EFFECTS OF CLEFT LIP AND PALATE ON TEMPOROMANDIBULAR JOINT COMPONENTS: A CBCT STUDY

Ahmad Reza Talaeeipour1,*, Bita Kiaee2,*, Shohreh Ghasemi3,*, Alireza Mirzaei4,*, Faezeh Amiri2,*, Ayda Jamilian5,*, Alireza Darnahal6,*, Abdolreza Jamilian7,*,

1Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Cranio-Maxillofacial Research Center, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran
2Department of Orthodontics, Faculty of Dentistry, Tehran Medical Science, Islamic Azad University, Tehran, Iran
3Department of Oral and Maxillofacial Surgery, Dental College of Georgia, University of Augusta, GA, United States
4Department of Psychology, York University, Toronto, Canada
5Division of Periodontology, Harvard School of Dental Medicine, Boston, MA, United States
6DDS, MSc, Professor; e-mail: ar_talaei@yahoo.com; ORCIDID: https://orcid.org/0000-0001-9219-2975
7DDS, MSc, Assistant Professor; e-mail: dr.bitakia@gmail.com; ORCIDID: https://orcid.org/0000-0002-9117-3593
8DDS, OMFS, Clinical Assistant Professor; e-mail: sghasemi@augusta.edu; ORCIDID: https://orcid.org/0000-0003-4489-2891
9DDS, Msc; e-mail: micayalireza70@gmail.com; ORCIDID: https://orcid.org/0000-0002-1569-6130
10DDS; e-mail: dr.faezehamiri1989@gmail.com; ORCIDID: https://orcid.org/0000-0002-8390-1052
11BSc Student (1st year); e-mail: ayda.jamilian@gmail.com
12Periodontics Resident; e-mail: alirezadarnahal@gmail.com; ORCIDID: https://orcid.org/0000-0001-9629-731X
13DDS, MSc, Professor; email: info@jamilian.net; ORCIDID: https://orcid.org/0000-0002-8841-0447

ABSTRACT

Introduction To assess the effects of cleft lip and palate (CLP) on the temporomandibular joint (TMJ) components using cone-beam computed tomography (CBCT).

Methodology This historical cohort study evaluated 20 CBCT scans of the TMJ area of patients with unilateral CLP as the test group and 20 CBCT scans of the TMJ area of non-CLP controls with class I occlusion. The morphological properties and dimensions of the condyle, the thickness of the glenoid fossa and articular eminence, and the articular eminence angle were measured and recorded. The two groups were compared regarding the above-mentioned variables by the Chi-square or t test (alpha=0.05).

Results The left and right axial condylar angles in CLP patients were significantly lower than the corresponding values in the control group by 1.8 degrees in the left and 2 degrees in the right side (p=0.005). The mediolateral condylar dimension at both sides was significantly lower in CLP patients than in the controls (p=0.001). The differences between the two groups were not significant in the anteroposterior condylar dimension, glenoid fossa thickness, and articular eminence thickness (p>0.05). The CLP patients had significantly lower articular eminence angle in the right side (p=0.016) but not in the left side (p>0.05), compared with the controls.

Conclusion Unilateral CLP patients have lower axial condylar angle and mediolateral condylar dimension at both sides, and lower articular eminence angle in the right side than the controls.

KEYWORDS

Dental Radiology; Cone-Beam Computed Tomography; Orofacial Cleft; Temporomandibular Joint.

1. INTRODUCTION

The temporomandibular joint (TMJ) is a complex joint located between the mandible and the temporal bone [1]. The loads applied to this joint affect both of the involved skeletal components, and can cause some alterations in their shape and thickness. In case of application of excessive forces, such alterations may exceed the normal range of variations (remodeling) and necessitate elimination of the etiology [2].

Cone beam computed tomography (CBCT) has gained popularity in recent years for imaging the craniofacial complex. CBCT can provide a significantly lower dose of radiation compared to conventional CT methods and has advantages over 2D images, including providing 1:1 orthogonal representations of structures. CBCT images can be used in the area of other 2D images, such as panoramic radiographic projection and lateral cephalogram, with the software capable of creating these images from the 3D data. Caution should be exercised to minimize radiation doses to patients. Studies have shown great variability in the amount of radiation exposure between different CBCT machines and the control of the field of view and intensity can help to minimize these levels. In addition, in cases with impacted teeth, CBCT images can provide a number of advantages over periapical and occlusal films for the...
Localization of these teeth, since they provide images free of distortion and overlapping structures [3]. Approximately 60% to 70% of the populations worldwide show signs and symptoms of temporomandibular disorders; however, only one-fourth of them are aware of these signs and symptoms [4]. Temporomandibular disorders are often characterized by pain at the TMJ, pain or tenderness of the muscles of mastication, mandibular movement limitation, mandibular deviation, and clicking of the TMJ.

The pathognomonic signs and symptoms include pain or tenderness of the TMJ and periauricular areas, mouth opening limitation, and TMJ sounds in function. The patients feel pain in an area anterior to the ear. Alternatively, they may complain of recurrent pain in the temporal region, neck, or shoulders [4]. Orofacial clefts including cleft lip, cleft palate, or cleft lip and palate (CLP) are the most common congenital anomalies of the head and neck region, which often involve the lips, hard palate, soft palate, and alveolar bone [5]. CLP patients have numerous problems such as dental anomalies, malocclusions, facial and nasal deformities, and nutritional, respiratory, auditory, and speech problems [6]. Several congenital and environmental factors are involved in the occurrence of CLP, such that it is considered a multifactorial disorder [7].

Since the dentomaxillofacial tissues in CLP patients have a different growth pattern than that of normal individuals, anterior and posterior crossbite are common in such patients [8]. Evidence shows that the presence of crossbite, especially posterior unilateral crossbite, is correlated with the asymmetric function of the facial muscles in involved patients [9,10]. Also, considering the dental changes related to CLP and also occlusal changes and malocclusions in such patients, alterations of the condyles are also expected since condyles are among the most sensitive areas to occlusal changes [11].

A number of studies have addressed the effects of CLP on the condylar position and dimensions, relationship of the condyle and the glenoid fossa, and mandibular ramus height. For example, Ucar et al. [12] evaluated the condylar position and temporomandibular fossa in CLP patients and found a significant difference in the condylar angle between the patients and the controls. Kurt et al. [13] assessed the mandibular asymmetry in CLP patients and found no significant difference between the patient and control groups in this respect. Considering the existing controversy in the available literature on this topic, and limited number of studies focusing on the changes in skeletal components of the TMJ in CLP patients, this study aimed to assess the effect of CLP on skeletal components of the TMJ using cone-beam computed tomography (CBCT).

2. METHODOLOGY

This historical cohort study was conducted on the available CBCT scans of 20 patients with definite diagnosis of unilateral CLP and 20 non-CLP controls. The CBCT scans had been taken for purposes not related to this study such as evaluation of impacted teeth, or orthodontic treatment in both the test and control groups.

The sample size was calculated to be 20 CBCT scans in each group according to previous studies [11-14]. The inclusion criteria for the CLP patients were aged between 15 to 22 years, and surgical closure of the lip and hard tissue before the age of 3.5 years. The exclusion criteria were history of previous orthodontic treatment, orthognathic surgery, trauma, systemic and syndromic conditions, and history of degenerative joint disease.

The patients were selected by targeted sampling such that the medical records of patients with definite diagnosis of CLP who already had CBCT of the head and neck region were retrieved from the archives of the School of Dentistry of of Azad and several private oral and maxillofacial radiology clinics until the required sample size was reached. Also, medical records of non-CLP patients with class I occlusion who already had CBCT scans of the head and neck region and matched the test group in terms of age and sex were selected as the control group. The study was approved by the Ethics committee of School of Dentistry (Number 577226984). The CBCT scans had been taken in an upright position with maximum intercuspation by NewTom CBCT scanner with a maximum voltage of 110 kVp, 17 s scanning time, and 8 x 12, 12 x 15, or 15 x 15 cm fields of view. Image reconstruction was performed by NNT Viewer 2.21 software.

All images were evaluated by an oral and maxillofacial radiologist in a mildly lit room. The observer was allowed to observe the images in all orthogonal planes (axial, sagittal and coronal). Also, the examiner was free to adjust the brightness, or zoom the images. After observation of the images, the radiologist recorded the morphological characteristics of the condyles, condylar dimensions, glenoid fossa and articular eminence thickness, and the articular eminence angle. The measurements were made using NNT Viewer 2.21 software. For this purpose, the images were reoriented in the software such that the horizontal reference plane was the Frankfurt plane (passing through the right and left porion and orbitale) and the sagittal reference plane was perpendicular to the horizontal plane and passed from the basion, mid-orbital, and nasion. The coronal plane was perpendicular to the previous two planes, and passed through the nasion. After standardization of images in terms of orientation, axial sections with 0.5 mm slice thickness were reconstructed. In the largest mediolateral dimension of the condyle on the axial section at both sides, the mediolateral and the anteroposterior dimensions of the condyles and the axial condylar angle relative to the sagittal axis (the line passing through the basion, mid-orbital, and nasion) were all measured [12,15](Fig. 1).
To obtain coronal and sagittal views of the condyles, lateral sections perpendicular to the longitudinal axis of the condyle were made with 1 mm slice thickness, and coronal sections were made parallel to the longitudinal axis of the condyle with 1 mm thickness. The condylar morphology in the coronal view was categorized into four shapes of convex, round, flat, and angulated. This view was prepared from the widest mediolateral section of the condyle in the axial view [16] (Fig. 2).

In the sagittal plane, the condylar morphology was categorized as round, flat, worn (between round and flat), and with osteophytes [17] (Fig. 3).

The articular eminence measurements were made using the following points and lines:

- Ce: The point at which line F intersects with the posterior surface of the eminence.
- Cu: Peak of the condyle.
- Po: Porion (the highest point of the external ear).
- R: The highest point of the fossa.
- T: The lowest point of the articular eminence.

Using the above-mentioned points, the following lines were drawn:

- Ebf line: The best fit of the articular eminence angle by passing through the Ce.
- F line: The Frankfurt plane.
- F1 line: A line parallel to the F line passing through the Cu point.
- F2 line: A line parallel to the F line passing through the R point.

The articular eminence angle was calculated by measuring the angle formed between the Ebf and F lines [17] (Fig. 4).

The articular eminence height (Eh) was measured by measuring the vertical distance between the highest point of the fossa (R) and lowest point of the articular eminence (T) [17] (Fig. 4).

The thickness of the glenoid fossa was measured at the thinnest part in the sagittal plane [16] (Fig. 4).

The above-mentioned variables were measured in the right and left sides for CLP patients and controls. To evaluate intra-observer reliability, 10 CBCT images were randomly selected from the two groups and were re-measured 2 weeks later by the same investigator, and the reliability of the measurements was ensured by test-retest reliability. Since R was found to be >0.8, the results were found to be adequately reliable.
The data were analyzed using SPSS version 25. The Kolmogorov-Smirnov test was applied to assess the normality of data distribution. The two groups were compared with the t-test for normally distributed data and Mann-Whitney test for the data with non-normal distribution. The level of significance was set at 0.05.

3. RESULTS

This study evaluated 40 participants including 20 unilateral CLP patients and 20 non-CLP controls. There were 12 females and 8 males in the CLP group with a mean age of 17.7±2.8 years, and 9 females and 11 males with a mean age of 18.7±1.9 years in the control group. The two groups were not significantly different in terms of age (p=0.215) or gender (p=0.342).

Table 1 presents the mean mediolateral dimension of the condyle, anteroposterior dimension of the condyle, glenoid fossa thickness, articular eminence thickness, articular eminence angle, and axial condylar angle relative to the sagittal plane in CLP patients and non-CLP controls. The results showed that the axial condylar angle in CLP patients was significantly lower than that in the non-CLP controls at both the right (p=0.035) and left (p=0.005) sides. The mediolateral dimension of the condyle in the CLP patients was also significantly lower than that of the non-CLP controls in both the right (p=0.001) and left (p=0.001) sides. The anteroposterior dimension of the condyle was not significantly different between the two groups in the right (p=0.308) or left (p=0.737) sides. The thickness of the glenoid fossa was not significantly different between the two groups, neither in the right (p=0.327) nor in the left (p=0.925) side. The articular eminence thickness was also approximately the same in the two groups in the right (p=0.094) and left (p=0.094) sides. The articular eminence thickness was significantly lower in the CLP group than the control group in the right side (p=0.016) but not in the left side (p=0.63).

Table 2 presents the frequency distribution of different morphologies of the condyle in the coronal view in CLP and non-CLP groups. Table 3 presents the frequency distribution of different morphologies of the condyle in the sagittal view in CLP and non-CLP groups.

4. DISCUSSION

Maxillofacial clefts are the most common congenital anomalies of the head and neck region, which can affect the lips, hard and soft palate, and alveolar bone [18]. CLP patients have many problems such as dental anomalies, malocclusion, facial and nasal deformities, and nutritional, respiratory, auditory, and speech problems [6,19]. This study aimed to assess the effect of CLP on skeletal components of the TMJ using CBCT. Different radiographic modalities may be used to assess mandibular asymmetry. However, accurate measurement is not possible by using panoramic radiography due to errors related to the patients’ head position and limitations such as magnification [20]. The accurate evaluation of the TMJ by conventional radiography is limited by the structure superimposition. Cone beam computed tomography (CBCT) provides high-resolution multiplanar images and delivers substantially lower radiation dose, compared with multi-slice CT. CBCT allows examination of TMJ articulation...
anatomy without superimposition and distortion to facilitate the analysis of bone morphology, joint space and dynamic function in all three dimensions. It is good to know that the goals of TMJ imaging by CBCT are to evaluate the integrity of the bony structures when disorders are suspected, to confirm the extent and stage of progression of disorders, and to evaluate the effects of the treatment [23]. Also, posteroanterior cephalometry may yield unreliable results due to the patients’ head rotation [7]. However, 3D radiographic modalities such as CBCT and MRI can overcome limitations such as magnification. CBCT can provide 3D images with higher resolution at a shorter time and lower patient radiation dose compared with computed tomography [21].

The present results revealed significantly lower axial condylar angle relative to the sagittal plane in both the right and left sides in CLP patients compared with the non-CLP controls. Ucar et al. [12] reported that the axial condylar angle in the right side in CLP patients was lower than that in the non-CLP controls, which was in agreement with the present result. Also, Kurt et al. [13] assessed mandibular asymmetry in CLP and non-CLP patients and reported that the gonial angle of the mandible in CLP patients was significantly larger than that in the non-CLP controls.

In the present study, the mediolateral condylar dimension at both sides was significantly smaller in CLP patients; however, this difference was not significant in anteroposterior dimension of the condyle. Veli et al. [11] evaluated the mandibular asymmetry in unilateral CLP patients and non-CLP controls. They reported that the mediolateral dimension of the right condyle in unilateral CLP patients was smaller than that in the non-CLP controls. This difference was approximately 0.4 mm in the left side, and not significant, which was almost similar to the present result. In the study by Ucar et al. [12] the condylar volume in bilateral CLP patients was lower than that in the healthy controls, but not significantly. Kurt et al. [13] evaluated mandibular asymmetry in vertical dimension in subjects with and without cleft palate. The condylar height in cleft palate patients was significantly higher than that in non-cleft controls. Paknahad et al. [14] showed higher prevalence of different types of mandibular asymmetries (condylar, ramal, and combined condylar and ramal) in unilateral CLP patients compared with bilateral CLP and control subjects, which was in agreement with the present findings. Veli et al. [11] reported smaller mandibular body volume in CLP patients than healthy controls, which was in accordance with the present results. Celikoglu et al. [22] found no significant difference regarding the thickness of glenoid fossa roof and the articular eminence thickness between CLP patients and healthy controls, which was similar to the findings of the present study. This topic has been rarely addressed in studies on CLP patients. However, Ucar et al. [12] reported insignificantly lower articular eminence thickness in the right and left sides in bilateral CLP patients than in the controls. Ejima et al. [16] evaluated the correlation of glenoid fossa root thickness, condylar morphology, and the number of residual teeth. The results showed that the thickness of glenoid fossa roof was not affected by the condylar head morphology in the coronal view. Joints with osteoarthritis had increased thickness of glenoid fossa roof.

In the present study, the articular eminence angle in the right side was significantly lower in CLP patients than in the controls. In the study by Ilguy et al. [17], the maximum articular eminence angle was recorded in 30-39-year-olds. In the present study, the condylar morphology was classified into different shapes according to Ejima et al. [16] and Ilguy et al. [17]. The most common morphology in the coronal view was the convex morphology in both groups while the most common morphology in the sagittal view was the round morphology. In the study by Ejima et al. [16] round morphology was the most common morphology in the sagittal view (128 out of 154 condyles) while the convex morphology was most common in the coronal view (111 out of 154 condyles). This study had a retrospective design and was based on patient records. Thus, some limitations existed with regard to the role of confounders since we did not have access to patients. Future studies are required to compare bilateral and unilateral CLP patients with non-cleft controls with class III malocclusion since most studies have evaluated healthy controls with class I occlusion.

5. CONCLUSION

Unilateral CLP patients have lower axial condylar angle and mediolateral condylar dimension at both sides and lower articular eminence angle in the right side than controls.

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COMPETING INTERESTS
None to declare.

DATA AVAILABILITY
The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

AUTHOR CONTRIBUTIONS
ART: drafting the manuscript. BK, SG and FA: data collection. AM: statistics. AJ: literature review. AD: manuscript revision and submission. AJ: study concept and design; critical revision of the manuscript for important intellectual content; administrative, technical, and material support; study supervision.
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Ahmad Reza TALAEIPOUR

DDS, MSc, Professor

Department of Oral and Maxillofacial Radiology Faculty of Dentistry

Cranio-Maxillofacial Research Center

Tehran Medical Sciences, Islamic Azad University

Tehran, Iran

CV

Dr. Ahmad Reza Talaeipour is the first Oral and Maxillofacial Radiologist in Iran. He has been a faculty member for 32 years at the Azad Tehran University of Medical Sciences. He is currently chair of the Iranian association of Radiologists, and Vice President of the Iranian dental association.
Questions

1. Which of the following is not an exclusion criterion for this study?
   a. History of previous orthodontic treatment;
   b. Orthognathic surgery;
   c. Trauma;
   d. Malocclusion.

2. What is the aim of this study?
   a. Assess the effect of CLP on skeletal components of the TMJ;
   b. Assess the effect of CLP on Dental components of the TMJ;
   c. Both;
   d. None.

3. Which of the following is not an inclusion criterion for this study?
   a. CLP patients age between 15 to 22 years;
   b. Surgical closure of the lip and hard tissue before the age of 3.5 years;
   c. CLP patients aged more than 22 years;
   d. None of the above.

4. Which statistical test was used to assess normality of the data in this study?
   a. Kolmogorov-Smirnov test;
   b. T-Test;
   c. Q-square test;
   d. None of the above.

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