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A computed tomography analysis of temporomandibular joint changes associated with the number of occlusal stops

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Abstract

Objective: This study aimed to evaluate the association between temporomandibular joint (TMJ) structure and occlusal support status using computed tomography (CT) images.

Methods: In this cross-sectional study, the computed tomography (CT) scans of 90 patients were categorized into six groups based on the number of posterior and anterior occlusal support areas (Eichner classification). In CT images, the articular eminence inclination, and glenoid fossa depth and angle were measured. Furthermore, condylar shape and position, and the presence of condyle-flattering or other pathologic changes were recorded. The TMJ variables were compared between different Eichner classification groups. The data were analyzed by paired samples T-tests, one-way ANOVA, and chi-square test ($\alpha=0.05$).

Results: The loss of posterior occlusal support was associated with TMJ flattening and a posterior condylar position ($P<0.001$). No significant difference was found in the inclination of the articular eminence and depth of the glenoid fossa between different Eichner groups ($P>0.05$). In patients with unilateral occlusal support, the TMJ on the edentulous side had a significantly lower articular eminence inclination, a greater angle of the glenoid fossa, and a decreased glenoid fossa depth ($P<0.001$).

Conclusions: Loss of posterior occlusal support may lead to changes in the structure of the glenoid fossa, joint space, and condylar position and cause flattening of the condyle. These changes may predispose the joint to degenerative changes.

Keywords: Computed tomography, Dental occlusion, Mandibular condyle, Temporomandibular joint disorders, Tooth loss, Stomatognathic system

Introduction

Temporomandibular joint (TMJ) dysfunction is currently the most common jaw disorder. The American Academy of Orofacial Pain defines temporomandibular dysfunction (TMD) as a broad term that encompasses musculoskeletal and neuromuscular disorders affecting masticatory muscles, TMJs, and associated structures. TMD affects approximately 5 to 12% of the general population and is considered the most common cause of chronic orofacial pain with non-odontogenic origin (1).

TMD is of multifactorial etiology. Malocclusion, oral parafunctions, oral habits, and trauma are the main factors associated with TMDs. However, the impact of these factors remains uncertain. The influence of occlusal disharmony on TMD has long been debated. Traditionally, occlusal factors were considered significant contributors to TMD, but recently the role of occlusion in the incidence of TMD has become questionable (2). Some studies confirmed a significant association between posterior crossbite, reduced

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overbite, tooth loss, and premature contact with TMD development (3-5).

Compromised occlusal support has been associated with sensitivity and pain in the masticatory muscles and TMJ structures. A decrease in posterior occlusal support in patients with a very short dental arch may increase the risk of mandibular instability and TMD development (6). Occlusal support is crucial for balanced occlusion and maintaining the vertical dimensions of the jaws. Loss of occlusal support leads to changes in the craniofacial structures, affecting neuromuscular adaptation and the position of the TMJ condyles in the glenoid fossa. However, several studies have shown that occlusal support and TMDs are only weakly correlated, as the stomatognathic system and motor function can adapt to a loss of occlusal support (7, 8).

The present study aimed to determine the relationship between radiographic changes in the TMJ structures and the number of occlusal stops based on the Eichner index classification.

Materials and method

Study design and participants

The protocol of this cross-sectional study was reviewed and approved by the research and ethics committee of Mashhad University of Medical Sciences (IR.MUMS.sd.REC.1396.281).

The computed tomography (CT) records of the head and skull were retrieved from patients who were referred to the Radiology Department of Shahid Kamyab Hospital, Mashhad, Iran from January to June 2023. The CT images had been prescribed for reasons other than that of this study. The patients who had systemic diseases and those with a background of trauma or fracture in the orofacial areas were excluded from the study. Multiplanar CT scans were performed using a 16-slice scanner (SIEMENS, Forchheim, Germany) in the supine position with centric occlusion. The TMJ was evaluated in sagittal, axial, and coronal planes. For the reconstruction of the sagittal and coronal planes, a section from the axial plane with the largest mediolateral diameter of the condyle was selected. The image reconstruction was performed with a slice thickness of 0.7 mm.

Grouping and Study variables

The patients were categorized into six subgroups based on the number of occlusal stops, according to the Eichner index classification (Table 1).

All images were evaluated by an oral and maxillofacial radiologist (NA). The following radiographic variables were assessed and recorded:

- The position of the mandibular condyle: The condylar position was defined in the sagittal and coronal planes and categorized as anterior, posterior, superior, inferior and centric position.
- The shape of the mandibular condyle: The condyle shape was classified into 5 categories including flat, convex, round, angled and other shapes in the coronal sections.
- Pathologic findings: The presence of TMJ flattening, condylar erosion, osteophytes, Ely's cysts, subcondylar sclerosis, and glenoid fossa sclerosis was recorded as yes or no for each condition.

Subsequently, the following variables were measured in CT images (Figure 1).

- Depth of the glenoid fossa: The glenoid fossa depth was defined as the vertical distance between the highest point of the glenoid fossa and a line passing through the lowest point of the articular eminence and the most posterior part of the glenoid process (9).

Table 1. Eichner index classification (10)

Eichner index category	
A	Four areas of posterior occlusal support (both sides with premolar and molar support)
B1	Three areas of occlusal support in the posterior region (one side with support from premolars and molars, the other side with support from premolars or molars)
B2	Two areas of occlusal support in the posterior region (one side with support from premolars or molars, the other side with support from premolars or molars)
B3	An area of occlusal support in the posterior region (support by premolars or molars on one side only)
B4	Contact between anterior teeth without occlusal support in the posterior region
C	No support in the anterior or posterior region

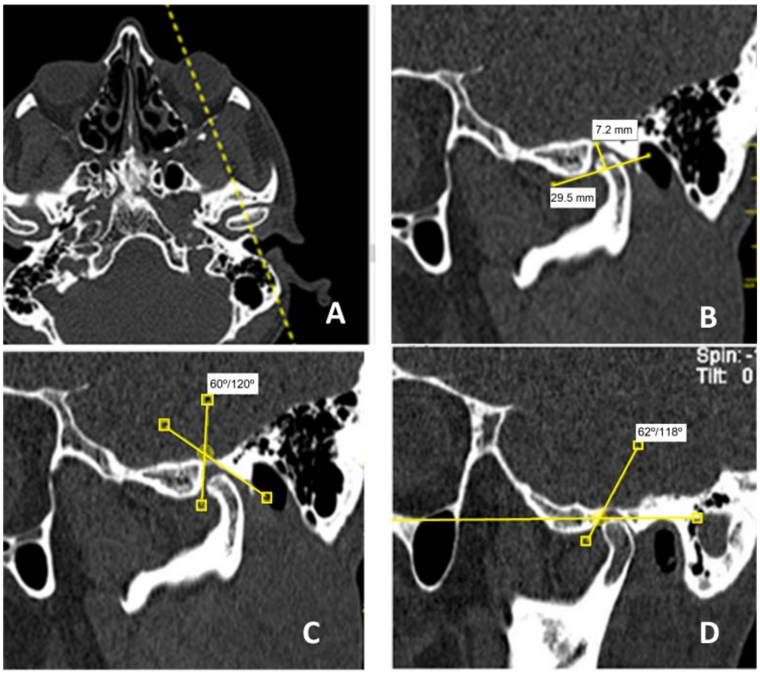

Figure 1. A: Drawing the corrected sagittal plane. B: The glenoid fossa depth was defined as the vertical distance between the highest point of the glenoid fossa and a line passing through the lowest point of the articular eminence and the most posterior part of the glenoid process. C: The angle of the glenoid fossa was calculated by measuring the angle between the best tangential plane with the anterior and posterior walls of the glenoid fossa. D: The inclination of the articular eminence was measured based on the best-fit line method. In this method, the best tangential plane is drawn to the posterior inclination of the eminence in the sagittal view. The Frankfurt plane is also drawn, and the angle between these two planes is measured.

- Angle of glenoid fossa: The angle of the glenoid fossa was calculated by measuring the angle between the best tangential plane with the anterior and posterior walls of the glenoid fossa.
- The inclination of the articular eminence: The inclination of the articular eminence was measured based on the best-fit line method. In this method, the best tangential plane is drawn to the posterior inclination of the eminence in the sagittal view. The Frankfurt plane is also drawn, and the angle between these two planes is measured (10).

Statistical analysis

SPSS version 25 software (IBM Inc., NY, USA) was used for statistical analysis. TMJ variables were compared between the Eichner classification groups using one-way ANOVA and the LSD post-hoc test. The chi-square test was used to compare the condyle position and flattening frequency among the Eichner classification groups. TMJ variables between the supported and unsupported sides in patients with unilateral posterior support were compared by paired samples t-test. The significance level was set at $P<0.05$.

Results

A total of 90 patients (180 condyles), comprising 55 males and 35 females with an average age of 37.90 ± 2.4 years, were included. Table 2 presents the frequency of various condyle shapes in the coronal plane and condylar positions in the sagittal plane. Most condyles were convex (57.1%) and positioned in the center of the glenoid fossa (63.3%).

Table 2. The frequency (N) and percentage (%) of condyle shapes and positions in the glenoid fossa in coronal and sagittal planes

Condyle shape	N (%)	Condyle position	N (%)
Convex	103 (57.2)	Superior	2 (1.1)
flat	33 (18.3)	Inferior	8 (4.4)
Round	17 (9.4)	Anterior	2 (1.1)
Angled	22 (12.3)	Posterior	54 (30.0)
Other forms	5 (2.8)	Central	114 (63.3)
Total	180 (100)	Total	180 (100)

Table 3. Frequency (percentage) of patients with centric and eccentric condylar positions and with or without condyle flattening in different Eichner index classes

Eichner index	Position of the condyle		Flattening of the condyle	
	Centric N (%)	Eccentric N (%)	Flattened N (%)	Not flattened N (%)
A	34 (100)	0 (0.0)	0 (0)	34 (100)
B1	8 (53.33)	7 (46.66)	5 (33.3)	10 (66.7)
B2	9 (64.28)	5 (35.71)	5 (35.7)	9 (64.3)
B3	3 (0.25)	9 (0.75)	6 (50)	6 (50)
C	3 (2.0)	12 (0.8)	7 (46.7)	8 (53.3)
Total	57(63.3)	33(36.7)	23 (25.6)	67 (74.4)
P value	<0.001		<0.001	

The A, B1, B2, B3, and C categories of Eichner classifications were observed in 34 (37.8%), 15 (16.7%), 14 (15.6%), 12 (13.3%), and 15 (16.7%) patients, respectively. None of the participants showed B4 classification.

Table 3 presents the position of the mandibular condyles in the sagittal plane in different Eichner classes. Overall, 63.3% of condyles were in centric, and 36.7% were in eccentric positions. The posterior position was the main eccentric condylar position observed in 30% of patients. Since the number of condyles in the superior, inferior, and anterior positions was low, they were not individually included in the statistical analysis, and the comparison was made between centric and eccentric condylar positions. The chi-square test showed a statistically significant relationship between the Eichner group and the condyle position (P<0.001). As the Eichner index increased and the number of occlusal stops decreased, the number of condyles in an eccentric (posterior) position increased (p<0.001).

Table 3 presents the distribution of condylar flattening in different Eichner classes. Most mandibular condyles presented normal morphology. However, condyle flattening was observed in 23 patients (25.6%) of subjects. The chi-square test showed a significant association between the presence of condylar flattening and the Eichner index group so that higher frequency of flattening was observed in patients with reduced occlusal stops. Other pathologic findings were osteophyte and Ely's cyst which were observed in 3 (3.3%) and 1(1.1%) patients, respectively.

Table 4 presents the mean and standard deviations (SD) of quantitative radiologic variables in different Eichner classes. One-way ANOVA revealed no significant difference between the depth of the glenoid fossa and the inclination of articular eminence between different Eichner groups. However, the angle of the glenoid fossa significantly differed among the groups (P=0.015). The result of the LSD post hoc test showed that the angle of

Table 4. Comparing the TMJ variables between the Eichner classification

Eichner classification	Articular eminence inclination (Degree)	Glenoid fossa angle (Degree)	Glenoid fossa depth (mm)
A	59.79 ± 8.95	71.15 ± 8.56^{a}	6.76 ± 0.79
B1	61.93 ± 7.24	69.07 ± 9.23^{a,b}	6.14 ± 0.93
B2	59.71 ± 9.03	62.29± 13.25^{b}	6.56 ± 1.15
B3	59.17 ± 9.17	65.17±7.59^{a,b}	6.16 ± 1.15
C	59.47 ± 9.31	63.93 ± 7.46^{b}	6.26 ± 1.34
P value	0.921	0.015	0.215

Different superscript letters indicate statistically significant differences at P<0.05.

Table 5. Comparing the TMJ variables between the left and right sides and the supported and unsupported sides in patients with unilateral posterior support

Variables	Posterior support status		P value
	Unsupported	Supported	
Articular eminence inclination (Degree)	55.3 ± 7.6	58.9 ± 7.7	<0.001
Glenoid fossa angle (Degree)	65.0 ± 8.2	61.8 ± 9.0	<0.001
Glenoid fossa depth (mm)	6.0 ± 1.0	6.3 ± 1.0	<0.001

the glenoid fossa was significantly greater in group A than in the B2 and C groups (P<0.05).

In 12 patients, unilateral posterior support was observed. The paired samples t-test showed that the unsupported side had a significantly lower glenoid fossa depth and articular eminence inclination and a significantly greater glenoid fossa angle than the supported side (P<0.001; Table 5). Furthermore, the chi-square test revealed a significant difference in the position of the condyle between individuals with unilateral occlusal support (P=0.003).

Discussion

In this study, the effect of occlusal support based on the Eicher index classification was evaluated on TMJ changes. CT images were used for a more detailed examination of the morphology of the mandibular condyle and TMJ structures. The results of this study indicated that as the number of occlusal stops is reduced, the condyle is displaced posteriorly, increasing anterior joint space. None of the individuals with bilateral occlusal stops had a posterior condylar position, whereas most of individuals with bilateral edentulism had a posterior condylar position. Although the exact position of the disc could not be determined in the present study, it can be assumed that the loss of posterior teeth (reduction of occlusal stops) may cause flattening of the posterior band of the disc, and lead to anterior disc displacement as a result of the posterior displacement of the condyles. Therefore, posterior tooth loss had a significant effect on posterior condyle position and anterior disc displacement.

In agreement with the outcomes of this study, Emshoff et al. (12) concluded that posterior tooth loss can lead to TMJ arthralgia and disc displacement and is also considered a predictive factor for condylar erosion. A descriptive and analytical study by Omrani et al. (13) stated that posterior tooth loss is significantly associated with the incidence of TMD. Sato et al. (16) also found that TMD symptoms increased with an increase in the number of extracted teeth in the Eichner index groups. Hatim et al. (17) and Ammanna et al. (18) concluded that unilateral and bilateral partial tooth loss cause posterior displacement of the condyle. In contrast to the results of this study, de Lira and Fontenele (14) and Manchikalapudi and Polasani (15) did not find a significant association between the incidence of TMD and posterior tooth loss. In the mentioned studies, TMD screening criteria included TMJ noises such as clicking and cracking, mandibular displacement, restricted mouth opening, mandibular locking, muscular tension, TMJ pain and bruxism, which could be the reason for the difference between their results and the present findings.

The findings of this study revealed no significant difference between the depth of the glenoid fossa and the inclination of articular eminence between different Eichner groups. However, the angle of the glenoid fossa was significantly greater in group A than in the B2 and C groups (P<0.05). In patients with unilateral occlusal support, The TMJ on the edentulous side had a significantly lower articular eminence inclination, a greater angle of the glenoid fossa, and a decreased glenoid fossa depth. This indicates that tooth loss can lead to significant bony changes in the joint structure on the same side. These changes are primarily characterized by a widening of the glenoid fossa in the transverse direction and a reduction in its depth. It is crucial to note that tooth loss on one side causes changes on the same side, which lacks occlusal support. Bertram et al (19) analyzed CBCT images to classify the severity of TMJ condylar erosion and noted a possible correlation between the degree of TMJ condylar erosion and the number of posterior teeth lost the number of quadrants in which posterior teeth were lost, and the presence of bilateral posterior tooth loss. Hansson et al. (20) have also shown that the loss of molar support leads to condylar changes on the same side. Chiang et al. (21) concluded that the inclination of the articular eminence decreases with edentulism. Acuna et al. (22) reported a reduction in articular eminence inclination in patients who have been edentulous for more than five years. In contrast, Jasinevicius et al. (23) evaluated dry skulls and found no significant difference in the depth and angle of the glenoid fossa groups with complete dentition and those with less than 17 teeth. In that. (23), however, it is unclear whether the individuals used dentures or not, and the study included both posterior and anterior edentulism.

In the current study, mandibular condyle flattening was the most common pathologic finding observed in the condylar structure. The statistical analysis revealed a significant difference in the frequency of condylar flattening between the Eicher group A, with bilateral posterior occlusal supports, and the other groups. This means that any loss of posterior occlusal support can cause condyle flattening. Ara et al. (25) concluded that mandibular condyle abnormalities increase with age and are more common in patients with tooth loss. The study by Sato et al. (16) also determined that condylar abnormalities are less in the Eicher group A compared to other groups. Gupta et al. (26) concluded that individuals who lose their first mandibular molars and subsequently develop a deep bite are more likely to exhibit condyle flattening.

One of the limitations of this study was using CT images for analysis. Despite the use of different kernels for image reconstruction, a clear image of the articular disc was not observed in many patients. It is recommended that future studies verify the disk changes in more detail using MRI images.

Conclusions

Under the conditions of this study

1- the loss of posterior occlusal support is associated with TMJ flattening and a posterior condylar position.
2- The angle of the glenoid fossa was significantly greater in Eichner class A than in the B2 and C groups.
3- In patients with unilateral occlusal support, the TMJ on the edentulous side had a significantly lower articular eminence inclination, a greater angle of the glenoid fossa, and a decreased glenoid fossa depth.
4- Overall the findings of this study suggest that the loss of posterior support will guide the patient towards the development of degenerative joint alterations.

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Conflict of interest

The authors declare no conflict of interest.

Authors' contributions

All authors have contributed equally to the work.

Ethical approval

The protocol of the present study was approved by the Ethics Committee of Mashhad University of Medical Sciences (code: IR.MUMS.sd.REC.1396.281).

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