Mean (mm)	SD (mm)	Difference	2-sided P value	Confidence interval
Right side or crossbite side							
y axis (inferior/superior)	1.10	0.87	0.80	0.56	0.3	.27	−0.25, 0.85
x axis (anterior/posterior)	0.90	0.71	0.43	0.42	0.47	.04**	0.03, 0.91
Left side or noncrossbite side							
y axis (inferior/superior)	1.33	0.98	0.87	0.58	0.46	.13	−0.14, 1.06
x axis (anterior/posterior)	1.07	0.65	0.73	0.53	0.34	.13	−0.1, 0.78
Transverse axis	0.37	0.44	0.30	0.32	0.07	.5	−0.22, 0.36

$^{**}P < .05$, $^{***}P < .01$; Student *t* test.

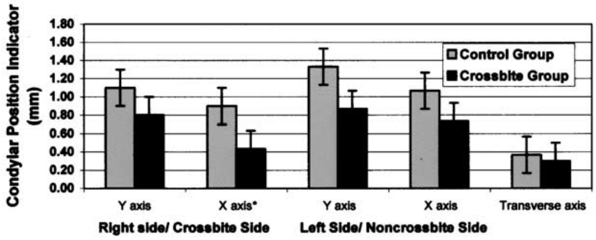

Fig 7. Difference between condylar positions within glenoid fossa between patients with PUXB and control group without crossbite, as measured by condylar position indicator.

group and the control group. In addition, all patients had their dental casts mounted in centric relation, thereby eliminating the functional shift component as an influence of dental asymmetry. Therefore, transverse dental asymmetry, and not skeletal asymmetry, was the primary contributor to the PUXB in adults.

Maintenance and stability of crossbite correction depends on modification of the original source of the problem. The literature shows that unilateral posterior crossbite correction is not always stable. Even for young patients who have been bilaterally expanded and obtained good intercuspation in a buccolingual relationship, treatment success rates as low as 50% have been reported.[30] The transverse dental asymmetry exhibited in PUXB adults, along with mandibular positional deviation, helps explain why crossbite correction is sometimes unstable.[6,9,31]

Using PA cephalograms, Brin et al[30] found that facial and maxillary widths were below normal in children. They indicated that the cause of unilateral crossbite was a deficient maxilla. In this study, we found that the dentoalveolar component of maxillary arch width was larger than in the controls. Moreover, the mandibular arch width of the crossbite group was 4 mm wider than in the control group. The adults with a posterior crossbite had a relative maxillary arch deficiency and not an absolute deficient maxilla, indicating that patients develop a unilateral posterior crossbite because of a large mandible and not because of a deficient maxilla.

Adaptive process of the TMJ complex

This study found no demonstrable maxillary or mandibular right-left skeletal asymmetry in the PUXB group as compared with the control group. This study did not support the belief expressed by some investigators[4,5,6,12,13] that untreated PUXB leads to skeletal asymmetry of the mandible. These results agreed with those of other studies that did not demonstrate mandibular skeletal asymmetry or condylar displacement in the glenoid fossa.[18,21]

The positional deviation method showed that the mandible in the crossbite group was significantly deviated or displaced when related to the cranial base as compared with the control group. The deviation of the mandible relative to the cranial base is not surprising because, by selecting adults with PUXB, this group invariably included patients who must have had mandibular functional shifts during childhood.[18] Although we cannot discount the possibility that the adults had preexisting skeletal asymmetries as children, it is unlikely, because 80% of children with PUXB had a mandibular functional shift.[2,9] It can be questioned whether the functional shifts in these patients as children were really eliminated. Many investigators have proposed that proper mounting of models on an articulator reduces or eliminates neuromuscular effects on the position of the mandible.[22,27,32-35] However, the adaptive posterior or anterior positioning of the glenoid fossa cannot be inferred until condyle positions in the glenoid fossa are measured between the 2 groups.

Several investigators[5,10,18,21] have used corrected tomograms to determine condylar positions in the glenoid fossa. In this study, we used the CPI to document the axis of rotation of the head of the condyle in relation to the glenoid fossa. Although tomograms were available for all patients in this study, CPIs were chosen because of the difficulties in analyzing tomograms. A tomograph is a 2-dimensional medium that does not image the entire joint and cannot be used to assess a 3-dimensional object.[27] Joint space measurements from corrected tomograms might have limited diagnostic value.[10] In contrast to the tomograms, the CPI has been demonstrated to be accurate, reliable, and useful in assessing the positional change of the condylar head in the glenoid fossa.[35]

There was no difference in condylar position between the PUXB group and the control group. Moreover, PA radiographic skeletal analysis showed no differences between the skeletal asymmetry of groups; however, there was a significant difference in the positional deviation of the mandible between the groups. With the combination of findings from the PA radiographs and the CPI analysis, it can be concluded that there was an adaptive repositioning of the glenoid fossa.

The adaptive nature of the glenoid fossa has been shown in numerous descriptions of the functional anatomy of the TMJ after changes in occlusion and the position of the mandible.[36-38] Pirttiniemi et al[20] postulated that the mandible might not remain in the asymmetric MIP long enough to affect the craniofacial growth adaptation. However, it has been shown that temporal muscle activity is asymmetric in the postural positions of patients with unilateral posterior crossbites.[39,40] Consequently, the mandible might be asymmetrically positioned most of the time.[20]

If the PUXB is uncorrected in adults, either the TMJ complex remodels or there are changes in the mandibular modeling process leading to skeletal asymmetries.[4-6] Our data lead us to speculate that the lack of functional shifts in adults with PUXB might be due to TMJ complex remodeling. Therefore, the asymmetric condylar position in children with PUXB leads to a progressive asymmetric compensation of the condyle-fossa relationship in adults with PUXB, resulting in a craniofacial deviation of the mandible with no detectable left-right skeletal asymmetry or noticeable functional shift.

This study demonstrates that PUXB in adults is primarily a result of dentoalveolar asymmetry and positional deviation of the mandible and not a right-left skeletal asymmetry of the craniofacial region. We hypothesize that the absence of functional shifts in adults with PUXB might be due to long-term remodeling of the TMJ complex. Glenoid fossa remodeling could lead to a positional deviation of the mandible, which, along with a distinct dentoalveolar asymmetry, serves to stabilize and maintain the crossbite occlusion in adults.

The results of this study suggest that early crossbite correction in children with PUXB is warranted. Failure to correct PUXB in childhood might be associated with transverse dental asymmetry and a persistent mandibular positional deviation in adulthood. Future research with larger and prospective studies is needed to confirm this association.

CONCLUSIONS

1. Adult patients with PUXB had statistically significantly more transverse mandibular dental asymmetry.
2. Unilateral posterior crossbite develops as a result of a large mandible rather than a deficient maxilla, as is commonly believed.
3. Transverse dental asymmetry and not skeletal asymmetry is the primary contributor to PUXB in adults; these patients do not exhibit any more functional shift deviations when compared with controls.
4. The combined findings of the PA radiographs and the condylar position analysis show an adaptive repositioning of the glenoid fossa with unilateral crossbites in adults.
5. Practitioners should treat young patients with unilateral crossbites early because untreated unilateral crossbites in children results in progressive asymmetric compensation of the condyle-fossa relationship if left untreated.

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COMMENTARY

This article reports that mandibular skeletal asymmetry is not evident in a group of adults with posterior unilateral crossbite when compared with an adult control group. Furthermore, the authors claim that posterior crossbite is due to increased width of the mandible and not a result of transverse deficiency of the maxilla. This study makes use of posteroanterior (PA) radiographs, in preference to previously used submental vertex radiographs, as used by Lam et al[1] to assess facial asymmetry in adolescents and O'Byrn et al[2] to evaluate skeletal asymmetry in adults.

According to Cook,[3] as little as 5° of side-to-side head rotation for a PA radiograph caused the side of the asymmetry to switch. In addition, PA radiographs could not be used to determine whether the source of the asymmetry was dentoalveolar, skeletal, or both. Furthermore, clarity of mandibular reference points is compromised by the use of PA radiographs.

In Table I, one third of the sample of crossbite subjects demonstrate a switch in side of mandibular positional deviation relative to the mandibular midline