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Magnetic Resonance Imaging Study on Temporomandibular Joint Morphology

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A B S T R A C T

Magnetic resonance imaging (MRI) has enabled the accomplishment of a more effective diagnostics of temporomandibular disorders (TMD). The sample included 40 patients with clinical symptoms of disc displacement (DD) of temporomandibular joint (TMJ) and 25 subjects included in our study were asymptomatic. DD were diagnosed by clinical examinations which were subsequently confirmed by MRI. DD was found in 18% of the TMJs of the asymptomatic patients. The highest prevalence of total DD without reduction was found in 44.1% of the patients' joints subsequently followed by total DD with reduction comprising 34.9% of the TMJs and by partial DD with reduction comprising 21% of the TMJs. This study may help us clarify the complicated relationship which exists between the radiographic and clinical findings of TMJ disorders.

Key words: *temporomandibular disorders, temporomandibular joint, magnetic resonance imaging, disc displacement, morphology*

Introduction

Temporomandibular disorders (TMD) are a collective term embracing a number of clinical problems that involve the masticatory musculature, the temporomandibular joints (TMJs) and their associated structures, or both. The etiology of TMD is now considered to be multifactorial and the diagnostics is mainly based on symptoms rather than etiology and/or pathogenesis[1]. Some studies have compared occlusal relationship and TMJ-status in population of TMD patients[2–4], and masticatory muscles activity of TMD patient related to splint treatment[5]. There was little evidence that some clinical procedures like measurement or registration of mandibular movements has diagnostic value for TMD[6].

Magnetic resonance imaging (MRI) has been used as the gold standard in determining the disc position, because anterior disc displacement (DD) is the most common condition of internal derangement of TMJs. There is a limitation in interpretation of structural bone changes in the MRI examination – the gold standard in the examination of hard structures is computerized tomography (CT). Mild structural bone changes and condylar hypomobility have no clinical significance[7–11].

MRI is an appropriate non-invasive diagnostic method introduced in numerous studies on subjects with no history and clinical signs of TMD[12–14]. Also, in several studies clinical diagnosis associated with TMJ pain has been compared with MRI findings of anterior DD[15–22].

The aim of the study was to determine the frequency rate of displaced TMJ disc in a clinically selected sample of patients with TMD as well as in asymptomatic subjects.

Subjects and Methods

A total of 40 patients with TMJ disorder (75% female) referred to the Department of Prosthodontics, School of Dental Medicine in Zagreb, Croatia, participated in this study which was conducted from January 2001 to February 2004. The age range of the patients' group was 15–71 years of age (standard deviation (SD) 35.5). Patients with

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previous diagnosis of systemic musculoskeletal disorders were excluded from the study. Twenty five asymptomatic subjects, (dental students, of which 72% female) participated in the investigation. Their age range was 21–27 years of age (SD 23.4)[23]. Prior to this investigation all the participants had signed an informed consent and the study was approved by the Ethics Committee, School of Dental Medicine, University of Zagreb, Croatia.

Clinical and MRI diagnostics

The patients had a history of TMD and that was verified by clinical examination confirmed by manual functional analysis according to Bumann and Groot Landeweer[24].

Including criteria were pain and clicking in the TMJ area, or limited mandibular movement. The researchers reporting the MRI images have been blinded to patients' clinical status and images have been randomly evaluated by two radiologists and one dentist (postgraduate student with some experience of DD diagnostics by MRI).

The patients with at least one TMJ partial anterior DD with reduction (pDDwR), total anterior DD with reduction (tDDwR) and total anterior DD without reduction (tDDwoR) were grouped with regard to the imaging diagnoses obtained by MRI[4,25]. The left and the right TMJs of each person were presented as two separate entities within the data analysis. The properties of joints with DD were observed separately. The statistical data analysis was performed with the help of the STATISTICA and SAS programmes. Fisher's exact test and chi-square test were used in comparison of left and right TMJ groups of patients and asymptomatic subjects.

MRI Protocol

The MRI – diagnostics of both TMJs of all the subjects who participated in the study was performed by a magnet on a »Harmony« supraconductive machine manufactured by Siemens (Erlangen, Germany) with the magnetic field power of 1T.

Characteristics for the specific TMJs were analysed for all the subjects.

The gradient magnets of 20 mT/ms power, with a rapid loading of the system and with a coil for the head with the radiofrequency related system were used in the study. The coil switched on the digitized transmitters and antennas with a 42 MHz frequency signal and with a 100 ns resulting resolution. Simultaneously, bilateral MR images were obtained of the TMJs of the patients on the coronal and sagittal planes of the images.

The TMJs images were obtained on the closing of the mouth when the subject's teeth were in their habitual occlusion. On the opening of the mouth the TMJs were in the course of imaging fixed by the intraincisal fixator (Optosil® P plus, Heraeus Kulzer).

The total number of images in seven slices was obtained with a 3mm thick matrix, 256 x 192 in size and with a 160 x 160 field of view. The imaging sequences included the T1 weighted image with a 450 ms time repetition and 12 ms time echo lasting 12 ms. The MRI assessment time on the parasagittal plane varied between 5.30 and 5.50 min for all the positions of the mandible. The angle of parasagittal planes was determined individually in concordance with the angle viewed on the angular layers of both the axial and coronal plane.

TMJ evaluation

The following variables of the analysis were defined on every selected parasagittal slice of the examined TMJ: configuration and contours of the articular eminence, configuration and contours of the glenoid fossa and configuration and contours of the condylar head, condylar position within the glenoid fossa, and both the shape and position of the disc. The MRI assessment was made regardless of the subject's condition which had been clinically determined prior to assessment. The MRI images were classified for all TMJs: degenerative changes of the articular eminence, degenerative changes of the condyle, the size of the condylar head with respect to the glenoid fossa, disc morphology, disc position, and condylar mobility in the open mouth position with respect to the articular eminence. The mild structural bone changes of the condyle (deplaned shape with normal density) were considered physiological.

The most important parameter of the MRI analysis is the position of the disc with respect to the condylar head. The physiological position of the disc is determined according to the intermedial zone position within the shortest span of the osseous contours of the ventocranial part of the condyle and the articular eminence. The pars posterior of the disc was located on the condylar head. DD was determined on the basis of the findings of the three representative slices of images in the parasagittal plane[28].

The reliability of MRI assessment was evaluated on the basis of two researchers' (a radiologist's and a dentist's) inspection, which was conducted on MRI images independently of the clinical signs of 12 patients twice on the same MRIs of both joints. The Kappa index of reliability was between 0.8 and 1.0 for all variables. The MRI assessment was judged to be very reliable.

Results

MRI images showing the TMJ structural characteristics in both the open mouth and closed mouth position are of utmost importance to the confirmation of the TMD diagnosis. With regard to the given criteria for the TMJ analysis, the MRI signals of different intensities, which

TABLE 1
RESOLUTION DISTRIBUTION OF TMJ STRUCTURES IN ALL SUBJECTS

MRI quality	Excellent	Satisfactory	Total
Subjects	60 (82.2%)	13 (17.8%)	73 (100.0%)

TMJ – temporomandibular joint, MRI – magnetic resonance imaging were well recognized, were transmitted by the osseous structures (the condyle, the glenoid fossa, the articular eminence) as well as by the cartilaginous structures of the disc (Table 1).

Morphology in the asymptomatic subjects

DD was observed in one male subject as well as in four female asymptomatic subjects. Physiological position of the disc was found in 20 subjects (80%), that is, in 44 (88%) TMJs (Table 2, Figure 1, and Figure 2). There were no structural bone changes of the condyle. The articular eminence is mainly oblique with well balanced signal intensity; the condyle shapes are also regular and in concordance with the size of the glenoid fossa. The shape of the disc is most commonly either biconcave or biplanar (Table 3). The condylar position within the glenoid fossa is centric in 23 (92%) of the left and 24 (96%) of the right TMJs. The most common were a normal mobility and a mild hypermobility of TMJs (Table 4).

Morphology in patients

The asymptomatic tDDwoR was determined in the right TMJ of two female patients with DD in the opposing joint (Table 5).

Frequency rates of variables such as configurations with respect to the TMJ structures of the patients with DD are shown in Table 6. Biconcave configurations of the disc were the most common findings. The proportions of almost identical frequencies were determined in the patients' TMJs, both the right and left TMJ. Although frequency rates were lower in a number of the TMJs, moderate to severe forms of structural bone changes of the

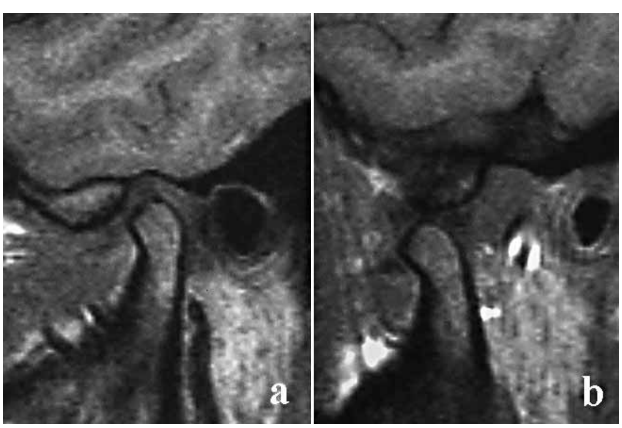

Fig. 1. MRI showing TMJ of a 21-years old asymptomatic female person with disc in physiological position (a, closed mouth; B, open mouth).

TABLE 2
THE FREQUENCY OF DD IN TMJs OF ASYMPTOMATIC SUBJECTS

Disc position	Left TMJ (n=25)	Right TMJ (n=25)
Physiological position	23 (92%)	21 (84%)
tDDwR	1 (4%)	2 (8%)
tDDwoR	1 (4%)	2 (8%)

TMJ – temporomandibular joint, tDDwR – total disc displacement with reduction, tDDwoR – total disc displacement without reduction

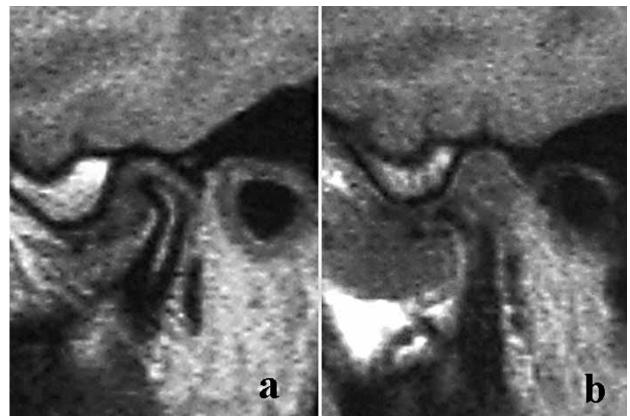

Fig. 2. MRI showing TMJ of a 23-years old asymptomatic female person: hypoplastic condyle, deformed form of DD (a, closed mouth) without reduction (B, open mouth) with condylar hypomobility.

TABLE 3
THE VARIABLE FREQUENCY IN A VISUAL ANALYSIS OF TMJs IN ASYMPTOMATIC SUBJECTS

Description of variables	left TMJ (n=25)	right TMJ (n=25)
Changes in the articular eminence shape		
Normal shape and density	15 (60%)	17 (68%)
Poor bone sclerosation	8 (32%)	6 (24%)
Moderate shape loss/Severe sclerosation	2 (8%)	2 (8%)
Condylar size with respect to glenoid fossa		
Condylar head of normal size	22 (88%)	21 (84%)
Hypoplastic condyle	3 (12%)	4 (16%)
Disc shape		
Biconcave	21 (84%)	14 (56%)
Biplanar	2 (8%)	11 (44%)
Deformed	2 (8%)	–

TMJ – temporomandibular joint

TABLE 4
THE FREQUENCY OF DIFFERENT FORMS OF CONDYLAR MOBILITY IN TMJs OF THE ASYMPTOMATIC SUBJECTS

Condylar mobility	Left TMJ (n=25)	Right TMJ (n=25)
Normal mobility	12 (48%)	13 (52%)
Mild hypomobility	3 (12%)	5 (20%)
Pronounced hypomobility	1 (4%)	1 (4%)
Mild hypermobility	9 (36%)	6 (24%)

TMJ – temporomandibular joint

articular eminence as well as some changes in the shape of the condylar head were evident (hypoplastic condyles). In addition, structural bone changes of the condylar head were also observed. Condyles were mostly located in central positions with respect to the glenoid fossa 35 (87.5%) of the left TMJs and 33 (82.5%) of the right TMJs. The frequency of the posterior condyle position is 4 (10.0%) in the left TMJs and 7 (17.5%) in the right, respectively. The anterior position of the condyle was found in only one TMJ.

TABLE 5
THE FREQUENCY OF DD DIAGNOSES IN TMJs OF THE PATIENTS WITH DD

Disc position/DD diagnoses	Left TMJ (n=40)	Right TMJ (n=40)
Physiological position	14 (35.0%)	21 (52.5%)
pDDwR	6 (15.0%)	3 (7.5%)
tDDwR	10 (25.0%)	5 (12.5%)
tDDwoR	10 (25.0%)	9 (22.5%)
asymptomatic tDDwoR	–	2 (5.0%)

TMJ – temporomandibular joint, DD – disc displacement, tDDwR – total disc displacement with reduction, tDDwoR – total disc displacement without reduction

TABLE 6
THE VARIABLE FREQUENCY IN A MRI ANALYSIS OF TMJs IN PATIENTS WITH DD

Description of variables	Left TMJ (n=40)	Right TMJ (n=40)
Shape/Degenerative changes in articular eminence shape as well as in bone density		
Normal shape and density	16 (40.0%)	12 (30.0%)
Poor bone sclerosation	11 (27.5%)	13 (32.5%)
Moderate shape loss/Severe sclerosation	12 (30.0%)	14 (35.0%)
Pronounced shape loss/Severe sclerosation	1 (2.5%)	1 (2.5%)
Shape/Degenerative changes in condylar shape as well as in bone density		
Normal shape and density	24 (60.0%)	32 (65.0%)
Deplaned shape/Moderately sclerosed areas	2 (5.0%)	1 (2.5%)
Normal shape/Moderately sclerosed areas	9 (22.5%)	4 (10.0%)
Tapered edges/Pronounced sclerosed areas	1 (2.5%)	2 (5.0%)
Osteophites and pronounced sclerosed areas	4 (10.0%)	1 (2.5%)
Condylar size with respect to glenoid fossa		
Condylar head of normal size	34 (85.0%)	32 (80.0%)
Hypoplastic condyle	6 (15.0%)	8 (20.0%)
Disc shape		
Biconcave	18 (45.0%)	21 (52.5%)
Biplanar	12 (30.0%)	13 (32.5%)
Deformed	10 (25.0%)	6 (15.0%)

TMJ – temporomandibular joint

TABLE 7
THE FREQUENCY OF CONDYLAR MOBILITY OF TMJs IN PATIENTS WITH DD

Condylar mobility	Left TMJ (n=40)	Right TMJ (n=40)
Normal mobility	14 (35.0%)	14 (35.0%)
Mild hypomobility	11 (27.5%)	14 (35.0%)
Pronounced hypomobility	4 (10.0%)	6 (15.0%)
Mild hypermobility	8 (20.0%)	6 (15.0%)
Pronounced hypermobility	3 (7.5%)	–

TMJ – temporomandibular joint

Low signal intensity was demonstrated on MRI dorsally with respect to the pars posterior disc in the form of progressive adaptation bilaminar zone (pseudodiscus) in one male patient with tDDwoR and in one female patient with tDDwoR.

In this study, the proportion of normal condylar mobility with respect to the posterior part of the articular eminence was approximately equal in all joints regardless of the side (Figure 3). Certain forms of limited translation of the condyle were more the common finding in the right TMJs, while the proportion of subluxation (hypermobility) was higher in the left TMJs (Table 7).

There is no structural bone change of condyle in TMJs of asymptomatic subjects. There was statistically significant difference between structural bone changes of articular eminence of right TMJs and disc morphology of left TMJs of patients and asymptomatic subjects in this study (Table 8).

Discussion and Conclusion

The TMD diagnostics should be based on clinical examination while MRI should be indicated by criteria which are based on both the clinical (tentative) and dif-

TABLE 8
STATISTICAL COMPARISON OF TMJ GROUPS OF PATIENTS WITH DD AND ASYMPTOMATIC SUBJECTS

Variables	Left TMJs	Right TMJs
structural bone changes of articular eminence	Fisher's exact test p=0.102	Fisher's exact test p=0.009
condylar size in the glenoid fossa	Fisher's exact test p=1.000	Fisher's exact test p=0.754
disc shape	chi-square test(df2)=9.766 with p=0.008	Fisher's exact test p=0.112
condylar mobility	Fisher's exact test p=0.373	Fisher's exact test p=0.209

TMJ – temporomandibular joint

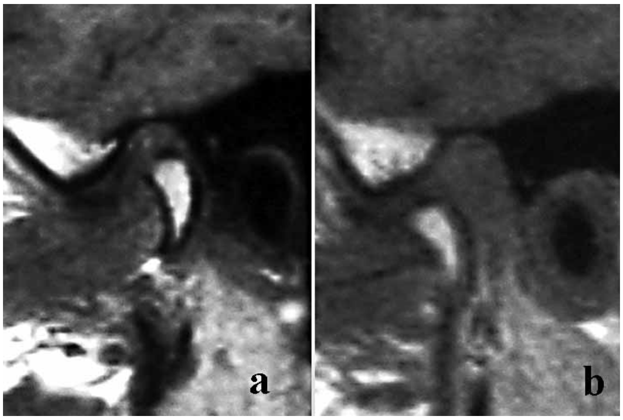

Fig. 3. MRI showing TMJ of a 38-years old male patient with DD (a, closed mouth). In the open mouth position (b) a reducible disc on deplaned condyle, which is extremely hypomobile, it seen.

ferential diagnosis[1]. In several studies, it has been concluded that TMJ pain is related to MRI diagnosis of DD, but the validity and accuracy of clinical assessment in the evaluation of different diagnosis of DD was not reliable[17,18,20]. The highest prevalence of TMD is to be found in the adult population aged from 18 to 45. Also, TMD occurs more commonly in women (75–80%) than in men, which was confirmed in this study[1,10,26].

A considerably high prevalence of DD has been observed by MRI in subjects without either history or clinical findings of the TMD. The prevalence rate has amounted to as much as 12–33% of the examined population, that is, 8–45% of the individually examined TMJs[12–14]. In this study DD was found in 20% of a well-selected age group of the asymptomatic subjects. A relatively high prevalence rate of DD in the asymptomatic subjects could be explained by the fact that DD is both the anatomic and physiological variation.

Wiberg B and Wänman A[28] found a high radiographic prevalence of TMJ osteoarthritis in young patients (58% of the joints). Nevertheless, it has not been proved that such joints exhibit more severe symptoms than the joints with DD. Brooks et al.[11] Moderate changes were also found in 35% of the joints of asymptomatic subjects without DD. According to Brooks et al.[11] minimal deplaned condyle and/or articular eminence is considered normal and was particularly common in samples of similar studies[19,21].

Cholitgul et al.[16] found deplaned condylar shapes in 17% of the joints with DD. Muller-Leisse et al.[15] found structural bone changes in between 10% and 12% of TMJs of asymptomatic subjects. Structural bone changes of the condyle were higher (81%) in TMJs with DDwoR than in joints of the patients with DDwR (81%) as well as in 12% of asymptomatic TMJs of same patients whose disc was in a physiological position. In this study the changes in the condylar head were exclusively typical of the patients' joints. Moderate changes of the articular eminence bone are a more common finding in the patients' joints (40.9%).

The high frequency rate of structural changes in the articular eminence bone can be a false positive MRI finding, which was confirmed by the TMJ radiographs[19,29]. Radiographic signs of structural bone changes in TMJs surfaces as well as DD without corresponding clinical signs and symptoms do not form a relevant basis for TMD. In this study we found such symptoms and signs in an asymptomatic subject while such a finding was expected in the patients. However, there can be a number of potential explanations that may account for the presence of such symptoms in the control group but we assume that they result from the functional load of interarticular structures which is present with DD together with its concomitant signs of osteoarthritis. Structural bone changes are the best visible by CT, as a most common radiological modality for diagnostics of clinical signs of osteoarthritis[7,8,24].

Incesu et al.[30] concluded that condylar dorsal position could indicate anterior DD. Kamelchuk et al.[12] has reported that there is a poor correlation or no correlation between the two. In this study we have attempted to analyze visually the position of the condyle in the glenoid fossa. However, we did not observe a higher frequency rate of the condyles of patient's TMJs which were in a non-centric position.

Hypermobility (subluxation) of the condyle can cause a painless choking in TMJs in as many as 70% of the population. This should be clinically differentiated from the symptoms of painless DD[31]. Kalaykova et al.[32] concluded that there is no significant difference between the hypermobile and non-hypermobile persons whose DD has been analysed on MRI images. In this study a relatively high frequency rate of limited translation of the condyle (hypomobility) was observed in TMJs of patients.

Bernhardt et al.[33] showed that in the epidemiological study by MRI on the basis of several good definite criteria of functional disturbances addressed to TMJs, OA changes were found in 25% of all subjects, unilaterally or bilaterally. The population of subjects with clinical signs of OA is not well investigated, and with no request for TMD treatment.

In conclusion, on the basis of comparing TMJ status of patients with DD and the asymptomatic subject sample, it has been concluded that both the shape and abnormal intraarticular structures of the TMJs (DD, structural bone changes, and condylar mobility) are not the unconditional indicators of diagnosis unless confirmed by clinical signs and symptoms.

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STUDIJA O MORFOLOGIJI ČELJUSNOG ZGLOBA POMOĆU MAGNETSKE REZONANCIJE

SAŽETAK

Magnetska rezonancija omogućila je veću učinkovitost dijagnostike specifičnih poremećaja čeljusnog zgloba. U našem istraživanju je sudjelovalo 40 pacijenata s kliničkim dijagnozama pomaka zglobne pločice, te 25 asimptomatskih osoba. Nalazom magnetske rezonancije potvrđen je kliničkim pregledom utvrđen pomak zglobne pločice. Utvrđen je pomak zglobne pločice kod 18% zglobova asimptomatskih ispitanika. Kod pacijenata s pomakom zglobne pločice najveća učestalost potpunog pomaka pločice bez repozicije je u 44,1% zglobova, potpunog pomaka pločice s repozicijom u 34,9% zglobova te djelomičnog pomaka zglobne pločice s repozicijom u 21% zglobova. Ovo istraživanje pomaže boljem objašnjenju povezanosti radioloških i kliničkih znakova artrogenih poremećaja čeljusnog zgloba.