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***ORIGINAL ARTICLE***

# The Effect of Disc Displacement on Temporomandibular Joint Morphology in Patients with Disc Displacement

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## ABSTRACT

**Objective:** To examine the morphological properties of temporomandibular joint structures by magnetic resonance imaging (MRI) on patients with and without disc displacement (DD). **Methods:** Thirty-eight patients with disc displacement and 13 patients without disc displacement were included. Age, gender, and clinical findings such as pain, joint sounds of patients were recorded. The patients were classified as anterior disc displacement with reduction (ADDWR) group, anterior disc displacement without reduction (ADDWoR) group, and control group on MRI. Disc morphology was categorized as biconcave, hemiconvex, biconvex, biplanar, or folded. Condyle morphology was characterized as convex, angled, flat, or rounded. Articular eminence morphology was classified as sigmoid, flattened, box, or deformed. A one-way analysis of variance was used to establish the differences between the values. **Results:** Biconcave disc and sigmoid articular eminence were the greatest incidence both in ADDWR and control group, folded disc and deformed articular eminence were the most in ADDWoR group. The most frequent types of condyle in DD and control group were flattened and convex, respectively. Statistical difference was found between pain and articular eminence morphology (p=0.02). The statistical difference regarding articular disc (p=0.001) and articular eminence morphology (p=0.02) was determined among the groups. A significant difference between condyle morphology and the presence of self-reported bruxism was detected (p= 0.03). **Conclusion:** The morphological characteristics of the articular disc and articular eminence are related to DD. It can be said that the morphological changes of temporomandibular joint structures point to DD.

**Key words:** magnetic resonance imaging, mandibular condyle, temporomandibular joint disc, temporomandibular joint morphology

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## INTRODUCTION

The temporomandibular joint, which is one of the body's most complex joints, is composed of the articular eminence of the temporal bone, the mandibular fossa, and the condyle of the mandible. The articular disc, which has a biconcave shape, separates the two bones. The articular disc is situated at the condylar head near the 12 o'clock point in the closed-mouth position, while the disc is located between the articular eminence and the mandibular condylar head in the open mouth position.[1,2] TMJ disc displacement (DD) is one of the most commonly seen pathologies in the internal derangement (ID) of the TMJ, and it is defined as an abnormally positioned or displaced disc.[1,2] The disc can become displaced in any direction, though anterior DD is the most common type of DD. Various imaging modalities have been used to examine the TMJ, such as magnetic resonance imaging, conventional radiography, arthrography, computed tomography, and cone-beam computed tomography. MRI, which is free of ionizing radiation, a non-invasive modality with the excellent soft-tissue resolution, is the gold standard for examination of the disc and DD[3-5] The anterior DD is an intracapsular disorder of TMJ that causes degenerative changes in the TMJ structures.[6] Recent studies have confirmed that patients with DD have altered TMJ structural morphologies. An association between the disc morphology types and DD was reported and changes of articular disc and articular eminence morphology are associated with DD.[4,5]

This study aimed to evaluate the morphologic features of the TMJ disc, mandibular condyle, and articular eminence on the healthy, anterior DD with reduction (ADDWR), and anterior DD without reduction (ADDWoR) TMJs using MRI.

## METHODS

This study was approved by the 98227 project number by the clinical research ethics committee of the Suleyman Demirel University hospital, and all participants signed approved consent forms. Fifty-two TMJs of 38 patients (6 males, 32 females) with TMJ disorders (TMD) and twenty-six TMJs of 13 healthy patients (7 males, 6 females) were evaluated in the present study. All patients included in this study were clinically examined according to the Research diagnostic criteria for temporomandibular disorders (RDC/TMD) axis I protocol.[7] Report of pain in the jaw, face, temples, inside the ear during function or rest, preauricular area, pain-free unassisted mandibular opening and joint sounds (clicking, crepitation, etc.), and self-reported bruxism of the participants were recorded. The painless unassisted mandibular opening was £40 mm was accepted as a limited mouth opening.[1] As a result of clinical examination, patients between 18 and 40 years old who presented at least two positives clinical TMD findings underwent MRI examinations, and then patients who detected anterior DD on MRI images included in the TMD group. Patients who had no clinical TMD symptom and normal disc-condyle relationship on MRI images were included in the control group. The exclusion criteria were as follows: trauma, maxillofacial bone fractures or surgeries in the TMJ area, systemic or inflammatory joint diseases, congenital deformities, or syndromes.

The MRI examinations were performed using a 1.5 T MRI scanner (Siemens Magnetom Avanto; Siemens Medical Systems, Erlangen, Germany). Each subject was placed in a supine position, with the Frankfort plane parallel to the scanner gantry and the sagittal plane perpendicular to the horizontal plane. A bite block (Dental Mouth Prop Bite Block; Shangai Carejoy Medical Co., Guangzhou, China) was used to fix the maximal mouth opening and reduce motion artifacts while open mouth position. The osseous structures of the TMJ were evaluated using a 0.9-mm thick section 3D flash T1-weighted sequence [repetition time (TR):

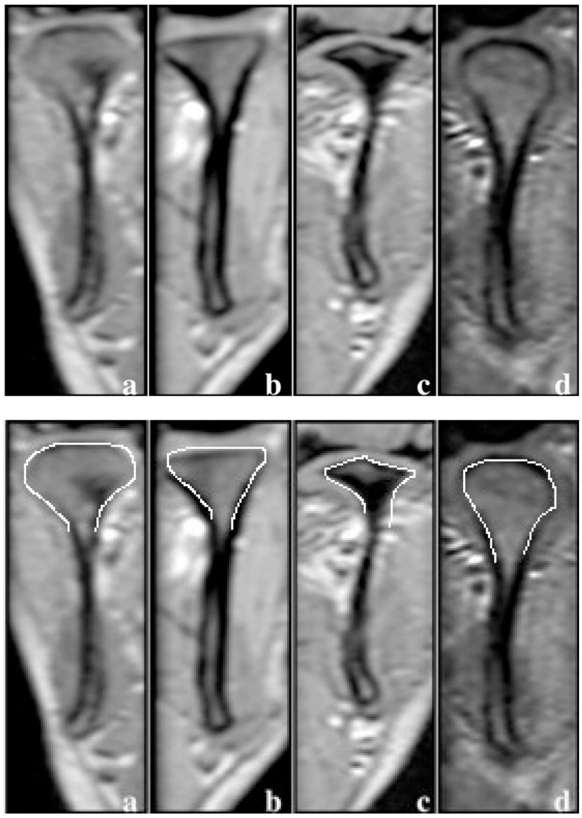

**Figure 1.** The condyle morphologies on the coronal MRI images. Convex (a), flat (b), angled (c) rounded (d) condyle.

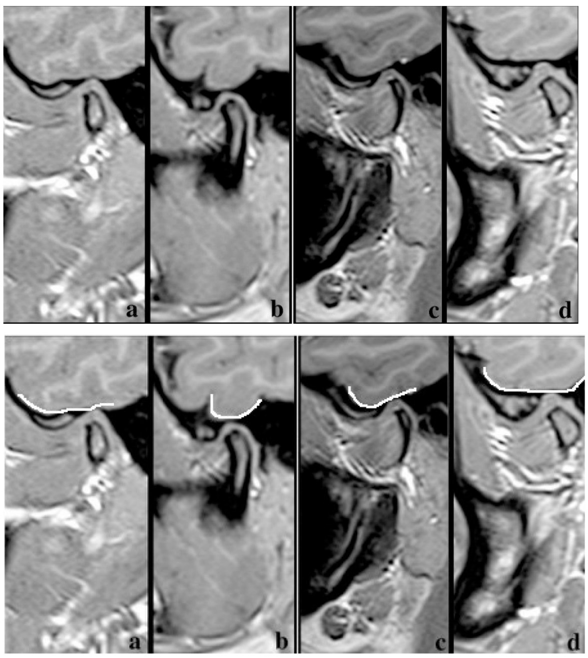

**Figure 2.** The articular eminence morphologies on the sagittal MRI images. Sigmoid (a), box (b), flattened (c), deformed (d) articular eminence.

21 ms, echo time (TE): 4.95 ms, matrix: 224x156 pixels, voxel size: 0.9x0.9x0.9 mm, field of view: 200 mm]. The articular disc was evaluated using a 1.2-mm section

**Table 1.** Association among gender, age and morphological features of the TMJ structures [n (%)]

| | | Gender | | | Age (year) | | |
|---|---|---|---|---|---|---|---|
| | | Female n(%) | Male n(%) | p | Group 1 (18-29 years) n(%) | Group 2 (30-40 years) n(%) | p |
| **Articular Disc Morphology** | Biconcave | 16 (30.8) | 3 (5.8) | 0.44 | 15 (28.8) | 4 (7.7) | 0.51 |
| | Biplanar | 6 (11.5) | 1 (1.9) | | 4 (7.7) | 3 (5.8) | |
| | Biconvex | 9 (17.3) | - | | 8 (15.4) | 1 (1.9) | |
| | Hemiconvex | 4 (7.7) | 2 (3.8) | | 5 (9.6) | 1 (1.9) | |
| | Folded | 10 (19.2) | 1 (1.9) | | 7 (13.5) | 4 (7.7) | |
| **Mandibular Condyle Morphology** | Convex | 14 (26.9) | 2 (3.8) | 0.45 | 12 (23.1) | 4 (7.7) | 0.77 |
| | Flat | 20 (38.5) | 5 (9.6) | | 18 (34.6) | 7 (13.5) | |
| | Angled | 3 (5.8) | - | | 3 (5.8) | - | |
| | Rounded | 8 (15.4) | - | | 6 (11.5) | 2 (3.8) | |
| **Articular Eminence Morphology** | Sigmoid | 20 (38.5) | 5 (9.6) | 0.22 | 20 (38.5) | 5 (9.6) | 0.43 |
| | Box | 12 (23.1) | 2 (3.8) | | 11 (21.2) | 3 (5.8) | |
| | Flattened | - | - | | - | - | |
| | Deformed | 13 (25) | - | | 8 (15.4) | 5 (9.6) | |

p<0.05

**Table 2.** Association between clinical findings and morphological features of the TMJ structures [n (%)]

| | | Pain | | | Limitation Mouth Opening | | | Self-reported Bruxism | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yes n (%) | No n (%) | p | Present n (%) | Absent n (%) | p | Present n (%) | Absent n (%) | Unaware n (%) | P |
| **ADM** | Biconcave | 9 (17.3) | 10 (19.2) | 0.93 | 12 (23.1) | 7 (13.5) | 0.19 | 6 (11.5) | 11 (21.2) | 2 (3.8) | 0.53 |
| | Biplanar | 4 (7.7) | 3 (5.8) | | 4 (7.7) | 3 (5.8) | | 3 (5.8) | 2 (3.8) | 2 (3.8) | |
| | Biconvex | 5(9.6) | 4 (7.7) | | 8 (15.4) | 1 (1.9) | | 2 (3.8) | 7 (13.5) | - | |
| | Hemiconvex | 3 (5.8) | 3 (5.8) | | 3 (5.8) | 3 (5.8) | | 3 (5.8) | 3 (5.8) | - | |
| | Folded | 7 (13.5) | 4 (7.7) | | 4 (7.7) | 7 (13.5) | | 3 (5.8) | 7 (13.5) | - | |
| **MCM** | Convex | 10 (19.2) | 6 (11.5) | 0.33 | 10 (19.2) | 6 (11.5) | 0.68 | 6 (11.5) | 10 (19.2) | - | **0.03*** |
| | Flat | 14 (26.9) | 11 (21.2) | | 13 (25) | 12 (23.1) | | 9 (17.3) | 14 (26.9) | 2 (3.8) | |
| | Angled | 2 (3.8) | 1 (1.9) | | 2 (3.8) | 1 (1.9) | | - | 1 (1.9) | 2 (3.8) | |
| | Rounded | 2 (3.8) | 6 (11.5) | | 6 (11.5) | 2 (3.8) | | 2 (3.8) | 5 (9.6) | 1 (1.9) | |
| **AEM** | Sigmoid | 15 (28.8) | 10 (19.2) | **0.02*** | 16 (30.8) | 9 (17.3) | 0.521 | 5 (9.6) | 16 (30.8) | 4 (7.7) | 0.13 |
| | Box | 10 (19.2) | 4 (7.7) | | 9(17.3) | 5(9.6) | | 8 (15.4) | 6 (11.5) | - | |
| | Flattened | - | - | | - | - | | | | | |
| | Deformed | 3 (5.8) | 10 (19.2) | | 6 (11.5) | 7 (13.5) | | 4 (7.7) | 8 (15.4) | 1 (1.9) | |

p<0.05; ADM: Articular Disc Morphology; MCM: Mandibular Condyle Morphology; AEM: Articular Eminence Morphology

thickness 3D proton-density (PD) weighted sequence (TR: 1200 ms, TE: 39ms, matrix: 256x228 pixels, voxel size: 0.6x0.6x1.3 mm, field of view: 165 mm). OsiriX MD v.7.5.1 software (2016; PixmeoSarl, Bernex, Switzerland) was used for the morphological evaluation. MRI images were examined by a radiologist having 10 years of experience and the patients were divided into three groups; ADDWR, ADDWoR, and control. ADDWR has considered the disc that was anterior to the condylar head at the closed mouth position and

**Table 3.** Disc, condyle and articular eminence morphology distribution among the groups.

| | AD-DWR n (%) | AD-DWoR n (%) | Control n (%) | p |
|---|---|---|---|---|
| **Articular Disc morphology** | | | | |
| Biconcave | 16 (51.6) | 3 (14.3) | 20 (76.9) | |
| Biconvex | 5 (16.1) | 4 (19) | - | |
| Hemiconvex | 4 (12.9) | 2 (9.5) | 3 (11.5) | 0.001* |
| Biplanar | 3 (9.7) | 4 (19) | 3 (11.5) | |
| Folded | 3 (9.7) | 8 (38.1) | - | |
| **Mandibular Condyle Morphology** | | | | |
| Convex | 9 (29) | 7 (33.3) | 13 (50) | |
| Flat | 18 (58.1) | 7 (33.3) | 10 (38.5) | 0.26 |
| Angled | 1 (3.2) | 2 (9.5) | 1 (3.8) | |
| Rounded | 3 (9.7) | 5 (23.8) | 2 (7.7) | |
| **Articular Eminence Morphology** | | | | |
| Sigmoid | 18 (58.1) | 7 (33.3) | 16 (61.5) | |
| Box | 8 (25.8) | 6 (28.6) | 9 (34.6) | 0.02* |
| Flattened | - | - | 1 (3.8) | |
| Deformed | 5 (16.1) | 8 (38.1) | - | |

ADDWR: Anterior DD with reduction; ADDWoR: Anterior DD without reduction

returned to normal position during the mouth opening. ADDWoR was diagnosed with the disc positioned anteriorly to the condyle both in the closed and open mouth positions and a normal disc-condyle relationship was accepted as the control group. All evaluations were made by a dentomaxillofacial radiologist having 5 years' experience. Discs' morphology was assessed in the sagittal closed-mouth position on MRI images. According to Murakami et al. (1993), the articular disc was classified as biconcave (normal disc position), wherein both lower and upper surfaces of the disc are concave; hemiconvex, where the lower surface is convex and the upper is concave; biconvex, where both lower and upper surfaces of the disc are convex; biplanar having even thickness of the disc; and folded, which is folded from the centre of the disc (1993).[8] On the coronal MRI, the morphology of the condyle was classified as convex, angulated, rounded, or flat, using the classification of Yale et al., which was modified by Alomar et al (2007).[9] (Figure 1) On the sagittal MRI, articular eminence morphology was classified as sigmoid, flattened, box, or deformed according to Hirata et. Al (2008).[5] (Figure 2)

The Statistical Package for the Social Sciences (SPSS 17.0 for Windows; SPSS Inc., Chicago, IL, USA) was used for the statistical analyses, and a p value of < 0.05 was considered to be statistically significant. According to the statistical power analysis, when considering the ratios in the ADDWR, ADDWoR and control groups, with 95% power, at least 9 observations were required from each of these three groups. Pearson $c^2$ test was used to establish the differences in the morphology of the disc, mandibular condyle, and articular eminence values concerning the ADDWR, ADDWoR, and control groups. All measurements were repeated after a month and the intraclass correlation coefficients were calculated for the intra-observer agreement. The values were evaluated as poor (<0.40), moderate (0.40–0.59), good (0.60–0.74), and excellent (≥0.75).

## RESULTS

Fifty-two TMJs with DD and twenty-six healthy TMJs were evaluated in this study. Most of the participants were women (84.2%) and the mean age was 26.7±7 years old. Patients divided into 2 age groups; group 1 patients aged between 18-29 and group 2 patients aged between 30-40 years. The first two most common findings were joint sounds and pain (whose values were respectively 94.7%, 73.7%). Biconcave disc and flat condyle were detected mostly in both groups, whereas deformed and sigmoid articular eminences were predominant types in group 2. (p>0.05) (Table 1) Biconcave disc, convex condyle, and sigmoid articular eminence were the most frequent types in both genders. (p>0.05) (Table 1). The pain was mostly in the biconcave discs, followed by folded discs. It was determined limitation of mouth opening was frequently in flat condyles. Only statistical difference was found between pain and articular eminence morphology (Table 2) (p = 0.02). A significant difference was detected between condyle morphology and the presence of self-reported bruxism (p = 0.03) (Table 2).

The biconcave type was predominated in control and ADDWR group at 76.9% and 51.6%, respectively. However, in the ADDWoR group, 14% presented the same morphology, and the folded type was predominant with 38%. Convex condyle was the most frequent in the control group (58.1%) and flattened condyle was most in the ADDWR group (50%). There was no statistical correlation among the groups regarding condyle morphology. The sigmoid articular eminence was predominated in control and ADDWR group with 58.1% and 61.5% respectively. However, deformed articular eminence was most frequent in ADDWoR group (38.1%). A statistical association between articular disc (p = 0.001) and articular eminence (p =0.02) morphology was found among the groups (Table 3).

## DISCUSSION

It was determined in this study that biconcave disc and sigmoid articular eminence were the greatest incidence both in ADDWR and control group, folded disc and deformed articular eminence were the most in ADDWoR group. The most frequent types of condyle in DD was flattened. TMD is an umbrella term that covers radiographic and clinical findings containing. TMJ structures, muscles of the orofacial region, and the masticatory system. ID is the most prevalent disorder of the TMJ and is observed when there is an aberrant anatomic relationship among the articular disc, mandibular condyle, and articular eminence.[2,10] For instance, in the case of the articular disc's displacement, adaptation in the TMJ structures leads to ID. Due to these alterations, morphological alterations in the TMJ structures are of clinical interest and are signs of TMJ disorders.[2]

TMD is more common in females, but the reason for this circumstance has not been fully clarified, although this might be related to biological, anatomical, or hormonal factors acting alone or in combination in females.

Moreover, in this study, the number of female subjects was more, like in many other TMJ studies. Farias et al. (2015) reported that biconcave disc was the most frequent type in both genders, flat condyle was most in male and convex condyle was most in the female.[4] In agreement with the present study, Farias et al. (2015) identified no association between gender and morphology of the disc and condyle.[4]

In a sagittal MRI, biconcave or bow-tie configuration is considered as the normal shape of the disc. In the literature, it was found that the discs tend to become deformed and displaced and lose their original biconcave form with the advancement of DD.[2,4,8-10] Biconcave disc was found in the normal disc position in most of the studies, while folded was mostly in the ADDWoR.[4,8-10] In accordance with the previous studies, most of the biconcave discs were in the control group and the entire range of the folded discs was detected in patients with DD in the present study. The results indicate an intrinsic association between the ID and form of the disc and the disc folds at the thin central part of the biconcave shape due to the condylar movement force.[8-10] This was supported in this study, because more severe morphologic deformation of the disc was observed in ADDWoR group.

Regarding the condyle morphology in the coronal MRI, previous studies reflected contradictory results. Farias et al. (2015) determined the convex type of the condyle to be the most common and the rounded type the rarest in DD joints.[4] Matsumoto et al.'s (2013) classification included convex, angled, flat, and others stated that convex type most frequent in patients both with and without DD.[12] Santos et al. (2013) observed flattened condyles were most prevalant in DD joints and angulated condyles were the least.[10] In the present study, the most frequent types of condyle in DD and control group were flattened and convex respectively, as concluded by Santos et al. (2013).[10] In agreement with Farias et al. (2015) no association was found between the condyle morphology and the patients groups in this study.[4] It has been considered that DD and morphologic changes of TMJ closely linked; thus, the alteration of the condyle morphology should bring about a change in disc position. The possible reasons why no association was found between the condyle morphology and among the groups are as follows. First, other factors such as masticatory and occlusal forces and malocclusion may affect the condyle morphology.[13] Second, the condyle morphology may be commented as a normal variation and not pathology itself, and may not be associate with DD.[12]

The sigmoid articular eminence was the most frequent in the ADDWR and control groups, while the deformed form presented the greatest incidence in the ADDWoR group in this study. Statistically, correlation between articular eminence morphology and groups was found ($p = 0.02$). Some authors found that in the ADDWR and ADDWoR groups, the most predominant form of the articular eminence sigmoid and flattened.[5,14] In these studies, the authors determined a statistical difference in the distribution of the flattened shape in the ADDWoR group. The articular eminence has a substantial role in the biomechanics of the TMJ and as a result of functional loads caused by occlusal forces, and these loads may influence its morphological form.[5,15,16]

The most significant limitation of this study was the low sample size. However, the present study confirmed that DD effectively changes the morphological features of the articular disc, condyle, and articular eminence.

## CONCLUSION

According to the results of this study, DD seems to affect morphologies of the articular disc and articular eminence, especially in patients with ID progression.

## CONFLICT OF INTEREST

None declared.

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