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Morphometric Analysis of the Glenoid Fossa in the Skull Base

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Objective: The aim of this study was to investigate the possible relationship between disc displacement and the presence of reduction by comparing condyle anteroposterior (AP) diameter, condyle height, mandibular fossa AP diameter, and mandibular fossa depth.
Methods: A total of 588 joints of 294 patients were included in the study for evaluation. Disc displacement and the presence of reduction, condyle AP diameter, condyle height, mandibular fossa AP diameter, and mandibular fossa depth were evaluated.
Results: Of the 588 temporomandibular joint examined in the study, there was disc displacement in 141 (24%) and no disc displacement in 447 (76%). Of the joints with disc displacement, reduction was observed in 53 (9%) and not in 88 (15%).

A statistically significant correlation was determined between condyle AP diameter and disc displacement ($P = 0.00$); in the cases with disc displacement, the condyle AP diameter was measured smaller. A statistically significant correlation was determined with condyle height, mandibular fossa AP diameter, and fossa depth. In the patients with disc displacement, the condyle height value was lower and the measured values of the mandibular fossa AP diameter and mandibular fossa depth were higher ($P = 0.00$). A statistically significant relationship was determined between the presence of reduction and age, condyle AP diameter, condyle height, and articular eminence depth.
Conclusions: In conclusion, a deep and wide mandibular fossa, and a short and small condyle lay the ground for disc displacement in the temporomandibular joint.

Key Words: Magnetic resonance imaging, mandibular condyle, temporomandibular joint

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The temporomandibular joint (TMJ) is a complex joint with functions in chewing, swallowing, and talking.[1] Temporomandibular joint disorders can be seen at any age, primarily at younger ages, and manifest with restricted jaw movements, clicks or crepitation, and pain in the jaw and adjacent tissues during jaw movement. In the general population, there is a 20% likelihood of any symptom related to a TMJ disorder being seen at some point in life.[2] Clinical examination generally provides limited information of TMJ disorders, so diagnostic imaging is usually required.[3] Magnetic resonance imaging (MRI) is accepted as the best method for the evaluation of the TMJ position.[4–6]

The aim of this study was to morphometrically evaluate patients who presented with complaints of TMJ pain and had MRI taken, and to investigate the possible relationship between disc displacement and the presence of reduction by comparing condyle AP diameter, condyle height, mandibular fossa anteroposterior (AP) diameter, and mandibular fossa depth.

METHODS

A re-evaluation was made on the picture archiving and communication system of 512 patients, who presented at the Radiology Clinic between October 2018 and January 2020 with the complaint of jaw pain and were applied with TMJ MRI examination. Patients aged >16 years were included in the study. Patients were excluded if they had a history of surgery, if the MRI was technically insufficient, a history of major trauma, or osteoarthritis determined in the joint. A total of 588 joints of 294 patients were included in the study for evaluation. All of the patients included in the study had chewing disorder, difficulty in speaking, and pain problems, which were thought to be originating from the TMJ. Data related to age, gender, and clinical history were retrieved from the hospital records system.

The MRI examinations were applied using an MRI unit with 3 Tesla magnetic power (Magnetom Skyra, Siemens Healthcare; Erlangen, Germany) and a 16-channel head coil. The measurements were taken on oblique sagittal T1-weighted images, which were obtained for all patients using the same parameters (repetition time: 989, echo time: 6.70, flip angle: 150, number of excitation: 2, slice thickness: 2 mm).

Disc displacement and the presence of reduction, condyle (AP) diameter, condyle height, mandibular fossa AP diameter, and mandibular fossa depth were evaluated again on the hospital picture archiving and communication systems for all patients included in the study. The condyle AP diameter was calculated as the distance measured between the anterior and posterior points of the condyle on the slice that showed the widest view of the condyle on oblique sagittal images. To determine the height of the condyle, 2 circles (O1 and O2) were drawn tangential to the outer lines of the condyle on the sagittal slices. One circle was drawn in the area joining the condyle head and the condyle neck, and the other was drawn in the

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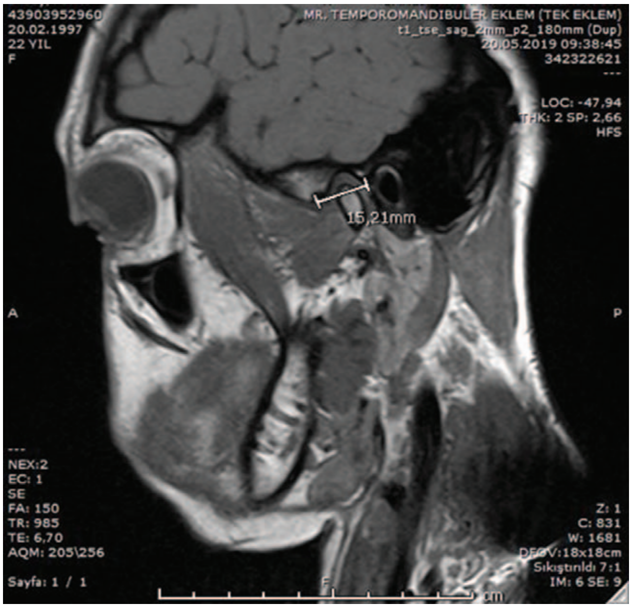

FIGURE 1. The mandibular fossa AP diameter was calculated by measuring the distance between the anterior and posterior ends on the slice that showed the best view of the mandibular fossa on oblique sagittal images. AP, anteroposterior.

widest section of the condyle neck. The line passing through the center of both circles was accepted as the true condyle neck axis (γ). Then perpendicular to γ, a line (x) was drawn passing through the deepest point of the mandibular sigmoid notch, and a line (x') parallel to x was drawn passing the peak of the condyle, and the condyle height was calculated as the vertical distance between x and x'.[7] The mandibular fossa AP diameter was calculated by measuring the distance between the anterior and posterior ends on the slice that showed the best view of the mandibular fossa on oblique sagittal images (Fig. 1). The fossa depth was measured perpendicularly as the distance from the deepest point of the fossa to the line drawn between the anterior and posterior ends.

Statistical Analysis

Data obtained in the study were analyzed statistically using IBM SPSS vn. 20 software. Numerical variables were presented as mean $\pm$ standard deviation, median, minimum, and maximum values, and categorical variables as number (n) and percentage (%). The Shapiro–Wilk test was applied to continuous variables with normal distribution when the sample size was <50, and the Kolmogorov-Smirnov test when sample size was ≥ 50. In the comparison of 2 independent groups, the independent samples t-test was applied when there was normal distribution of data, and the Mann–Whitney U-test was used when parametric conditions were not met. In the comparison of more than 2 groups of continuous variables, the analysis of variance (ANOVA) test was applied when there was normal distribution, otherwise, the Kruskal-Wallis test was used. When there was normal distribution but not homogeneity of variances, the Welch test was applied. The post hoc tests used after ANOVA were the Tukey test if variances were homogenous, and Tamhane $T2$ test when homogeneity of variances was not present. Following the Kruskal-Wallis test, the post hoc test applied was the Kruskal-Wallis 1-way ANOVA (k samples) test. In the 2×2 comparisons between categorical variables, the Pearson chi-square test was applied when the expected value was >5, the chi-square Yates test when the expected value was 3 to 5, and Fisher exact test when <3. In the comparisons greater than 2×2 of categorical variables, the Pearson chi-square test was applied when the expected value was >5, and the Fisher-Freeman-Halton test when the expected value was <5. The level of statistical significance was set at $P < 0.05$.

RESULTS

Evaluation was made of 294 patients, comprising 84 (29%) males and 210 (71%) females with a mean age of 30.99 years (range, 16–73 years). No significant relationship was determined between gender and the presence of disc displacement and reduction. Of the 588 TMJ examined in the study, there was disc displacement in 141 (24%) and no disc displacement in 447 (76%). Of the joints with disc displacement, reduction was observed in 53 (9%) and not in 88 (15%).

A statistically significant correlation was determined between condyle AP diameter and disc displacement ($P = 0.00$); in the cases with disc displacement, the condyle AP diameter was measured smaller (Supplementary Digital Content, Figure 2, http://links.lww.com/SCS/C782). A statistically significant correlation was determined with condyle height, mandibular fossa AP diameter, and fossa depth. In the patients with disc displacement, the condyle height value was lower and the measured values of the mandibular fossa AP diameter and mandibular fossa depth were higher ($P = 0.00$). A statistically significant relationship was determined between the presence of reduction and age, condyle AP diameter, condyle height, and articular eminence depth. In cases that could be reduced, larger condyle AP diameter, condyle height, and mandibular fossa depth values were measured (Supplementary Digital Content, Figure 3, http://links.lww.com/SCS/C782), (Supplementary Digital Content, Table 1, http://links.lww.com/SCS/C783, Supplementary Digital Content, 2, http://links.lww.com/SCS/C784).

DISCUSSION

The TMJ is a diarthrodial joint located immediately anterior to the external auditory pathway between the mandibular condyle and the mandibular fossa of the temporal bone. In the mouth closed position of the normal TMJ, there is a biconcave joint disc formed of dense fibrous tissue, which sits over the apex of the condyle.[8,9] According to the Marguelles-Bonnet et al[9] classification, in the normal TMJ, the posterior band of the disc in the sagittal plane is located in the upper part of the condyle, and moves together with the condyle. In the frontal plane, the disc is in the upper part of the condyle. In a reduced anterior disc displacement, the disc is placed anterior in the intercuspal position and is positioned together with the joint head during opening movement, whereas without reduction, the disc is placed anterior in the intercuspal position and remains there during the opening movement.[10]

The aim of this study was to investigate the effect of the fossa mandibularis and condyle morphometry on disc displacement and reduction. No study could be found in literature related to the morphometry of the fossa mandibularis. Previous studies have been more focused on investigation of the disc morphology and morphometry. In a study by Ertan et al,[10] disc deformation was seen more in cases with disc displacement, and it was stated that disc deformation was affected by the displacement type.[11]

Several studies have attempted to clarify TMJ disc displacement associated with condylar morphology. Generally, in cases with disc displacement, the condyle shows different morphology (reduced height, distal inclination, reduced volume).[12,13] In the current study, the measured values of condyle AP diameter and condyle height were smaller in cases with disc displacement. Furthermore, the measured values of mandibular fossa AP diameter and depth were greater in these cases. In the light of these findings, it can be considered that an increase in mandibular fossa size and a decrease in condyle size facilitate disc displacement. In addition, the values of condyle AP diameter, condyle height, and mandibular fossa depth were greater in cases that could be reduced than in those which could not be reduced, which supports the hypothesis.

In a study of asymptomatic subjects by Yang et al,[13] oblique sagittal images were stated to be the best MRI examination in the evaluation of the TMJ anatomic structures, disc and condylar position, and the disc and mandibular condyle were shown to be bilaterally symmetrical in a healthy population.[14] Oblique sagittal T1-weighted sequences, showing the anatomic structures better, were used in the current study measurements.

Seo et al[14] examined changes in condyle size in cases with disc displacement in the TMJ, and reported that condyle dimensions were significantly affected by disc displacement, irrespective of gender.[15] In patients determined with disc displacement and followed up without treatment, Cai et al[15] reported that the mean condyle height value decreased in the follow-up measurements.[6] In another study by Hu et al[6] of patients with disc displacement and followed up without treatment, the mean condyle height was measured to be greater in the group with reduction compared to the group without reduction.[16] Similarly in the current study, the values of the condyle AP diameter, condyle height, and mandibular fossa depth were measured as greater in the group which could be reduced. Vieira-Queiroz et al[16] stated that a narrow condyle structure increased the predisposition to disc displacement.[17]

The articular eminence is located in the anterior of the mandibular fossa, and it has been reported that exposure to functional loading because of chewing forces and movements of the condyle disc complex may change the morphology of the articular eminence.[18,19] Although there are studies reporting that TMJ disorders can cause structural changes in the articular eminence,[20–22] there are also studies claiming that morphological variations in the articular eminence could be a reason for TMJ disorders.[23,24] Therefore, in the current study, the mandibular fossa was examined without taking the articular eminence into consideration, and greater values of mandibular fossa AP diameter and fossa depth were measured in patients with disc displacement.

There were some limitations to this study, primarily the relatively low number of patients. In addition, although MRI is the only examination method that allows you to view the entire TMJs without exposing the patient to ionizing radiation, it is widely used in the evaluation of capsuloligamentous structures. On the other hand, computed tomography with ionizing radiation allows the evaluation of bone structures, does not allow the evaluation of disc structures, and is preferred for evaluating bone morphology. Both computed tomography and MRI must be performed and correlated for a complete assessment of condyle, disc, and fossa spatial relationships. New studies on this subject, which will be carried out with scientific care, can give us new information.

In conclusion, a deep and wide mandibular fossa, and a short and small condyle lay the ground for disc displacement in the TMJ. Consideration of the morphometry of these structures in patients with disc displacement could predict the predisposition for displacement and reduction status. Nevertheless, there is a need for further, more extensive studies on this subject.

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