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ORIGINAL ARTICLE

MRI evaluation of the classification, frequency, and disc morphology of temporomandibular joint disc displacements: a multicenter retrospective study in a Turkish population

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Abstract
Objectives Magnetic resonance imaging (MRI) of the temporomandibular joint (TMJ) and temporomandibular disorders (TMDs) have been discussed in detail for various populations. As no such study has examined the Turkish population, we determined the frequency of TMDs in the Turkish population through a multicentric investigation using MRI.
Methods This retrospective study examined 504 TMJs of 252 symptomatic patients who had undergone bilateral MRI investigation in four different dental schools. The image analysis included the assessment of disc position and morphology, and recaptured the coronal and sagittal planes in the closed and open mouth positions. The TMJ disorders were classified using the Clinical Diagnostic Criteria for Temporomandibular Disorders (CDC/TMD). The correlations among the groups of TMJs and disc morphologies were analyzed statistically using the chi-square test ($P \leq 0.05$).
Results Disc displacement and abnormal disc morphology were detected in 69.5% of the symptomatic TMJ patients. Of the joints examined using MRI, 154 were normal, 135 had anterior disc displacement with reduction (ADDwR), 145 had anterior disc displacement without reduction (ADDwoR), 30 had partial anterior disc displacement, and 18 had sideways disc displacements. Regarding disc morphology, enlargement in the posterior band was the most commonly encountered type and was observed in 152 TMJs. Overall, the average time for referral for treatment, which was defined as the time from symptom onset until the time of referral, was 1.5 years.
Conclusions The most common type of disc displacement found in the Turkish population studied was ADDwoR. In addition, patients did not perceive the symptoms of TMDs as a disease and did not seek help until the TMJ derangement caused a major complaint.

Keywords Temporomandibular joint · Temporomandibular joint disorders · Temporomandibular joint disc · Deformation · Magnetic resonance imaging

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Introduction

Temporomandibular joint (TMJ) problems are common and affect up to one-third of all adults at some stage in their lives, as well as children and adolescents. In epidemiological studies, subgroups of temporomandibular disorders (TMDs) are often evaluated only through clinical examination of the population investigated [1, 2]. However, when assessing the prevalence of joint pathology, the difference

between objective diagnosis and subjective patient-reported pain can pose a challenge in terms of making a diagnosis. Moreover, for scientific studies, an objective diagnosis using imaging techniques must be reproducible, especially for prevalence studies [3]. To this end, various TMJ imaging techniques are used, including computerized tomography [4], sonography [5], arthrography [6], and magnetic resonance imaging (MRI) [7]. MRI is the most common and reliable imaging method of highlighting soft tissues without using ionizing radiation for classifying internal TMJ derangements and identifying the position and structure of the TMJ discs [7–10]. However, an unclear correlation often exists between clinical signs and symptoms and the imaging findings in all TMD patient groups, especially in particular populations [11, 12]. Several investigations have examined the clinical and imaging findings in different populations [3, 13]. Recently, Abou-Atme et al. [3] compared TMJ symptoms in Lebanese and Italian populations and found varying results regarding TMJ pain and sounds. Fabian and Mumghamba [14] stated that the use of chewing sticks and advanced age are risk factors for the high prevalence of signs and symptoms of TMD in the Tanzanian population. A significantly higher prevalence of difficulty in opening the mouth and pain in the preauricular area was reported for Quechua Indians than for Colorado Indians [13]. Since no published data existed on the Turkish population, we deemed it worthwhile to determine the frequency of disc displacement and degenerative changes in a large group of Turkish patients referred for the evaluation of TMJ dysfunction and pain, utilizing state-of-the-art MRI equipment in a multicenter investigation.

Materials

Magnetic resonance images and data of 252 symptomatic patients with TMJ complaints who were referred to the outpatient clinics at Ankara University, Yeditepe University, Gulhane Military Medical Academy, and Hacettepe University between January 2002 and December 2005 were evaluated retrospectively in terms of the patients' clinical complaints and MRI findings related to TMJ disc displacement and disc morphology. The study group consisted of 192 women and 60 men with a mean age of 35.9 years (range 18–79 years). As the researchers were located in different facilities, all of them participated in training sessions on the TMJ clinical examination using the Clinical Diagnostic Criteria for Temporomandibular Disorders (CDC/TMD) before the study for standardization purposes.

Clinical examinations and MRI were performed on all patients. The TMJ disorders were examined according to the CDC/TMD [15]. The criteria for each diagnostic group were specified as guidelines to be used in the clinical diagnosis. Clinical evidence of the absence of TMDs (normal TMJ) was used in the absence of clinical inclusion criteria defining one of the TMD subgroups according to the CDC/TMD. In addition, the subjects were specifically asked when their symptoms had started and how long they had been suffering from these complaints. After each clinical evaluation, the subjects underwent MRI.

All participants had MRI of the TMJs bilaterally. The images were taken with 1.5-T imaging units (Signa Horizon, GE Electric, Milwaukee, WI; Gyroscan Intera, Philips Medical Systems, Bothell, WA; Magnetom SP4000, Siemens, Erlangen, Germany) using dual-surface coils (3-inch and 6 × 8-cm surface coils). All patients underwent imaging in the axial, sagittal, and coronal planes using fast spin-echo sequences. Images were taken in the closed, partially opened, and maximally opened mouth positions to detect disc displacement.

All patients had T1-, T2-, and proton-density-weighted images taken using similar repetition (TR) and echo (TE) times in different magnetic resonance machines. For the Signa Horizon and Magnetom SP4000, T1-weighted images were taken with TR = 150 and TE = 4.2, while bilateral sagittal and coronal proton density-weighted images and T2-weighted images were taken with TR = 2,500 and TE = 17 and TR = 2,500 and TE = 102, respectively, with a 10-cm field of view, 192 × 256 matrix, NEX = 2, bandwidth = 15.6 kHz, and 3-mm slice thickness. For the Gyroscan Intera, T1-weighted images were taken with TR = 300 and TE = 16, while bilateral sagittal and coronal proton density-weighted images and T2-weighted images were taken with TR = 2,000 and TE = 19 and TR = 2,000 and TE = 80, respectively, with a 10-cm field of view, 256 × 128 matrix, NEX = 2, bandwidth = 15.6 kHz, and 3-mm slice thickness.

Two radiologists separately evaluated and interpreted the images twice without knowledge of the clinical condition of the patients. When the assessments differed, a consensus was reached through a repeated evaluation and discussion between the radiologists. The disc displacement of the TMJs was classified as normal, partial anterior disc displacement (PADD), anterior disc displacement with reduction (ADDwR), anterior disc displacement without reduction (ADDwoR), and sideways disc displacement [MDD/LDD (medial disc displacement/lateral disc displacement)] according to the following MRI criteria [7, 16, 17].

Normal: In the closed mouth position, the posterior band of the disc is located superior to the condyle so that it is at the apex of the condylar head (12 o'clock position). When the jaw is opened, the disc remains interposed between the osseous components and moves anteriorly in a synchronized fashion. In the coronal plane of imaging, the disc is centered on the condylar head perfectly (Fig. 1).

PADD: A disc exhibiting anterior displacement in the lateral or medial slices, but a normal position in the other sagittal slices, which was not displaced laterally or medially in the coronal slices. If the disc is recaptured by the condyle and the disc condyle relationship appears normal when the jaw is opened, it was considered PADD (Fig. 2).

ADDwR: In the closed mouth position, the posterior band of the disc is anterior to the condylar head in all sagittal sections. When the jaw is opened, the disc is recaptured by the condyle, and the disc–condyle relationship appears normal (Fig. 3).

ADDwoR: In the closed and open mouth positions, the posterior band of the disc is anterior to the superior aspect of the condylar head in all sagittal sections. When the jaw is opened, the disc is compressed anteriorly, regardless of whether its morphology is modified (Fig. 4).

MDD/LDD without an anterior component: Sideways displacements of the disc are well documented in the coronal plane. The disc crosses over one of the sagittal planes tangential to one of the condylar poles (Fig. 5).

In this study, stuck discs (STDs) were also identified, although they were not disc displacements. A STD is defined as one that remains in the same plane in relation to the mandibular fossa or articular tubercle during jaw movements. The STD may be fixed in a normal or displaced position and may or may not be associated with

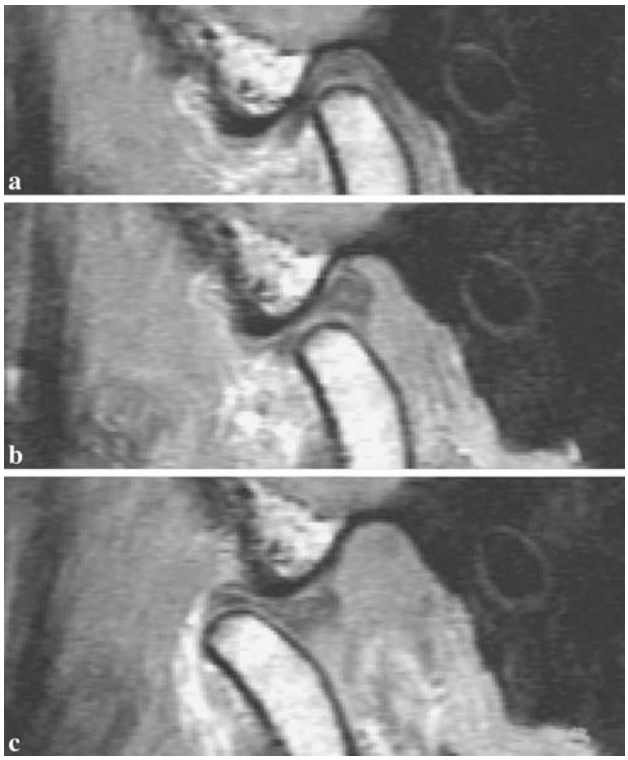

Fig. 1 MRI of a normal joint: **a** closed, **b** partially open, and **c** open mouths

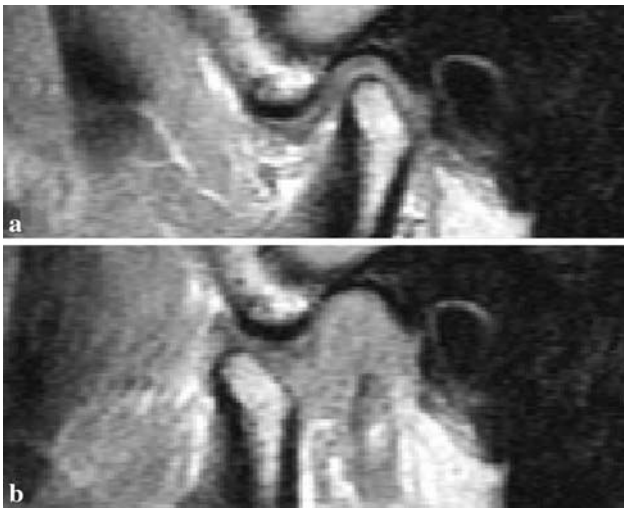

Fig. 3 MRI of ADDwR: **a** closed and **b** open mouths

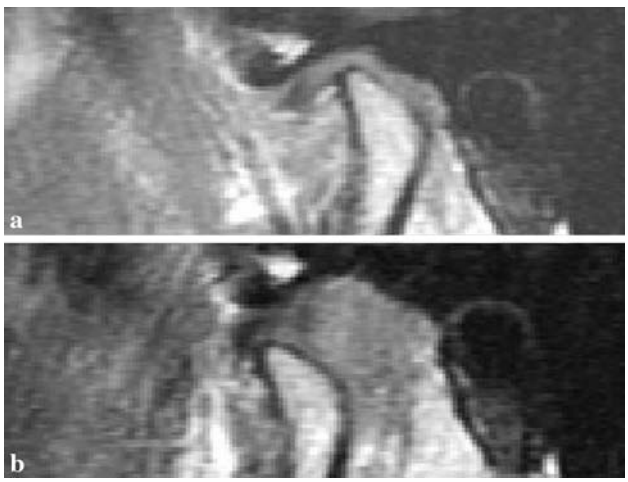

Fig. 2 MRI of PADD: **a** closed and **b** open mouths

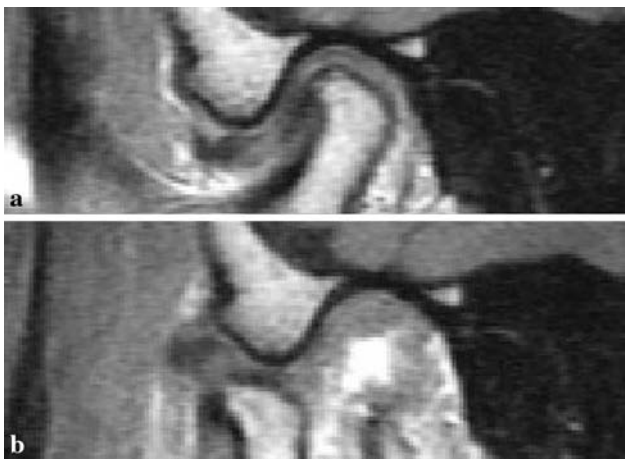

Fig. 4 MRI of ADDwoR: **a** closed and **b** open mouths

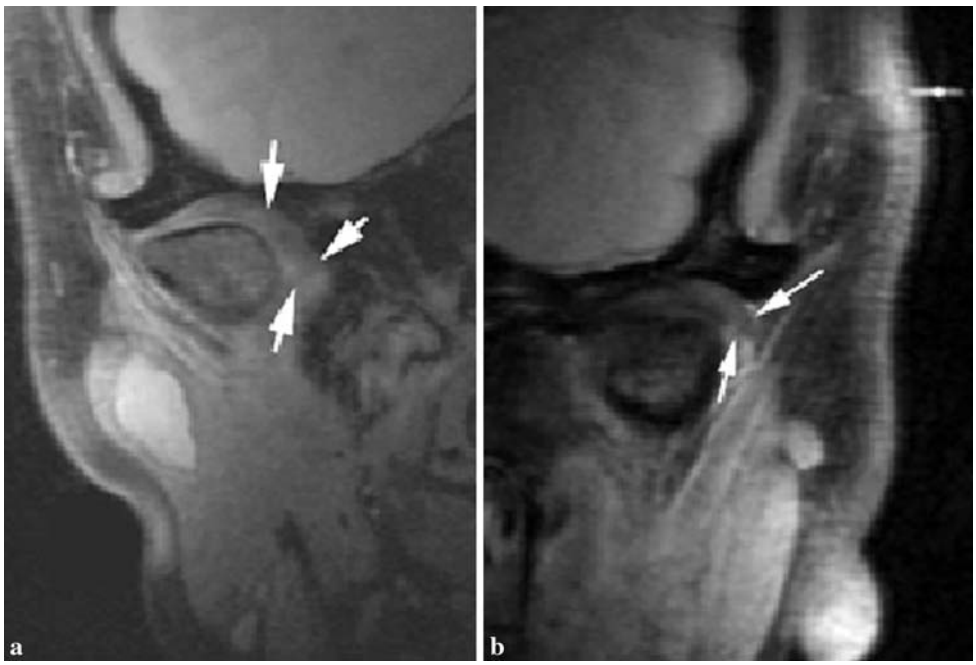

Fig. 5 MRI of **a** medial and **b** lateral disc displacement

normal mobility of the condyle [16]. Flattening, erosive changes of the articular surfaces, anterior osteophytes, and subchondral lacunas were also noted and classified as degenerative joint diseases (ART, arthrosis) [16].

In line with previous studies [5, 11, 17], disc morphology was classified into six categories: biconcave (a disc with clearly identifiable posterior and anterior bands and a tapered intermediate zone), biplanar (a disc with equal thickness in all three parts), biconvex (a humped disc), enlargement in the posterior band (a disc in which the posterior band is thicker and longer anteroposteriorly), Y-shaped, and folded (irregular; Fig. 6).

The chi-square test was used to determine the significance of any association between unilateral and bilateral disc displacements, the frequency of disc displacement types, and disc morphologies according to age and sex. $P \leq 0.05$ was considered significant.

Results

This study determined disc position, the frequency of different categories, types, disc morphology, relationship to gender, and the association with both reduction and bony changes in a group of patients with symptomatic TMJs. Overall, 48 participants were found to have had a TMD for more than 1.5 years. In addition, 45% of the participants stated that their major complaints were severe pain and limited mouth opening. The average time to referral was 1.5 years for the entire group as calculated from the onset of symptoms to the time of referral.

The distribution of disc displacements in the patient group ($n = 252$) according to the examination criteria is shown in Table 1. MRI indicated that 69.5% of the patients had disc deformation and displacements, while 154 joints (154/504) were normal in the sagittal and coronal slices, although the patients were clinically symptomatic. Disc displacements were found in 65% (328/504; ADDwR + ADDwoR + PADD + MDD/LDD) overall. ADDwoR was the most common in 28.7% (145/504), while sideways was the rarest type of disc displacement (3.5%; 18/504). STDs are included in Table 1 to help calculate the exact number of TMJs.

Regarding disc morphology, enlargement in the posterior band was the deformation most commonly seen (30.1%; 152/504), while a Y-shaped disc was the morphology observed the least often (2.1%; 11/504; Table 2).

The distribution of unilateral and bilateral disc displacement and normal disc position was also investigated in the patients: 143 patients had bilateral displacement, and 21 had unilateral. In addition, 11 patients had STDs, which were all located anterior to the condyle, causing deviation and difficulty in opening the mouth. Table 3 shows the disc displacements according to age group. PADD was found significantly less often in the 26–50 age group.

Regarding gender, no significant connection was found between sex and the prevalence of any specific disc position ($P > 0.05$).

Normal function with normal osseous condition was noted in all of the joints that had discs in the superior position. ART was significantly more common in patients

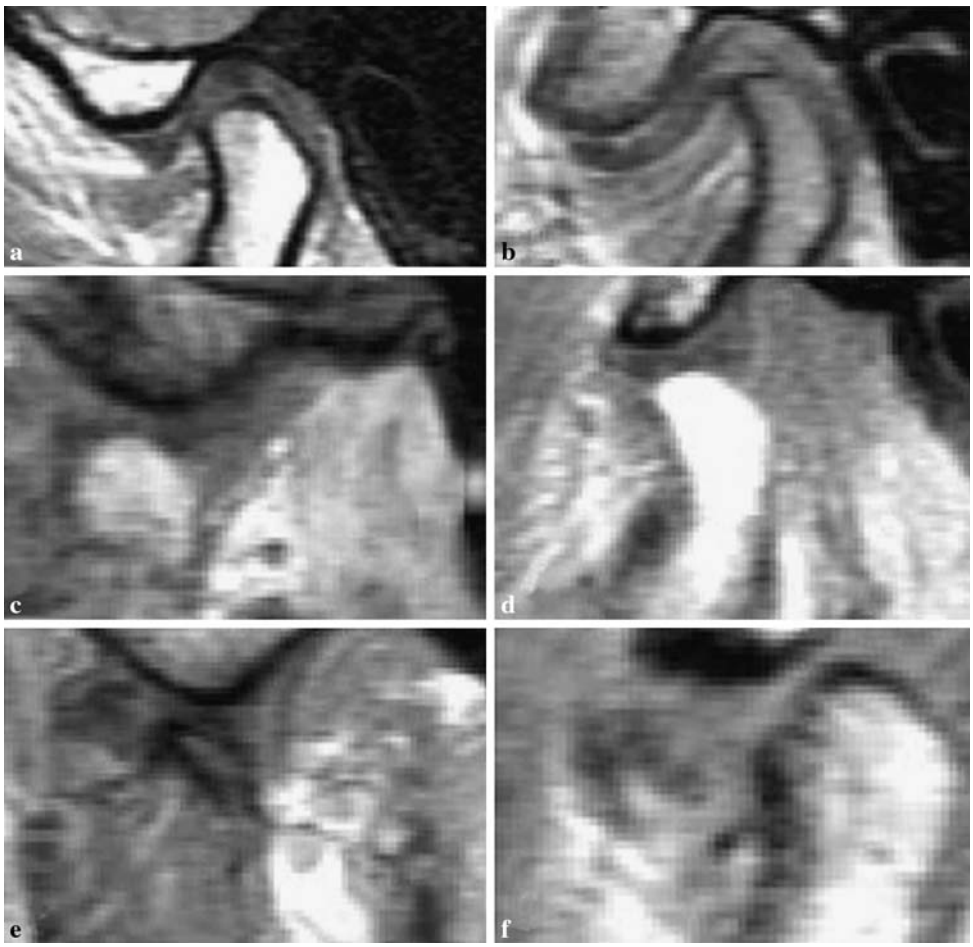

Fig. 6 MRI showing **a** biconcave disc, **b** biplane disc, **c** biconvex disc, **d** enlarged posterior band, **e** Y-shaped disc, and **f** folded disc

Table 1 The distribution of disc positions

Disc position	Number of TMJs	%
Normal	154	30.5
ADDwR	135	26.7
ADDwoR	145	28.7
PADD	30	5.9
MDD/LDD	18	3.5
STD	22	4.3
Total	504	100

ADDwR anterior disc displacement with reduction, *ADDwoR* anterior disc displacement without reduction, *PADD* partial disc displacement, *MDD/LDD* sideways disc displacement (medially/laterally), *STD* stuck disc

Table 2 The distribution of disc morphologies

Disc morphologies	Number of TMJs	%
Biconcave disc	154	30.5
Biconvex disc	71	14
Biplanar disc	37	7.3
Enlargement of posterior band	152	30.1
Y-shaped disc	11	2.1
Folded disc	79	15.6
Total	504	100

with ADDwoR and was not significant with other types of disc displacement ($P = 0.0001$). ART was observed in 25 TMJs with ADDwR (4.9%) and 77 TMJs with ADDwoR (15.2%).

Biconvexity was significantly less frequent in patients with ADDwR and ADDwoR ($P = 0.0001$), while no significant relationship was seen with other disc displacement types. The folded disc morphology was significantly more common in patients with ADDwoR, and less so in other types of disc displacement ($P = 0.0001$).

Discussion

Using MRI of 504 TMJs in symptomatic patients, data were obtained on TMDs for different types of disc displacement and disc morphologies in the Turkish population living in Ankara and Istanbul, the two most cosmopolitan, largest, and most crowded cities in Turkey. Therefore, our study population cannot be said to reflect the entire

Table 3 Disc positions according to age groups

Disc positions	18–25 age n_p: 72 Number of TMJs	26–50 age n_p: 137 Number of TMJs	51–79 age n_p: 43 Number of TMJs	*P*
Normal	46	86	22	0.543
ADDwR	36	80	19	0.366
ADDwoR	39	76	30	0.172
PADD	18	4	8	0.0001*
MDD/LDD	5	10	3	0.763
STD	0	18	4	0.0001*
Total *n*: 504	144	274	86	

ADD anterior disc displacement, *PADD* partial disc displacement, *MDD/LDD* sideways disc displacement, *STD* stuck disc

* Significant ($P \leq 0.05$) (n_p: number of patients)

country, although some inferences can be made regarding the general population.

A review of the literature revealed differences among different populations. Jagger et al. [13] stated that the prevalence of TMD in Colorado Indians differed from that in Quechua Indians, but was similar to that in Arab and Scandinavian populations. In Finns, the signs of TMDs were associated with age; a greater prevalence of TMD signs was observed with older age, although when TMD was stratified by gender, the association with age was not as clear and gender differences were observed in the prevalence of single TMD signs at different ages [18]. Moreover, habits unique to certain populations increase the prevalence of TMDs, as in Tanzanians who habitually chew on sticks [14]. Therefore, this study sought to determine the distribution of TMDs in the Turkish population.

Regarding disc displacement, a high proportion of disc displacements was found in this study, in agreement with other reports on symptomatic subjects, although our rate of 65% was much less than the range of 77–95% reported by others [8, 19, 20].

In our study, despite the presence of TMD symptoms such as pain, TMJ sounds, difficulty opening the mouth, deviation, or deflection, some patients in the study group were found to have neither disc displacement nor deformation, which is an indication of a referred pain originating from a muscle or an extra-articular disorder, such as an elongated coronoid process [21].

In this study, ADDwoR was the most frequent type of disc displacement (28.7% of the joints), while sideways was the rarest (3.5% of the joints). This might have occurred because the anterior direction is the line of least resistance to disc movements, whereas the medial and lateral surfaces are more firmly supported by their ligaments. Although our report supports some previous findings [22, 23], the rates differ from others [24, 25].

Looking at the other disc displacements, we observed that besides the typical anterior displacement, the disc may slip medially or laterally or cause only partial anterior displacement, in agreement with Katzberg and Westesson [16] and Tasaki et al. [8]. We observed lower rates (5.9%) than Tasaki et al. [8], who reported that 13% had PADD.

In a study of 366 patients, Foucart et al. [17] found that 4% had isolated STDs. Rao et al. [26] found STDs in 20% of their patients and stated that 18% of the STDs were associated with disc displacement. In our series, STDs were observed in 4.3% of all TMJs and was usually found in ADDwoR. It was diagnosed both with imaging and clinically, although a STD may be missed easily on clinical examination or confused with muscle restriction.

Bony changes and degenerative lesions referred to as ART were found in 115 (22.8%) joints. ART was mostly found in ADDwoR, as observed in many studies [3, 17, 19]. Foucart et al. [17] reported that degenerative changes increased with age mainly in disc displacements without reduction. This confirms that long-term disc displacements may produce degenerative changes. Milano et al. [19] stated that bone deformations were mostly seen in females, although we found no significant difference between the sexes.

In our study, the average time to referral was 1.5 years. Duan et al. [20] stated that the length of time that patients suffered from TMDs (period of affliction) ranged from 1 day to nearly 20 years. Pow et al. [27] reported that 1% of the Hong Kong Chinese population had TMD-related jaw pain, and only 0.6% of the population had sought treatment for jaw pain, impaired jaw opening, or joint clicking that occurred often in the previous year. In our study, we postulate that the patients who had a TMD problem for more than 1.5 years and did not consult a clinic until the TMJ derangement caused a major complaint might not have been aware of the origin of their problem or they did not perceive clicking in the TMJ, deviation, or deflection as a disease. They did not seek treatment until their quality of life had decreased due to severe pain and limited mouth opening.

The osseous structure of the TMJ is not always intact in cases with ADDwR. Despite the fact that 26.7% of the joints had ADDwR, osseous changes were observed in only 4.9% of the TMJs, proving that the pathology also begins in the reduced state. However, this does not mean that osseous changes are always encountered in delayed stages of TMD like ADDwoR because 13.4% of the joints had ADDwoR despite normal osseous conditions.

Regarding disc deformation, enlargement of the posterior band was the most commonly seen type of deformation. This concurs with the findings of Larheim [28], but not with other studies [19, 29]. These differences may have arisen because the patients examined in the other studies were at different stages.

In our study, significant relationships were found between disc morphology and disc displacement. Biconvexity was significantly reduced in the absence of ADD with or without reduction ($P = 0.0001$). In addition, the biplanar shape of the disc was significantly reduced in the absence of ART.

This study provides a baseline regarding the frequency and type of TMD associated with referral time and the possible causes of referral in a Turkish population. The data may serve as a reference for different types of disc displacement of the TMJ in a limited Turkish population. However, additional studies of larger populations are needed to provide population-based information on TMJ internal disorders.

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