Original Article

Is there an asymmetry of the condylar and coronoid processes of the mandible in individuals with unilateral crossbite?

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ABSTRACT

Objectives: To evaluate if there is a true skeletal asymmetry of the condylar and coronoid processes of the mandible in growing individuals with unilateral posterior crossbite (UPC) either functional or not.

Materials and Methods: This cross-sectional study screened a total of 1120 cone beam computed tomography (CBCT) scans based on inclusion and exclusion criteria. The final sample comprised 20 CBCT images of individuals with UPC and 19 CBCT images of individuals without transverse malocclusion. The lengths of the condylar and coronoid processes were measured to evaluate asymmetry, as well as the magnitude of the mandibular lateral deviation in the UPC group.

Results: There was a significant difference between the lengths of the affected and nonaffected sides of the coronoid processes in the UPC group ($P < .01$). The same was not observed in the condyle in the UPC group ($P > .05$). There were no significant differences between the groups ($P > .05$).

Conclusions: Although no differences in the condyle were observed, the coronoid process was asymmetric in individuals with UPC. However, this asymmetry was not considered to be clinically significant. (*Angle Orthod.* 2019;89:464–469.)

KEY WORDS: Crossbite; Coronoid process; Mandibular condyle

INTRODUCTION

Posterior crossbite (PC) is one of the most frequent malocclusions and is found in 8% to 22% of the population.[1–5] PC may be unilateral or bilateral. Unilateral posterior crossbite (UPC) comprises half of all crossbites.[6] UPC is an asymmetric malocclusion characterized by an inverted transverse relationship between posterior upper and lower teeth restricted to either the left or right side and may affect one or more teeth.

UPC may be of skeletal or dental origin, or a combination of both. In most cases, a mandible shift occurs accompanied by a deviation of the lower midline and is known as functional unilateral posterior crossbite (FUPC).[6,7] The most probable cause for FUPC is a reduced width of the maxillary dental arch. This atresia may be established as a result of habits such as non-nutritive sucking habits, atypical swallowing or by blockage of superior airways caused by adenoid hypertrophy or nasal allergies.[8]

If it is not treated early, FUPC may affect craniofacial growth and tooth positioning.[9] The mandibular deviation may lead to permanent adverse effects to the stomatognathic system. This asymmetric maxillary activity and that of the masticatory muscles would presumedly result in both sides of the mandible developing differently. Some authors defend the hypothesis that individuals with FUPC show a posterior superior displacement of the ipsilateral condyle and an anterior and inferior displacement of the contralateral condyle, stimulating greater growth of the latter.[8,10,11] However, other studies did not show any differences in condylar position between the posterior crossbite side and the opposite side in individuals who have UPC or FUPC.[1,12,13]

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Accepted: October 2018. Submitted: May 2018.
Published Online: December 28, 2018

 DOI: 10.2319/052518-398.1

The masseter and temporalis muscles also contract in an altered and asymmetric pattern in patients with FUPC.[10,11] The posterior temporalis muscle on the same side of the crossbite showed an electromyographic signal greater than the contralateral side at rest, and maximum habitual intercuspation. On the other hand, the anterior bundle of the ipsilateral temporalis muscle was less active than the contralateral muscle at rest.[14] The same asymmetric muscular activation pattern was observed in children with FUPC during mastication.[15]

The relationship between bone morphology and muscular function has been studied since the 19th century. The interaction between these two factors was determined by Wolff's theory, according to which morphology and bone architecture also depend on the loads applied to the bone by the muscles attached to it.[16] The musculoskeletal system in the craniofacial region is complex because of this morphofunctional relationship.[17,18] For example, the mandibular coronoid process is where most of the temporalis muscle is inserted and these two elements show a morphofunctional dependency from the embryonic stage.[17] The differentiation and development of the coronoid process during this period is connected to the differentiation of the temporalis muscle. A reduction or complete absence of this process after experimental surgical removal of the muscle in newborn rats was observed. This suggests that the dependency relationship continues throughout the post-natal period.[19,20] These findings indicate that the growth and morphology of the mandibular coronoid process during this period are also completely dependent on the presence of an active temporalis muscle.[21,22] Hence, the tension exerted by this muscle may influence growth and morphology of the coronoid process in various transverse and anteroposterior skeletal asymmetries.[23,24]

The aim of this study was to assess whether a true skeletal asymmetry exists in the coronoid and condylar processes in growing individuals who have UPC, whether it be functional or not.

MATERIALS AND METHODS

This was a cross-sectional retrospective study carried out using a cone-beam computed tomography (CBCT) sample from COMPASS 3D (Belo Horizonte, Brazil) database, a company specialized in intelligence and technology in dentistry. All subjects' rights were protected and the study was approved by the Institutional Review Board of the University of Sao Paulo.

Sample

CBCT images were chosen according to inclusion and exclusion criteria based on a screening of 1120 exams. Inclusion criteria were: CBCT scans of individuals with and without UPC, aged between 8 and 15 years, acquired by an iCAT Scanner (Imaging Sciences International, Hatfield, PA, USA) with 0.3 mm^3 voxel and Full FOV. Exclusion criteria were: CBCT of individuals with craniofacial deformities, syndromes, open bite, anterior crossbite or bilateral posterior crossbite and inconclusive CBCT exams.

A total of 39 patients were selected in,cluding males and females with an average age of 10.04 ($\pm$ 1.57) years. These patients were divided into two groups: G1, 20 individuals with unilateral posterior crossbite; G2, 19 individuals with no transverse alterations.

Measurements

The software used to take the measurements was ITK-SNAP, version 3.0.6 (Cognita, Philadelphia, PA, USA). Each patient's head orientation was oriented so that the mandibular body was parallel to the floor. A mandibular plane tangent to the lowest point of the symphysis and the lowest point of the mandibular ramus after the antegonial notch on both sides was used for reference.

Both sides, with and without crossbite, were identified in 20 patients from G1. Additionally, these individuals were classified according to the presence or lack of mandibular deviation by quantifying the lateral shift of the Pog (Pogonion) point in relation to the median sagittal plane in the frontal view. Shifts greater than 1.5 mm were considered to be mandibular deviations. Linear measurements were carried out in both groups as follows:

(A) Length of the coronoid process: shortest distance (perpendicular) from the mandibular plane to the uppermost point of the coronoid process (Figure 1).
(B) Length of the condylar process: shortest distance (perpendicular) from the mandibular plane to the uppermost point of the condyle (Figure 2).

Therefore, four linear measurements were made to evaluate mandibular deviation (dependent variables) using CBCT images for each individual, totaling 156 measurements. Examiner calibration for all linear measurements was accomplished in a dark and quiet room. They were made using parasagittal multiplanar reconstructions (MPR).

Statistical Analysis

To assess the intraobserver agreement, measurements were executed using CBCT images of 20 individuals who were randomly selected. They were redone at a 15-day interval. Intraclass correlation coefficients (ICC) were used to calculate the repeat-

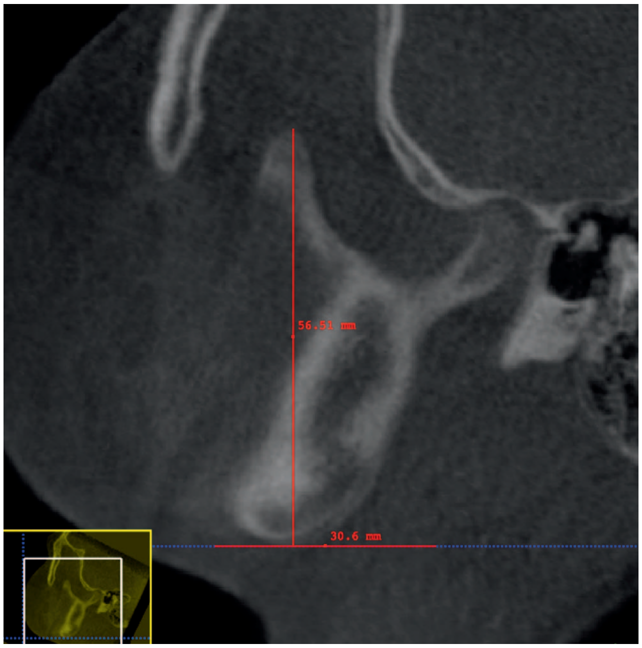

Figure 1. Length of the coronoid process: shortest distance (perpendicular) from the mandibular plane to the uppermost point of the coronoid process.

ability of the measurements. ICC scores above 0.75 were considered to be excellent; scores between 0.40 and 0.74 were considered to be fair to good and scores below 0.40 were considered poor.[25] Normality was checked using the Shapiro-Wilk test and the variance normality was checked using the Levene test. Differences between the groups for age and sex were assessed by Student's *t* test for independent samples and chi-square test, respectively. The intragroup analysis was carried out using paired *t* tests whereas the intergroup analysis was carried out using independent *t* tests. Correlation analysis between age and asymmetry was carried out using the Pearson's correlation coefficient.

RESULTS

The repeatability of the dependent variables was measured using the ICC, which varied between 0.996 and 0.997. Subsequently, CBCT images of 20 individuals from group G1 (unilateral crossbite, average age 10.05 years ± 2.22) and 19 individuals from group G2 (no crossbite, average age 10.03 years ± 1.92) were measured to assess the height of the coronoid and condylar processes. There was no difference in the distribution between groups with regard to sex or age of the participants ($P > .05$) (Table 1).

Based on the intragroup analysis, a statistically significant difference in G1 was noted for the height of the coronoid process on the side of the crossbite compared to the contralateral side ($P < .01$). However,

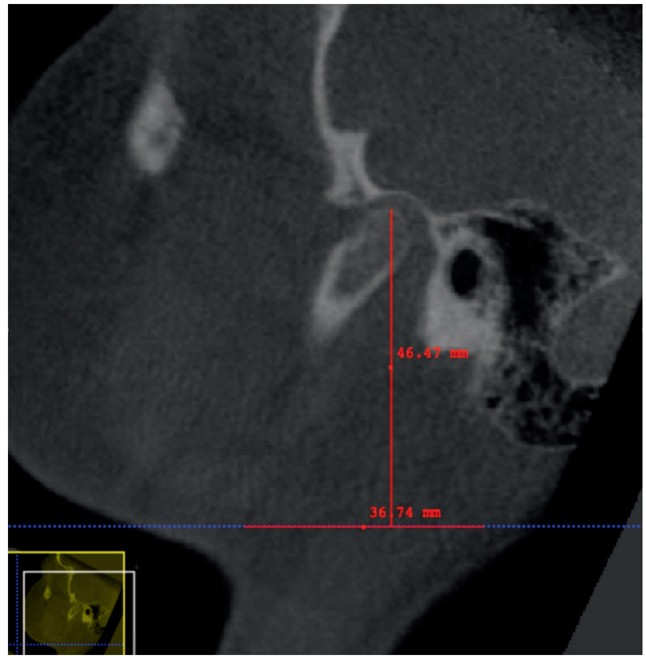

Figure 2. Length of the condylar process: shortest distance (perpendicular) from the mandibular plane to the uppermost point of the condyle.

no differences were observed for the condylar measures ($P > .05$) (Table 2). There was no significant correlation between the age of the individuals from G1 and the severity of the skeletal asymmetry in the coronoid process (the difference between the length of the side with and without crossbite) ($P > .05$). In group G2, no significant statistical differences were found between the left and right sides for either the condylar or coronoid processes ($P > .05$) (Table 3). There were no statistically significant differences between the studied groups ($P > .05$) (Table 4).

DISCUSSION

FUPC accounts for 92% of all unilateral posterior crossbites.[5] It probably occurs due to the inability of the mandible to accommodate to a transverse deficiency of the maxilla.[8] This deviation is perceptible in the face

Table 1. Sample Distribution According to Participants' Age and Sex[a]

	Control Group		Crossbite Group		
	Mean	SD	Mean	SD	*P* Value
Age	10.03	1.92	10.05	2.22	.971
Sex					
M	7		10		.408
F	12		10		

[a] Student's *t* test was carried out to analyze age differences between groups and chi-square test to analyze sex differences between groups. The level of significance was set at 5% ($P < .05$). SD indicates standard deviation; M, male; F, female.

Table 2. Lengths of the Condylar and Coronoid Processes of the Mandible in the Crossbite Group (mm)[a]

	Crossbite Side		Non-crossbite Side		
	Mean	SD	Mean	SD	*P* Value
Coronoid Process					
G1, N = 20	52.81	5.01	51.79	4.93	.006
G1 (MS >1.5 mm), N = 12	53.12	4.89	51.88	5.40	.015
G1 (MS < 1.5 mm), N = 8	52.35	5.49	51.64	4.47	.236
Condylar Process					
G1, N = 20	42.43	5.05	42.30	5.02	.717
G1 (MS >1.5 mm), N = 12	42.16	3.03	41.73	3.90	.409
G1 (MS < 1.5 mm), N = 8	42.84	7.39	43.14	6.57	.628

[a] Paired *t* test was carried out for intragroup comparison between sides. The level of significance was set at 5% ($P < .05$). MS indicates mandibular shift; SD, standard deviation; M, male; F, female.

during the deciduous dentition, and is mainly located in the lower part of the face.[26] In the mixed dentition, a soft tissue asymmetry is also observed in the middle part of the face.[26] Beside facial asymmetry, individuals with this malocclusion also display an asymmetric activation pattern of the masticatory muscles.[14,23,24] However, there is a lack of evidence to prove that these facial, dentoalveolar, and muscle asymmetries have repercussions at a skeletal level. In this sense, this study aimed to compare the mandibular morphology of individuals with and without unilateral posterior crossbite.

Some studies have previously attempted to correlate different types of malocclusion with the presence of skeletal mandibular asymmetry.[27,28] However, most of these studies were carried out using two-dimensional radiographic evaluation.[29] It is known that such evaluations may result in errors because 3D structures are projected onto a 2D surface-generating distortion, magnification, and overlap.[30] The present study used CBCT images to reduce potential assessment biases.

Previous studies have described asymmetric growth of the mandible in individuals with FUPC.[8,10,28,31,32] However, several authors claimed no correlations and that individuals with normal occlusion presented the same degree of asymmetry.[12,13,30] Unfortunately, these findings were based on the spatial positioning of the condyle within the glenoid fossa. For this reason, it is not prudent to suggest that there was a true skeletal asymmetry in the samples studied.

Table 3. Lengths of the Condylar and Coronoid Processes of the Mandible in the Control Group (mm)[a]

	Right Side		Left Side		
	Mean	SD	Mean	SD	*P* Value
Coronoid Process	55.05	6.38	54.56	6.61	.202
Condylar Process	45.75	5.49	45.49	6.39	.534

[a] Paired *t* test was carried out for intragroup comparison between sides. The level of significance was set at 5% ($P < 0.05$). SD indicates standard deviation.

Table 4. Intergroup Analysis of the Differences Between Sides in the Coronoid and Condylar Processes (mm)[a]

	Control Group		Crossbite Group		
	Mean	SD	Mean	SD	*P* Value
Coronoid Process	0.48	1.58	1.02	1.49	.278
Condylar Process	0.27	1.83	0.14	1.68	.882

[a] Student's *t* test was carried out to analyze differences between groups. The level of significance was set at 5% ($P < .05$). SD indicates standard deviation.

Few studies assessed true morphologic skeletal asymmetry rather than positional asymmetry. One study sought to verify mandibular skeletal asymmetry at a condylar level in individuals with FUPC and in those with normal occlusion.[12] Results suggested that, despite the existence of some asymmetry in the individuals with FUPC, similar asymmetry was also present in individuals with normal occlusion. Therefore, this asymmetry may be attributed to the shape of the condyle or even to anatomical alterations resulting from a unilateral masticatory pattern. Thus, as in the present study, no differences between the groups were found, despite having carried out two-dimensional evaluations.

Veli and colleagues sought to assess the presence of mandibular asymmetry with computed tomography in three groups of individuals: with unilateral crossbite, bilateral crossbite, and normal occlusion.[30] Volumetric and linear measurements of the mandible were used for analysis. The authors did not find asymmetry in the condylar and coronoid processes in any of the groups. These findings partially differed from the current study where a mandibular asymmetry in the coronoid process was detected in individuals with FUPC. The fact that no asymmetry was detected may have been due to a smaller sample size (a beta type error) or a result of the methodology used. Initially, the present study also sought to use the mandibular foramen as a reference for linear measurements; however, the data were inconsistent due to the difficulty in visualizing the foramen in multiplanar reconstructions. For this reason, the mandibular plane was used as a reference.

The present study initially included volumetric data because it is an illustrative method and fairly commonly included in the current literature. However, it became clear that the measurements were subject to a variety of factors such as operator skill (manual segmentation), image contrast, and clinical interpretation, among others. Therefore, given the poor reliability of the findings and the difficulty in being able to replicate the method in future studies, it was decided that this evaluation process should not be part of the present methodology. If the voxel size had been smaller than 0.3 mm, it is likely that more reliable data would have been obtained from the volumetric analysis; however, it would still have low levels of reproducibility.

There is widespread consensus that PC, whether functional or nonfunctional, should be treated early.[29] Based on the current findings, the decision to treat FUPC early should not be made to prevent possible mandibular skeletal asymmetry in young patients. It is important to note that the crossbite did not result in significant skeletal asymmetry from a clinical standpoint (approximately 1 mm). Instead, its importance was solely statistical. In the same way, there was no correlation between the age of the individual and the severity of the asymmetry. Therefore, the decision should be based on the fact that this malocclusion is not self-correcting but, rather, dependent on loosening maxillary sutures and maxillary buttress, which are most easily obtained during early ages.[33]

Even though a statistically significant difference was found between the sides with and without crossbite in the test group, no differences were seen between the test group and the control group. This may be a result of the small sample size for intergroup analysis. This study presented a power of 80% for detection of a 1.38 mm difference between the groups. From a clinical point of view, it should probably suffice. It is suggested that new studies be carried out including other age groups in which craniofacial growth has been completed.

CONCLUSIONS

No differences were observed at a condylar level. Notwithstanding, the coronoid processes were shown to be asymmetric in individuals with FUPC. However, this asymmetry should not be considered clinically significant.

ACKNOWLEDGMENT

The first author is currently supported by The Brazilian Federal Education Agency (CAPES).

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