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Investigating possible correlation between condylar asymmetry and clinical dysfunction indices in patients with temporomandibular dysfunction using Cone-beam computed tomographic

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ABSTRACT

Purpose: Temporomandibular disorder (TMD) is a common problem in modern societies. Causes of TMD, as a consequence of condylar asymmetry index (CAI), are still a subject of controversy. The aim of the present study was to determine the possible correlations between the degree of condylar asymmetry and clinical dysfunction indices.

Materials and methods: In this cross-sectional study, we used the Habets method to measure the CAI in 42 TMD patients. The participants' age and sex were matched in the control group. Patients were divided into mild, moderate and severe dysfunction groups based on Helkimo's clinical Di. The data were analyzed using Mann–Whitney U and Kruskal–Wallis tests. Also, the study attempted to assess the possibility of correlation between age and CAI.

Results: The CAI values of TMD patients were significantly higher than those of the control group ($P = 0.001$). However, CAI was not significantly different among TMD patients with different dysfunction index. There was no significant correlation between CAI and age (Spearman $r = 0.655$, $P = 0.23$).

Conclusion: Based on the findings of the present study, patients with condylar asymmetry index are more susceptible to TMD. However, degree of the condylar asymmetry is not a criterion for TMD signs and symptoms.

1. Introduction

Temporomandibular disorder (TMD) is one of the most frequent causes of pain in the orofacial region (Sharma et al., 2011). TMD is a multifactorial condition with muscle hyperactivity as an important contributing factor, along with stress, arthrogenous factors, parafunctional habits and structural issues in the anatomy of the joint. Condylar asymmetry and angulation of the condylar head on the horizontal plane are among these structural changes (Schokker et al., 1990; Yáñez-Vico et al., 2012).

In the event of an overload situation, condylar asymmetry could affect both hard and soft tissue components of TMJ's articulating surfaces. In particular, the undifferentiated mesenchymal cell layer can be altered and may, in turn, lead to progression of osteoarthritis (Hansson et al., 1977).

Habets et al. investigated condylar asymmetry (CA) and observed greater asymmetry in the vertical condylar height of the patients with TMD in comparison with those in the asymptomatic group (Habets et al., 1988). Furthermore, Bezuur et al. (Bezuur et al., 1988) evaluated CA in TMD patients and indicated that most of them presented with a vertical CA.

Habets et al. pioneered a method to determine asymmetry between the mandibular condyles, which was based on the comparison of the vertical height of the right and left mandibular condyles. In that technique, the CA index (CAI) was assessed using panoramic views and was defined as the ratio of the difference between the right and left condylar heights compared with their total (Fig. 1) (Habets et al., 1988). The CAI has been used to validate the clinical

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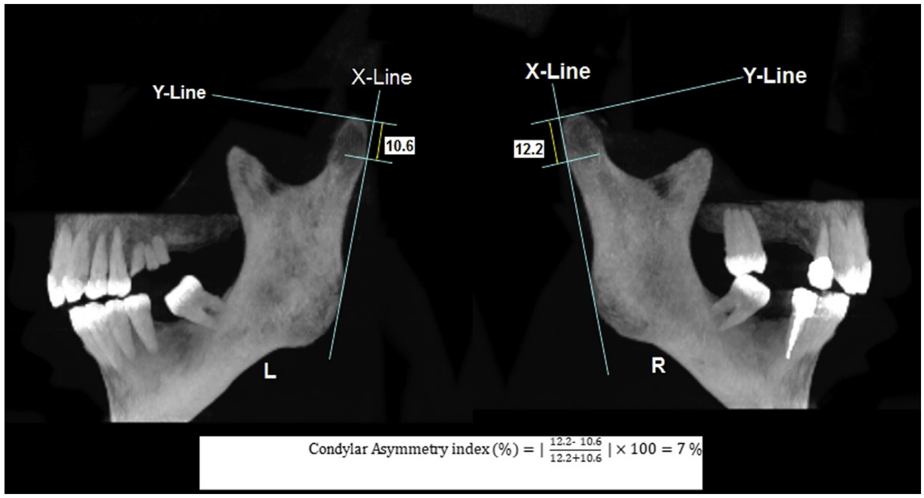

Fig. 1. Example of measuring condylar asymmetry according to Habets et al. in a patient.

tests with diagnostic purposes in patients with temporomandibular disorders (Miller et al., 1998).

The conclusion from the study by Habets et al. regarding the significant relationship between the asymmetrical height in the condylar process and TMD has been confirmed by some researchers (Schokker et al., 1990; Miller et al., 1998; Yáñez-Vico et al., 2012), but is not supported by certain others (Saglam and Sanli, 2004).

Therefore, there is no conclusive evidence to establish the possible effects of the amount of condylar asymmetry on the clinical situation of these patients.

Many authors believe in the necessity of standardized criteria in the evaluation of TMD patients with different signs and symptoms to measure and assess the improvement of patients' condition after treatment (Vojdani et al., 2012). The clinical dysfunction index (Di), developed in 1974, is a functional evaluation of the masticatory system which classifies the individuals according to 5 basic signs, including impaired range of mandibular movement, impaired TMJ function, TMJ pain during palpation, muscular tenderness, and pain during mandibular movement (Helkimo, 1974).

Cone beam computed tomography (CBCT) is becoming the modality of choice for evaluation of TMJ osseous components. It can provide sub-millimeter spatial resolution for imaging of the dental and maxillofacial structures, offering markedly shorter scanning times (10–70 seconds) and lower radiation doses than traditional CT imaging methods (Schulze et al., 2014).

It is not yet clear how the degree of condylar asymmetry could actually affect the clinical condition of TMD patients, and some study results have not even supported the proposed relationship between condylar asymmetry and TMD (Saglam et al., 2004). The aim of the present study was to compare the CAI between normal and TMD cases based on CBCT 3D images and determine the possible correlations between the amount of condylar asymmetry and clinical dysfunction indices in patients with TMD.

2. Materials and methods

2.1. Study patients

The Ethics Committee of Shiraz University of Medical Science approved the study. A total of 42 patients, including 31 women and 11 men, with clinical signs and symptoms of TMD were recruited for this study. These patients were referred from a private TMD clinic to the Maxillofacial Radiology center for CBCT scans of both TMJs as part of the assessment procedure. The age of the patients ranged from 18 to 65 years (33.93 ± 13.18 years). Positive history of a number of conditions such as jaw trauma, condylar fracture, TMJ surgery, pathology in the region of the temporomandibular joint, and orthodontic therapy, as well as the presence of any congenital abnormalities and/or any systemic disease that could affect the joint morphology such as rheumatoid arthritis, were considered as the exclusion criteria for the case and control groups. All participants voluntarily took part in this study and signed written consent forms after they were informed about the nature of the study in detail.

2.2. Control group

CBCT images and clinical records of 42 patients who had sought treatment for purposes other than TMD were used retrospectively to form the control group. The age and sex distribution of patients in the non-TMD group was similar to those of the patients in the TMD group in order to eliminate their effect on the results (31 women and 11 men, ranging from 18 to 65 years with a mean age 35.67 ± 10.75 years). Inclusion criteria for the non-TMD group were the absence of pain affecting the TMJ area or the muscles of mastication, absence of the joint sound, and lack of limitation in movement or function of the TMJ (Di = 0).

2.3. Data collection

Clinical Dysfunction indexes (Di) were calculated for all participants according to Helkimo's examination protocol and scoring system (Helkimo, 1974). The score of 0, 1, or 5 was assigned to five different signs, including impaired TMJ function, muscle tenderness, TMJ pain during palpation, pain during mandibular movement, and range of mandibular mobility. The sum of allocated scores for each of these five items was recorded as the patient's clinical dysfunction or Helkimo index. Depending on the clinical dysfunction score (total score), the individuals were classified into four groups of dysfunction index (Di), namely normal (index 0), mild (index I), moderate (index II), and severe (index III) as follows:

Di 0 = Helkimo dysfunction index 0 = 0 points = No clinical symptoms (Control group)

Di I = Helkimo dysfunction index 1 = 1–4 points = Mild dysfunction

Di II = Helkimo dysfunction index 2 = 5–9 points = Moderate dysfunction

Di III = Helkimo dysfunction index 3–5 = 10–25 points = Acute/serious dysfunction

To ensure consistency in the interpretation of the answers provided by the patients, all clinical examinations were carried out by a single expert clinician with more than 15 years of experience in diagnosis and treatment of TMD patients.

All CBCT scans were taken with a NewTom VGi scanner (QR Srl; Verona, Italy, kVp = 110, Scanning time = 18 seconds, exposure time = 3.6 seconds) in the standard mode (voxel size = 0.3 mm). Bilateral CBCT images of both TMJs were acquired in the upright standing position with the field of view set at 15 × 12. Also, the patients' heads were positioned in a manner to keep the Frankfort plane parallel to the floor. The subjects were asked to keep their teeth in maximum intercuspal position during the scan time. All radiographs were taken in a standard manner by the same operator.

Using NNT software, version 6.2 (Quantitative Radiology, Verona, Italy), three-dimensional (3-D) images were prepared to assess the condylar asymmetry. An expert maxillofacial radiologist who was blinded to the results of the clinical examinations selected the points, drew the lines, and measured the right and left condylar heights (RCH and LCH) on the 3-D images according to the method devised by Habets et al., (1988) (Fig. 1). The most posterior points of the condyle and ramus were marked on both sides of the mandible. Next, a line was drawn through these points that was referred to as the X-line. Another line, called the Y-line, was drawn from the most superior points of the condyle perpendicular to the X-line. The distance between their confluence and the most posterior point of the condyle was measured as the condylar height. Condylar asymmetry index was then calculated, using the following formula developed by Habets et al.:

$$\text{Condylar Asymmetry index}(\%) = \left|\frac{\text{Right CH} - \text{Left CH}}{\text{Right CH} + \text{Left CH}}\right| \times 100$$

All measurements were made twice with intervals of at least 2 weeks to evaluate the significance of any error during measurements. The results of the first and second measurements were compared using intra-class correlation.

2.4. Statistical analysis

All statistical analyses were performed using the Statistical Package for Social Sciences for Windows (version 17; SPSS Inc., Chicago, IL, USA). In addition, descriptive statistics were performed. The Mann–Whitney U-test was used to determine the statistically significant differences between the condylar asymmetry of the cases in the control group and that of the TMD patients. The Kruskal–Wallis test was used to establish the difference between condylar asymmetry indexes among different classes of TMD. The Kruskal–Wallis one-way analysis of variance was used to identify the statistically significant differences between CAIs among different classes of TMD. The significance level set at 0.05.

3. Results

There was no statistically significant difference between the first and second measurements. Also, there were no systemic errors based on the paired t tests. Correlations between the first and second measurements ranged from 0.846 to 0.918.

Table 1 shows the amount of condylar asymmetry index (CAI) in TMD patients and the control group subjects. According to the Mann–Whitney U Test, the CAIs of the TMD patients were significantly higher than those of the control group (P = 0.001).

Table 1
Comparison of the degree of condylar asymmetry index (CAI) between TMD patients and control group (Mann–Whitney U test).

Group	N	Condylar Asymmetry Index		P value
		Mean ± SD	Median	
Control	42	3.03 ± 1.95	3.13	0.001
TMD patients	42	5.12 ± 3.61	4.29	

According to the Helkimo dysfunction index, 28.57% of the TMD patients showed a Helkimo index of 1; 33.33% of TMD subjects presented a Helkimo index of 2; and 38.09% of this group had a Helkimo index of 3. Table 2 shows the CAI of TMD patients with different classes of Dysfunction index. The Kruskal–Wallis test revealed that there were no statistically significant differences in terms of CAI among TMD patients with different classes of dysfunction index (P = 0.22). No significant correlation was observed between CAI and age (Spearman r = 0.655, P = 0.23).

4. Discussion

The diagnosis of TMD often involves history taking, clinical examination, and imaging of the TMJ (Sharma et al., 2011). Helkimo's Di, a standardized index for classification of patients with signs and symptoms of TMJ disorders, was considered to be a practical tool for evaluating TMD and comparing different studies (Fricton and Schiffman, 1986). Condylar asymmetry has been widely used to complement clinical diagnostic tests in patients with TMD (Miller et al., 1998; Sağlam, 2003).

The morphology of the mandibular condyle may change when the articular surface of the temporomandibular joint (TMJ) is overloaded (Rodrigues et al., 2009; Yáñez-Vico et al., 2012). We hypothesized that condylar asymmetry leads to hyperactivity of the muscles, which can overload the surface of the joint and affect the soft and hard tissue component of TMJ. Therefore, more asymmetry in the condyles may cause more clinical signs and symptoms, but the results failed to support our hypothesis. This means that although there is a relationship between condylar asymmetry and TMD, the causative relationship is not clear.

The degree of CA was in fact greater in patients with TMDs of myogenic origin than in those with TMDs of arthrogenic origin (Bezuur et al., 1988). There is currently no consensus with respect to the reliability and utility of the different techniques employed to measure mandibular asymmetries (Van Elslande et al., 2008). Fuentes et al. concluded that the Habets method provides acceptable clinical information on condylar asymmetries (Fuentes et al., 2011).

Panoramic radiography is the most frequently used imaging technique used to detect mandibular asymmetry. Yet, two-dimensional X-rays have inherent limitations such as elongation

Table 2
Comparison of the condylar asymmetry index (CAI) among TMD patients with different classes of Dysfunction index (Kruskal–Wallis test).

Helkimo Score (Di)	N	Condylar Asymmetry Index		P value
		Mean ± SD	Median	
Di I	12	3.53 ± 2.70	3.11	
Di II	14	5.21 ± 3.24	4.44	0.220
Di III	16	6.23 ± 4.22	5.35	

Code:Di I= Helkimo dysfunction index 1 (1–4 points in Helkimo scoring system, mild dysfunction); Di II= Helkimo dysfunction index 2 (5–9 points in Helkimo scoring system, moderate dysfunction); Di III= Helkimo dysfunction index 3 (10–25 points in Helkimo scoring system, severe dysfunction).

or distortion of the image and different head position errors, which may lead to an incorrect diagnosis (Bumann and Lotzmann, 2000). According to the studies by Yáñez-Vico et al. and Zhang YL et al., craniofacial asymmetries may be diagnosed using conventional radiographic approaches although 3-D methods seem to be necessary for a more complete diagnosis (Yáñez-Vico et al., 2011; Zhang et al., 2016). The present study used CBCT examination in order to improve the validity and the reliability of the imaging data.

There have been some studies that used the panoramic technique to assess the condylar asymmetry in TMD patients. Some of them found a relationship between asymmetry and parafunction and headache (Schokker et al., 1990; Miller et al., 1998).

Saglam and Sanli reported no statistically significant differences in terms of the condylar asymmetry index on panoramic radiographs between patients who had TMD and those who did not (Sağlam, 2003). The criterion for choosing their patients was referral for treatment of TMD with a primary myogenous problem, and they did not use any index for standardized manner. In the present study, we employed Helkimo's classification, a widely used index for clinical evaluation of TMD (Fricton et al., 1986). Piancino et al. used orthopantomography and showed that the condyles of the patients with juvenile idiopathic arthritis compared to the normal patients were highly asymmetric (Piancino et al., 2015). The discrepancy in the findings may be attributed to the different imaging modalities applied in these studies, including the use of panoramic radiography and the evaluation methods.

Buranastidporn et al. have reported a relationship between the vertical asymmetry of the mandible and the occurrence of TMD signs. They suggest that disturbance in the direction of stress distribution through asymmetry of the mandible is one of the mechanisms related to disc displacement (Buranastidporn et al., 2004). Yáñez-Vico et al., (2012) used 3-D CT, indicating that condylar width, height and length asymmetries were a common feature of TMD, which is in agreement with the results of the present study. Condylar asymmetry in TMD patients may be due to the disruption in the normal load subjected to the TMJ.

Reliability of the Helkimo index has been supported for application in epidemiological and clinical studies (Fricton et al., 1986; Wänman, 1987). The results of the present study showed no statistically significant differences in terms of condylar asymmetry between TMD patients with different Helkimo indexes. To the best of the authors' knowledge, there is no other investigation in the literature on condylar asymmetry in TMD patients with different Helkimo indexes. Su et al. investigated the correlation between the bony changes measured with Helkimo index in patients and found a significant correlation between the degree of Helkimo's Di and the maximum condylar bony changes as well as the glenoid fossa bony changes, but they observed a poor correlation between the degree of Helkimo's Di and joint space changes (Su et al., 2014).

There is research that demonstrates a correlation between age and the condylar asymmetry index of the temporomandibular joint in TMD patients (Miller, 1992; Miller et al., 1994). A greater depletion rate of the mesenchymal cells with the increase in age has been reported. The results of the present study, however, appear to contradict these study results and showed no significant correlation between the condylar asymmetry index and age. Miller and Bodner (1997) as well as Miller and Smidt (1996) found no correlation between the condylar asymmetry index and age in patients with Angle's Class II division 2 and Class III malocclusions.

In this study, individuals who had a history of trauma, TMJ surgery, or any systemic disorders such as rheumatoid arthritis were not included because these factors could affect the morphology and position of the condyle.

Certain differences between the findings of this study and those achieved previously suggest the need for further studies in this field involving other populations while considering and eliminating possible confounding factors.

5. Conclusion

Based on the findings of the present study, patients with condylar asymmetry are more susceptible to TMD. However, the degree of the condylar asymmetry is not a criterion for TMD signs and symptoms.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcms.2018.12.012.

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