Original papers

Comparative assessment of condylar position in patients with temporomandibular disorder (TMD) and asymptomatic patients using cone-beam computed tomography

Ocena porównawcza położenia wyrostka kłykciowego u pacjentów z zaburzeniami stawów skroniowo-żuchwowych i bez objawów klinicznych z wykorzystaniem tomografii stożkowej

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Abstract

Background. Temporomandibular disorders (TMD) are the most common reason of non-dental pain in the orofacial region. A clinical examination of the temporomandibular joint (TMJ) with additional imaging is the most recommended procedure for TMD diagnosis.

Objectives. The objective of this study was to evaluate the association between TMD and the condylar position in the glenoid fossa by examining a group of patients suffering from TMD compared with a control group of patients without TMD. In this study, we used cone-beam computed tomography (CBCT) images for measurements.

Material and methods. Sixty-five symptomatic joints were selected from 48 patients with TMD. Sixty-five joints were selected from a total of 96 asymptomatic joints in the control group. The superior, anterior and posterior area of the joint, and the steepness of the articular eminence were measured on the CBCT images. The data was analyzed using Pearson's χ^2 test.

Results. The position of the condyle was significantly more posterior in the joints with TMD, and more anterior and centric in the asymptomatic joints. Statistically, the vertical position of the condyle and the steepness of the articular eminence had no significant relation with the occurrence of TMD.

Conclusions. In this study, we observed that the posterior condylar position is more common in TMD patients, but it is not the reason for diagnosing TMD, and the reason of the posterior position of the condyle should be investigated before any decisions pertaining to treatment are made. In future, studies should focus on evaluating how the position of the condyle will change after the treatment of patients with TMD.

Key words: cone-beam computed tomography, temporomandibular disorders, condylar position

Słowa kluczowe: stożkowa tomografia komputerowa, zaburzenia stawów skroniowo-żuchwowych, położenie wyrostka kłykciowego

Introduction

The term 'temporomandibular disorders' (TMD) refers to a group of pathologic conditions that affect the temporomandibular joints, jaw muscles, or all of the associated tissues.[1] Temporomandibular disorders are the most common reason for non-dental pain in the orofacial region, which can be accompanied by otalgia, headache, neuralgia, and toothache.[2] It is estimated that 6–12% of Americans suffer from TMD symptoms.[3]

According to the American Dental Association (ADA) guidelines, TMD comprise a triad of the temporomandibular joint (TMJ) pain, TMJ sounds during jaw function, and deviation or restriction of mandibular movements.[4] The research diagnostic criteria for temporomandibular disorders (RDC/TMD) have been the most frequently employed diagnostic protocol for TMD research since its publication in 1992. This method has been based on physical and psychological criteria.[5]

The TMJ imaging, in addition to clinical assessment, is the most recommended procedure for diagnosing TMD in the literature.[1] Plain film radiography, conventional tomography, computed tomography (CT), cone-beam computed tomography (CBCT), and magnetic resonance imaging (MRI) are different radiographic methods that have been used in previous studies for TMJ assessment.[6,7] Cone-beam computed tomography is suggested as a high resolution and precise 3-dimensional (3D) technique for analyzing the condylar position in the glenoid fossa.[8]

Some of the reasons why CBCT is preferred when compared with other imaging techniques at the region of TMJ are as follows: 3D images, higher accuracy and a smaller slice thickness as compared to the conventional tomography and radiography[6]; spatial resolution even higher than in the case of spiral CT[6]; effective dose and scanning time, and cost lower than in spiral CT[6,8]; the fact that MRI is not suitable for the evaluation of hard tissue.[9]

The position and function of the condyle is directly controlled by the oral structures.[10] Many dynamic variables, such as growing, remodeling, functional matrix activities, occlusion changes, and physiologic adaptations, affect the condylar position. A considerable posterior position of the condyle often reveals a disorder.[11] It appears that joints with disk displacement tend to have a posterior condylar position.[12] The TMJ disk is interposed between the posterior slope of the eminence and the functional surface of the condyle to act as a buffer between the 2 bones. It appears that disk displacement can change the condylar position.[13]

Some studies suggest that the condyle–fossa relationships can be used as a significant index for TMD and, consequently, therapeutic procedures based on optimizing the condylar position have been indicated. However, other studies deny this association.[6]

The condylar movements and pathways during mouth opening and closing are different, depending on the condylar position in the glenoid fossa. Physical loading on the articular disk and the condylar head would also be different in various condylar positions.[14]

The purpose of this study was to evaluate the association between TMD and the condylar position in the glenoid fossa by examining a group of patients suffering from TMD and comparing it with a control group of patients without TMD. In this study, we used CBCT images for measurements.

Material and methods

Forty-eight patients with symptomatic TMD were referred to the Department of Oral and Maxillofacial Prosthodontics, at Hamadan Dental School in Iran. An expert prosthodontist visited the patients and filled out the questionnaire, and then ordered a CBCT image for the symptomatic TMJ. Patients were selected according to RDC/TMD, which is an international diagnostic system and is widely used as a valid and reliable system.[15] This study was carried out in 2017.

From a total of 96 joints in the patients' group, 65 symptomatic joints were diagnosed and their CBCT images were analyzed.

The criteria for the selection of patients in the TMD group were as follows:

- any history of pain in the region of TMJ, or pain during function or palpation of TMJ;
- TMJ noises during opening and closing, or lateral jaw movements;
- limitation in jaw movements.

In the control group, 48 patients were selected from those who had CBCT images as a result of implant treatment or surgery of impacted teeth, and who also had no signs and symptoms of TMD. Patients with malocclusion were excluded from the study. Since in the TMD group 65 symptomatic joints were selected, we also selected 65 asymptomatic joints from a total of 96 asymptomatic joints in the control group.

The criteria considered for the selection of the control group were as follows:

- no history of TMD observed;
- no signs and symptoms of TMD observed during the visit;
- no deviation during jaw function;
- no asymmetry observed;
- no history of trauma to the jaw;
- the difference between the centric relation and centric occlusion position <1 mm;
- no radiographic signs of TMD observed (patients with radiographic symptoms of osteoarthritis, joint lesions and cysts, subcortical sclerosis, and congenital and size abnormalities in the condylar head were excluded from the study).

In both groups, patients with any congenital abnormalities or systemic diseases that could be related to the TMJ morphology, like rheumatoid arthritis, were excluded from the study. Patients with a history of prosthetic or occlusion treatment were also excluded.

All patients took part in the study voluntarily and written consent forms were taken from each of them after they had been informed about the study. The study was approved by the local ethical committee of Hamadan Dental School, Iran (No. 16/35/9/221).

The CBCT scans were performed with the ProMax® apparatus (Planmeca, Helsinki, Finland) with a field of view of 8 × 8 cm^2, maximum output of 84 KVP and time exposure of 12 s.

The CBCT images were taken in the position of habitual occlusion with the mouth closed. Linear measurements of the superior, anterior and posterior joint space between the condyle and the glenoid fossa, and also the steepness of the articular eminence were performed through the landmarks defined in the sagital CBCT images. Multiplanar CBCT images were reconstructed with the Romexis® software v. 3.8.0 (Planmeca).

The axial view, in which the condylar process had the widest mediolateral diameter, was chosen as the reference view for secondary reconstruction. On this selected view, a panoramic curved line, parallel to the long axis of the condylar process was drawn and lateral slices were reconstructed with 1-millimeter slice intervals and a thickness of 0.5 mm. The central saggital slice was selected as the reference image for the assessment of the condylar position.

Assessment of horizontal (antero-posterior) position of condyle in saggital plane

Two lines were traced from the most superior point of the glenoid fossa adjacent to the most anterior and posterior points of the condyle. The shortest distance to the anterior and posterior border of the glenoid fossa was called the anterior and posterior TMJ space, respectively (Fig. 1). The condylar position was analyzed with Pullinger and Hollender's formula:

$$\text{condylar ratio} = \frac{P - A}{P + A} \times 100 \qquad (1)$$

where:
P – posterior joint space;
A – anterior joint space.

The position of the condyle was considered concentric if the ratio was within ±12%. If the ratio was smaller than −12%, the condylar position was considered posterior, and if the ratio was greater than +12%, the condylar position was considered anterior.[16]

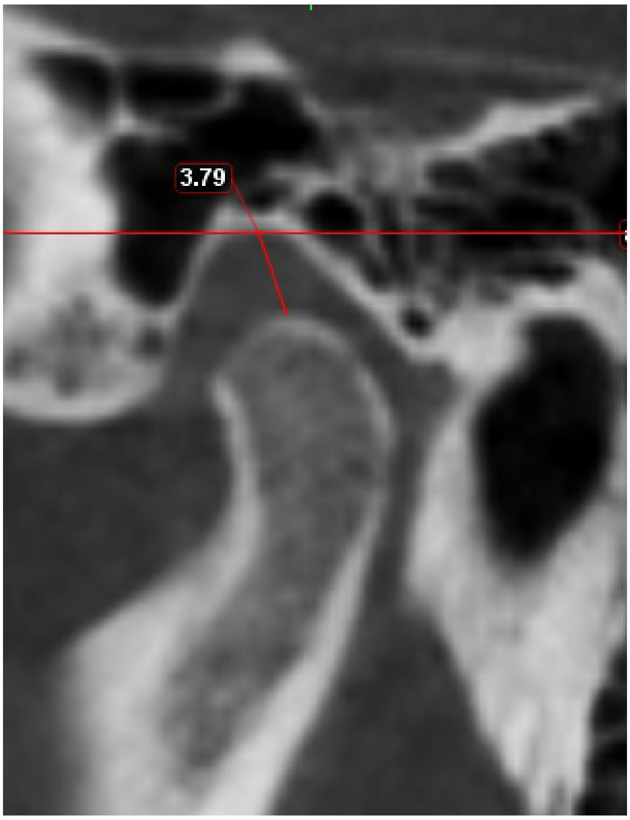

Fig. 1. Two lines traced from the most superior point of the glenoid fossa adjacent to the most anterior and posterior points of the condyle. The shortest distance to the anterior and posterior border of glenoid fossa was called the anterior and posterior TMJ space, respectively

Assessment of vertical position of condyle in saggital plane

The distance from the most superior point of the condyle to the deepest point of the glenoid fossa was measured (Fig. 2). The vertical distance of 1–4 mm was considered as normal. The distance >4 mm and <1 mm were considered as the lower and upper condyle vertical position, respectively. The value of 0 mm was indicated as the bony contact.[17]

Assessment of articular eminence steepness in saggital plane

A tangent line to the anterior wall of the glenoid fossa was drawn. The true angle between this line and the true horizontal line (THL) was measured as the slope of the articular eminence (Fig. 3). Angles of 15–30°, 30–60° and 60–90° degrees were considered as mild, moderate and severe articular eminence steepness, respectively.[18]

Statistical analyses were performed with the IBM SPSS software v. 22 (IBM Corp., Armonk, USA) using Pearson's χ^2 test to compare the TMJ measurements between the 2 groups of patients at the significance level of 0.05. All measurements were performed twice with an interval of 1 week, and the inter- and intraclass correlation

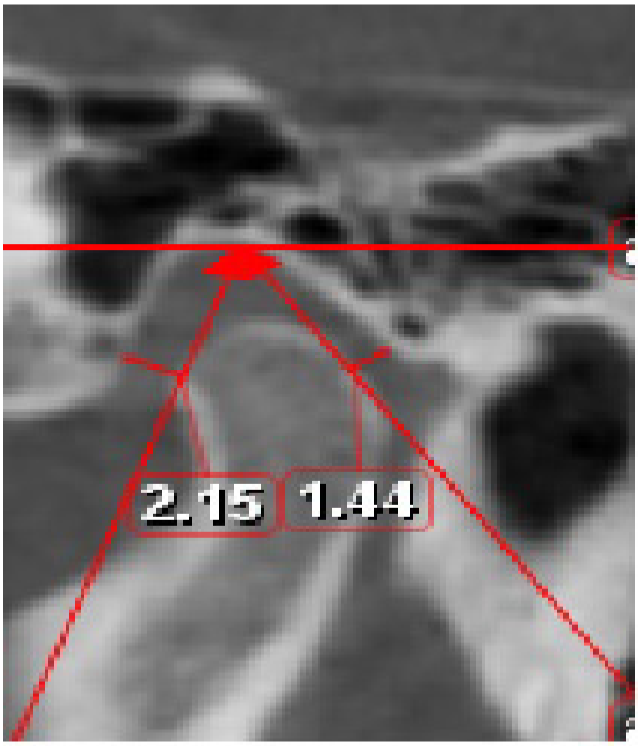

Fig. 2. Distance from the most superior point of the condyle to the deepest point of the glenoid fossa, called the superior joint space

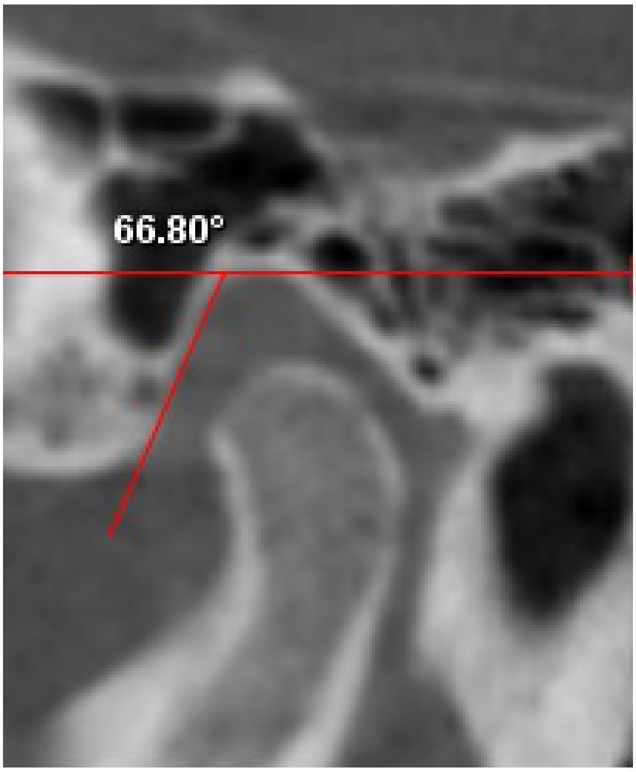

Fig. 3. A tangent line to the anterior wall of the glenoid fossa was drawn. The true angle between this line and the true horizontal line (THL) measured as the steepness of the articular eminence

coefficients (ICC) were analyzed using the paired t-test for any errors in the measuring process with a level of significance set at $p < 0.05$.

Results

Out of 130 patients (both symptomatic and asymptomatic groups) in our study, 29 were male and 101 were female. Thirty-one percent of males suffered from TMD, but this value for females was 55.4%. The average age in the TMD group was 31 years. This value for the control group was 25 years.

There were no significant differences between dual measurement values, which shows a minimum error in identifying the reference points in the study. The value for intraclass correlation was 93% and for interclass correlation – 97%.

The relation between TMD and the horizontal position of the condyle was statistically significant ($p < 0.05$). The results showed that the position of the condyle with TMD was mostly posterior (52.3%), and the position of the asymptomatic condyle was mostly anterior (38.5%) and concentric (33.8%) (Table 1).

There was no significant difference between the symptomatic and asymptomatic groups with regard to the steepness of the articular eminence and the vertical position of the condyle in the glenoid fossa ($p > 0.05$) (Tables 2,3).

Table 1. Results of the assessment of the horizontal condylar position in patients

Group	Horizontal condylar position			*p*-value
	posterior	concentric	anterior	
Symptomatic TMD group (65 joints)	34 (52.3)	18 (27.7)	13 (20)	0.011
Asymptomatic group (65 joints)	18 (27.7)	22 (33.8)	25 (38.5)	0.011

Data presented as numer (percentage). TMB – temporomandibular disorders.

Table 2. Results of the assessment of the steepness of the articular eminence in patients

Group	Steepness of articular eminence			*p*-value
	mild	moderate	severe	
Symptomatic TMD group (65 joints)	1 (1.5)	48 (73.8)	16 (24.6)	0.312
Asymptomatic group (65 joints)	1 (1.5)	40 (61.5)	24 (36.9)	0.312

Data presented as numer (percentage).

Table 3. Results of the assessment of the vertical position of the condyle in the glenoid fossa in patients

Group	Vertical position of condyle			*p*-value
	upper	normal	lower	
Symptomatic TMD group (65 joints)	1 (1.5)	49 (75.4)	15 (23.1)	0.312
Asymptomatic group (65 joints)	0 (0)	48 (73.8)	17 (26.2)	0.312

Data presented as numer (percentage).

Discussion

Our study evaluated the relationships between TMD and age, gender, horizontal condyle position, vertical condyle position, and steepness of articular eminence.

In our study, the average age in the TMD group was 31 years and in the asymptomatic group – 25 years. We were not able to select exactly the same age of the control group as in the study group because of the ethical limitations for CBCT imaging regarding the ALARA (as low as reasonably achievable) principle for radiation protection.

Manfredini et al. indicated 2 age peaks of patients seeking the TMD treatment: 30–35 years and 50–55 years.[19]

It is widely recognized that females more often suffer from TMD.[20–22] Warren and Fried indicated the prevalence of TMD in females of up to 70% of the population in some studies.[23] Furthermore, they indicated the peak age of involving in TMD as 20–40 years, which is similar to the gestational age of females. That is why they proposed a relationship between the TMD pathogenesis and hormonal changes in females.[23] Nevertheless, Widmalm et al. found no gender relation with TMD.[24]

We indicated that the position of the condyle was more posterior in the joints with TMD, and was more anterior and centric in the asymptomatic joints. Paknahad and Shahidi observed that the condylar position was more posterior in severe TMD patients.[9] Imanimoghaddam et al. also showed that decreased posterior joint space is a ore prominent finding in TMD patients.[11] Cho and Jung reached a similar conclusion, which is in agreement with the present study.[25] Lelis et al. found that there were no significant differences in the condylar positions between the centric relation and the maximum intercuspation in either symptomatic or asymptomatic young adults.[26] This could be due to different accuracy of the imaging technique, different anatomy of the samples or the young age of the patients in this study (the patients did not have enough time to develop changes in the condylar position).[26]

Some researchers believe that the reasons for the posterior condylar position arise from disk displacement,[13] osteoarthritis,[23] bone remodeling of the articular eminence and the condyle,[27] and osteoarthrosis.[28]

One MRI study revealed that the posterior condyle position was the main feature of TMJ with slight and moderate anterior disk displacement.[29] Magnetic resonance imaging is the best way to assess disk displacement; nevertheless, Ikeda and Kawamura indicated that changes in the disk position, particularly the posterior band position, can be detected as changes in the joint space on the CBCT images in adolescents and young adults, which is why they concluded that the direction and extent of disk displacement could be observed on the CBCT images.[13]

Some studies revealed that the condylar position in TMD patients is directly relevant to the condition of the articular disk during function, which is classified into 2 groups of anterior disk displacement – with and without reduction.[30–32] The condylar position was more posterior in anterior disk displacement with reduction, and more concentric and anterior in anterior disk displacement without reduction.[33]

Yang et al. selected a total of 52 TMJs with the anterior, concentric and posterior condylar position.[14] They traced the condylar movements by simulating mandibular movements with 3D CT data and a position tracking camera. They observed that the joint space during TMJ movements was significantly narrower, and the length of the condylar pathways with narrower joint space was larger in the posterior condylar position than in the concentric and anterior condylar position. Therefore, the condylar position can have an accelerating or worsening effect on biomechanical loading on the TMJ components during function.[14]

However, there is a question pertaining to whether repositioning the condyle can be used as a treatment for the reduction of the TMD symptoms. There is a hypothesis here that the posterior position of condyle can press the retrodiscal tissues and perceptional nerves; therefore, repositioning the condyle can reduce the pressure on the retrodiscal tissues.[34,35]

There exists a disagreement in recent studies as to the significance level of the relationship between the condylar position in the glenoid fossa and TMD. Some studies suggested that the posterior horizontal position of the condyle is associated with TMD.[13,36–38] However, others have disagreed on this relationship.[6,39–41]

The former group suggested repositioning the condylar position in order to optimize the treatment of TMD,[42] while the latter group of studies did not recommend such a treatment.[43] Therefore, evidence-based and organized studies are needed to answer the above-mentioned question.

The subjects' age, ethnicity, gender, the morphology of the craniofacial complex, and also different radiographic techniques, accuracy of clinical examinations and the methods of measurements can explain such a difference in the results of the studies.[9] In the present study, we excluded patients with a history of prosthetic or occlusion treatment and systemic diseases, which could affect the measurements of the condylar position.

In our study, there was no significant difference between the TMD and asymptomatic patients in the vertical position of the condyle. Mazzetto et al. indicated that the superior space of the joint was slightly increased in the TMD group, but it was not statistically significant.[1] The same observation was made in our study. They also noticed that males had the superior joint space higher than females in the asymptomatic joints.[1]

In our study, there was no significant difference between the TMD and asymptomatic group regarding the steepness of the articular eminence. Shahidi et al. reached the same conclusion. They indicated that there was no apparent relationship between the articular eminence inclination and clinical dysfunction.[44]

Toyama et al. suggested that an increase in the articular eminence gradient was one of predisposing factors of disk displacement,[45] and Ren et al. indicated that the articular eminence gradient was decreased in patients with TMJ disorders.[46] This can due to degenerative or remodeling changes in the joint. However, these changes are not observable in the preliminary phase and are more considerable with disease progression in older patients.[47]

Conclusions

In this study, we observed that the posterior condylar position is more common in TMD patients, but it is not the reason for diagnosing TMD. Therefore, the reason of the posterior position of condyle should be investigated before any decision regarding treatment is made.

In future, studies should focus on evaluating how the position of the condyle will change after the treatment of patients with TMD.

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