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Original scientific paper

Disc and Condylar Head Position in the Temporomandibular Joint With and Without Disc Displacement

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A B S T R A C T

The purpose of this study was to evaluate the difference between disc and condyle position between temporomandibular joints (TMJs) without disc displacement (DD) in asymptomatic volunteers, and patients who have DD in contralateral joints, respectively unilateral DD. Secondly, there were two TMJ groups which consisted of measurements from patients' symptomatic DD and volunteers with asymptomatic DD. The study included 79 TMJs of 40 patients with unilateral DD. In the group of 25 asymptomatic volunteers, 20 volunteers were without DD bilaterally (40 joints), while five had DD in at least one TMJ. All subjects were examined clinically and DD was confirmed by magnetic resonance imaging. Left and right TMJs were analysed independently for each participant based on their DD status (symptomatic, asymptomatic, and without DD). All asymptomatic TMJs did not have any clinical signs of TMJ functional abnormalities. There was a significant statistical difference between disc position among TMJs without DD in asymptomatic volunteers and TMJs without DD in patients (p=0.016). Moreover, no significant differences were found between condyle position in the same groups of joints (p=0.706). There were no significant differences in the DD position (p=0.918) or condyle position (p=0.453) between the group with asymptomatic volunteers' joints and the group with symptomatic patients' joints. There was a significant difference between patient and volunteers' joints without DD: the disc was positioned more anteriorly in patients' joints without DD than in joints of asymptomatic volunteers without DD.

***Key words**: magnetic resonance imaging, temporomandibular joint, temporomandibular joint dysfunction syndrome*

Introduction

Temporomandibular disorders (TMDs) include functional impairment in the area of temporomandibular joints (TMJs) and masticatory muscles. Magnetic resonance imaging (MRI) has been used as the »gold standard« in the examination of soft tissue and condylar bone morphology of TMJ in both symptomatic and asymptomatic persons[1–3]. The aetiology of anterior disc displacement (DD) is unclear, and the potential risk factors, such as its relationship with the posterior condylar position evaluated via different metric analyses, are controversial[4–8]. Several MRI studies have demonstrated DD in 34% of TMJs in volunteers without symptoms of TMD[9,10].

The clinical and radiological analyses on heterogeneous samples of patients were used in the overall analysis of the stomatognathic system and they contributed to the research of ethiopathogenesis, diagnostics and treatment of osseous structures of the orofacial region as well as of TMJ disorders[11–18]. Clinical diagnoses of DD have been compared with MRI findings and TMJs with DD have been compared with TMJs without DD in the same patients[5,19–21].

There is a discrepancy in the use of criteria of clinical diagnostics and subsequently confirmed DD[22], as well as some disagreements about the criteria used to distinguish between physiological disc position and anterior DD in MRI images[23]. In ethiopathogenesis of DD, the specific load of TMJ, particularly of the disc in functional joint movements, should be taken into consideration[24,25].

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The purpose of this study was to test differences between disc and condyle position in TMJs without DD in asymptomatic volunteers and in TMJs without DD in patients with DD in contralateral joints. Degenerative cortical bone and the disc morphology of asymptomatic TMJs were analysed. The difference between symptomatic TMJs in patients and asymptomatic TMJs with DD in both patients and asymptomatic individuals was then tested.

Subjects and Methods

Total of 65 persons participated in this study. In all the participants, both left and right TMJs were evaluated independently. The symptomatic group consisted of 40 consecutively examined patients with internal derangement of the TMJ who were referred to the Department of Removable Prosthodontics at the School of Dental Medicine. All patients were aged between 15 and 71 years (mean: 35.5 years; ranging from 15–71; 75% female). The inclusion criteria were pain and clicking or a history of clicking with limited mouth opening. Clinical diagnosis was verified on the basis of a history of TMD, clinical diagnostics according to Research Diagnostic Criteria (RDC)/TMD Axis I, and further refined diagnostics was provided by manual functional analysis according to Bumann and Groot Landeweer[26,27]. No treatments were performed on any patients included in this study during the period between the clinical examination and the MRI scanning. The articular disc status of all TMJs based on clinical diagnostics was confirmed by using MRI.

Based on evaluation criteria there were two subgroups of patients' joints: 43 joints with symptomatic DD in at least one TMJ and 34 TMJs without DD and without clinical signs and symptoms of TMD (Table 1). One joint with clinical and MRI findings of osteoarthritis and without DD was excluded. The patients' TMJs were separately analysed depending on MRI confirmed symptomatic DD, asymptomatic DD, or absence of DD. Symptomatic DD in a patient's TMJ meant that the patient had DD diagnosed in this joint and also presented with clinical symptoms and signs of TMD.

The asymptomatic group consisted of 25 volunteers (median age 23.4; ranging from 21–27; 72% female). Based on evaluation criteria, asymptomatic group was further divided into two subgroups of joints: 40 TMJs without DD bilaterally in the 20 volunteers, and 5 volunteers with DD in at least one TMJ by MRI analysis (Table 1)[28].

From these two groups of participants, a third group was made that consisted of all eight asymptomatic TMJs. These included six TMJs with DD from five asymptomatic volunteers and two TMJs with asymptomatic DD from two symptomatic patients with TMD (Table 1).

Prior to this investigation, all participants had signed an informed consent, and the study was approved by the Ethics Committee, School of Dental Medicine, University of Zagreb, Croatia.

TABLE 1
SUBGROUPS OF EXAMINED TMJ PATIENTS AND ASYMPTOMATIC VOLUNTEERS ACCORDING TO DD STATUS

Subgroups of joints	Without DD	Asymptomatic DD	Symptomatic DD
Asymptomatic volunteers	40*	6	
Patients with TMD	34	2	43

* joints without DD – bilaterally only; DD – disc displacement; TMD – temporomandibular disorder; TMJ – temporomandibular joint

MRI protocol

The bilateral MRI of the TMJ was performed with the following spin-echo-sequent parameters using a 1 T scanner (Magnetom Harmony Siemens, Erlangen, Germany): T_1 weighted image TR/TE 450/12, T_2 weighted image TR 3000/TE 66, field of view of 160 x 160, matrix of 256 x 192 and 3 mm slice), and using a 1.5T scanner (Magnetom Avanto, Siemens, Erlangen, Germany) T_1 weighted image TR/TE 410/9.4, T_2 weighted image TR 460/TE 15, field of view of 180 x 180, matrix of 410 x 512 and 2 mm slice). All subjects were scanned in the closed mouth position and the open mouth position was fixated with an inter-incisal individual fixator performed using the Optosil® P plus (Heraeus Kulzer, Hanau, Germany). The angle of the parasagittal imaging is individually determined by the angle shown on the individual angulated layers of the axial and coronal slice.

Qualitative MRI analysis

The disc's physiological position was defined according to the placement of its inter-medial zone between the articular eminence and the shortest distance of the bone contours of the condyles' ventrocranial part in the parasagittal plane in the closed mouth position[27,29].

The following cortical bone and disc morphology abnormalities were analysed on the examined TMJ: configuration and contours of the articular eminence (normal shape and density, poor bone sclerosation, moderate shape loss, or severe sclerosation), condylar head (normal shape and bone density, deplaned shape with normal density, deplaned shape or moderately sclerosed areas, normal shape or moderately sclerosed areas, osteophyte and pronounced sclerosed areas), and disc deformation (biconcave, biplanar, deformed).

Quantitative MRI analysis

Analysis of the position and the relationship between the disc and the condyles was described using the method of Kurita et al.[30] on the parasagittal images. A tangent was drawn between the lowest part of the articular eminence (T) and the highest edge of the external auditory canal (P). A line was drawn; perpendicular to the tangent, touching the back edge of the disc, and their intersection was marked as point D. Another perpendicular, touching the back edge of the condyle was also drawn, and point C marked the intersection of this line and the tangent. The distances between points T and P were taken as measurement reference values, and individual distances on the tangent – distances between points T and C, and points T and D (Figure 1) were also measured. Absolute values (TP, TC and TD) were measured with the aid of Adobe Photoshop® 7.0 (Adobe Systems Incorporated, San Jose, California, USA). Millimetre values to one decimal place were calculated based on the measurement scale shown in the MRI. The disc and condyle positions were calculated as TC/TP and TD/TP and expressed in one-hundredths of distance between points T and P. A lower value indicates a more anterior condyle or disc position.

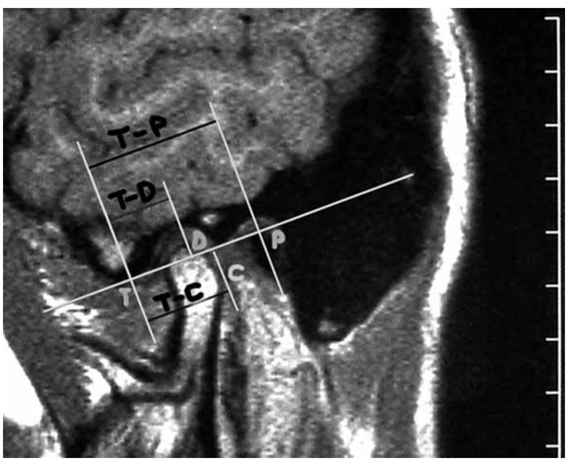

Fig. 1. Measuring the position of the disc and condyles in the parasagittal plane. The TP, TD, and TC distances are measured in millimetres.

Statistical analysis

The statistical data analysis was performed by STATISTICA (StatSoft Inc., Tulsa, Oklahoma, USA) program. Differences in distribution were analysed by non-parametric statistics (Kruskal-Wallis test, Chi-square test, and Fisher's exact test). Differences were considered statistically significant at values of.05 and.01. The measured values of the metric evaluation are displayed by means of a box-and-whisker plot data display. The box was defined by the first and the third quartiles, the median was the horizontal line in the box, and all measured values apart from those in the non-outlier range were defined by whiskers. The outliers were placed beyond the limits.

The reliability of MRI assessment was evaluated on the basis of two researchers' (a radiologist's and a dentist's) inspection, which was conducted independently of the patient's clinical signs on MRI images. The Kappa index of reliability was between 0.8 and 1.0 for all variables.

The reliability of results for the metrical analysis of variables was tested by calculating the method error according to Dahlberg[31]. When no measurement error exists then the Dahlberg error equals 0. To calculate the method error (ME) according to Dahlberg, the following formula was used:

$$ME = \sqrt{\sum d^2 / 2n}$$

where d – difference between two measurements and n – number of measured MRI images twice.

The reliability of the measurements of the metrical analysis was conducted on 12 patients twice using the same MRIs of both joints (24 measurements in all). The comparison of the results for the two measurements of the metrical analysis of variables showed ME values for all measured distances between 0.10 and 0.07.

Results

Contrary to the hypothesis of this study, there was a statistically significant difference in the calculated disc position between groups of joints without DD in asymptomatic volunteers and in asymptomatic joints among patients with confirmed DD in the contralateral joints (Kruskal-Wallis test KW(1.78)=5.801 with p=0.016 – Figure 2a).

The hypothesis that there were no differences between the calculated condyle position in the groups of joints without DD in asymptomatic volunteers and joints without DD in patients with DD in contralateral joints was confirmed (Kruskal-Wallis test KW(1.78)=0.142 with p=0.706 – Figure 2b).

Differences in shape and degenerative changes in the articular eminence, as well as in bone density in the group of joints without DD in patients were not confirmed (χ^2-test p=0.086) (Table 2). Changes in the condylar head were found only in the group of joints without

TABLE 2
STRUCTURAL BONE CHANGES OF THE ARTICULAR EMINENCE IN THE GROUP OF TMJS WITHOUT DD AND THE GROUP OF TMJS WITHOUT DD IN PATIENTS WITH DD IN CONTRALATERAL JOINTS

Shape and degenerative changes in articular eminence shape and bone density	TMJs without DD in asymptomatic volunteers (number, %)	TMJ without DD in patients with DD in contralateral joints (number, %)
Normal shape and density	26, 59.1%	18, 50.0%
Poor bone sclerosation	14, 31.8%	8, 22.2%
Moderate shape loss or severe sclerosation	4, 9.1%	10, 27.8%
	χ^2=4.912, df=2, p=0.086	

TMJ – temporomandibular joint; DD – disc displacement

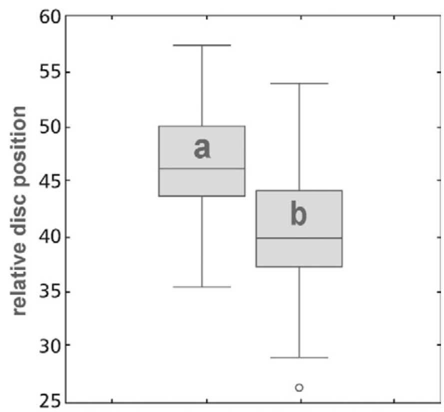

Fig. 2a Box-plot comparison of the calculated relative disk position (y-axis, expressed in one-hundredths between points T and P) between the groups of TMJs (x-axis) without DD of asymptomatic volunteers (a) and TMJs without DD of the patients with DD in the contralateral TMJs (b). Thick black horizontal line in the box=median value; the box encompassed 50% of the results.

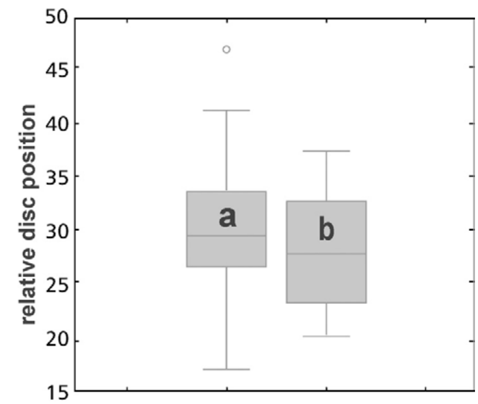

Fig. 3a Box-plot comparison of the calculated relative disk position (y-axis, expressed in one-hundredths between points T and P) between the groups of TMJs (x-axis) with DD of patients (a) and TMJs with asymptomatic DD consisted of asymptomatic volunteers and patients (b).

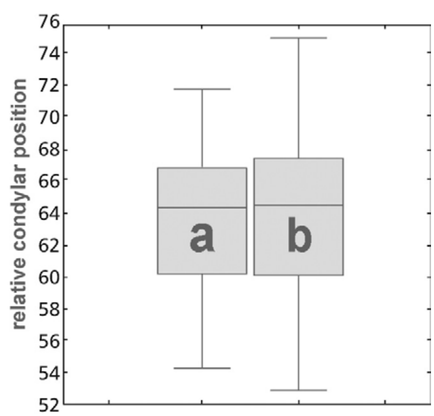

Fig. 2b Box-plot comparison of the calculated relative condyles position (y-axis, expressed in one-hundredths between points T and P) between the groups TMJs (x-axis) without DD of asymptomatic volunteers (a) and TMJs without DD of the patients with DD in the contralateral TMJs (b).

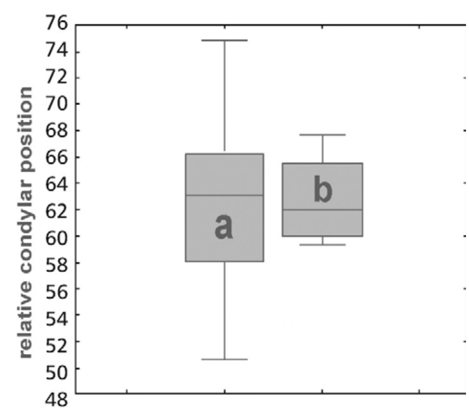

Fig. 3b Box-plot comparison of the calculated relative condylar position (y-axis, expressed in one-hundredths between points T and P) between the groups of TMJs (x-axis) with DD of patients (a) and TMJs with asymptomatic DD consisted of asymptomatic volunteers and patients (b).

DD in patients (normal shape and bone density in 23, 67.7%, of joints, deplaned shape with normal density in 5 (14.7%) of the joints, normal shape or moderately sclerosed areas in 4 (11.8%) of the joints, and deplaned shape or moderately sclerosed areas and osteophytes with pronounced sclerosed areas in one of the joints (2.9%). There was no statistically significant difference in the distribution in the various disc morphology in both groups of joints (Table 3, Fisher's exact test p=0.66).

TABLE 3
DISC MORPHOLOGY OF THE GROUP OF PATIENTS WITH TMJ AND NO DD AND THE GROUP OF TMJS WITH NO DD OF PATIENTS WITH DD IN CONTRALATERAL JOINTS

Disc morphology	TMJ without DD in asymptomatic volunteers (number, %)	TMJ without DD in patients with DD in contralateral joints (number, %)
Biconcave	35, 79.5%	26, 76.5%
Biplanar	9, 20.5%	7, 20.6%
Deformed		1, 2.9%
	Fischer exact test, p=0.660	

TMJ – temporomandibular joint; DD – disc displacement

The second metric analysis of this study was performed on TMJs with asymptomatic or symptomatic DD. There were no statistically significant differences in the calculated disc position (Kruskal-Wallis test KW (1.51) =0.011 with p=0.918 –Figure 3a) and calculated condyle position (Kruskal-Wallis test KW (1.51) =0.564 with p= 0.453 – Figure 3b) between TMJs with symptomatic DD at least in TMJs of the group consisting of patients and the group consisting of both asymptomatic DD TMJs in the patients and volunteers.

Discussion

Manual functional analysis was used for further refined clinical diagnostics with the goal of establishing a more secure clinical diagnosis[2,12,14,20,27]. Studies by Haley et al.[10] and Costa et al.[18] suggest that DD of TMJ appears unilaterally. Therefore, bilateral examination of TMJs in the same person is recommended in the study of the relationship between clinical and radiological findings, such as radiography of knees[32]. DD is very common in asymptomatic volunteers, which has been demonstrated by MRI studies in up to one third of TMJs in volunteers[9,10], however, in many studies TMJs without DD were used as a control group in the comparison of symptomatic joints in the same patients[19–21].

The MRI-covered study demonstrated discrepancies between MRI findings of DD (40% of TMJs) and a clinical diagnosis without confirmed DD[22]. Another study showed that there were only 14 TMJs without DD in the TMJs of 126 patients[21]. There was a report that suggested a correlation between TMJs and physiological disc position in a sample of patients and asymptomatic volunteers and the influence that TMJs with and without DD have on condylar position in the contralateral joint[5].

The possible causal relationship between posterior condyle position and anterior DD has shown contradictory findings. According to some studies[4,6,7], posterior condyle position could indicate DD. However, other studies have reported that posterior condyle position is neither predictive nor associated with DD of the TMJ, nor did condylar position depend on DD subdivisions[5,33]. In this study, there was no statistically significant difference between condyle position in both examined groups of TMJs without DD.

Moreover, in another study[22], changes of the articular eminence were found in all subgroups of joints, including the asymptomatic volunteers. Differences between the subgroups of asymptomatic volunteers' TMJs (same students' sample from our recent study) and asymptomatic TMJs of patients' with osteoarthritis in the contralateral TMJ were specially analyzed and they did not reveal any statistically significant data[34]. Mild structural bone changes, such as a deplaned condyle and/or articular eminence with normal density, were considered physiological in the samples of similar studies[17,18,22,26]. Campos et al.[16] found that degenerative osseous changes were a risk factor for TMJ pain; however, osteoarthritic changes on MR images were not predictive of possible pain conditions in TMJ. In the present study, moderate shape loss or severe sclerosation of the articular eminence were found in both groups of TMJs without DD; however the structural changes in the condylar bone occurred in joints without DD among patients only.

Biconcave discs are associated more with normal joints, especially in non-TMD subjects (82%)[35], however the frequency in TMD patients was 20.8%/24.7% (left/right TMJs) only[36]. In the present study, the difference between disc morphology of the two investigated groups of joints without DD was not found. The relationship between symptomatic and asymptomatic DD is not clear; however MRI analysis improved the view in the TMJs of patients and volunteers.

It was observed that the possible causes of asymptomatic DD were as follows: if the DD is not congenital, functional disturbances can produce symptoms, especially pain in the TMJ, during functional (over)loading[10,28]. Also, the present study showed that in the patients' group, there was a low frequency of asymptomatic DD, as DD was detected in two patients only.

The pathophysiological basis for DD could be the role of the disc as a stress absorber and force distributor during mandibular movements. In dynamic visualization of TMJ disc, Gallo[25] found disc deformation during condylar-disc complex motion. The clinical implication of the results of this study assumed that the quantitative difference in physiological position or position without displacement between asymptomatic volunteers' and patients' TMJs has a role in many aspects (biomechanical, biological, and morphological) of the everyday functional response of this small and very loaded joint[24]. Because there were statistically significant differences, metric analysis (p=0.016) was not able to unite these two TMJ groups of asymptomatic volunteers and patients into the same group of TMJs with or without DD. However, Salé et al.[37] followed the TMJs during 15 years and found changed intraarticular status (status of displaced disc and bone changes) in one (5.6%) patient and in three (10.4%) asymptomatic volunteers.

Conclusion

The results of this study showed that there were statistically significant differences between quantitatively evaluated physiological disc positions or without displacement in the group of asymptomatic TMJs of patients with painful contralateral TMJ and asymptomatic volunteers. There was no difference in condylar positions between them. Further studies including a large sample size of TMJs with different disc status of patients and asymptomatic volunteers are warranted to improve knowledge about TMJs with different disc status, especially in asymptomatic TMJs with physiological disc position.

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POLOŽAJ DISKA I GLAVICE KONDILA U ČELJUSNOM ZGLOBU SA I BEZ POMAKA DISKA

S A Ž E T A K

Svrha istraživanja bila je testirati razliku između položaja diska i kondila čeljusnih zglobova bez pomaka diska u asimptomatskih dobrovoljaca te pacijenata koji imaju pomak diska u kontralateralnim zglobovima, odnosno jednostrani pomak diska. Drugi dio istraživanja činila su mjerenja razlika u zglobovima pacijenata sa simptomatskim pomakom diska i dobrovoljaca sa asimptomatskim pomakom diska. Istraživanje je obuhvatilo 79 čeljusnih zglobova u 40 pacijenata s unilateralnim pomakom diska. Iz skupine od 25 asimptomatskih dobrovoljaca njih 20 bilo je bez pomaka diska bilateralno (40 zglobova), dok ih je pet imalo pomak diska u najmanje jednom zglobu. Svi ispitanici su podvrgnuti kliničkom pregledu, a pomak diska je dodatno potvrđen magnetskom rezonancijom. Lijevi i desni zglob analizirani su za svakog ispitanika pojedinačno temeljem stanja pomaka diska (simptomatski, asimptomatski i bez pomaka diska). Svi asimptomatski zglobovi nisu imali nikakve kliničke znakove abnormalnosti funkcije. Postojala je značajna statistička razlika između položaja diska čeljusnih zglobova bez pomaka diska u asimptomastkih dobrovoljaca i zglobova bez pomaka diska u pacijenata (p=0,016). Nadalje nije nađena značajna razlika između položaja kondila u istim skupinama zglobova (p=0,706). Nije bilo značajne razlike niti u položaju pomaka diska (p=0,918) ni položaju kondila (p=0,453) između skupine zglobova simptomatskih dobrovoljaca i skupine simptomatskih zglobova pacijenata. Postojala je značajna razlika između zglobova pacijenata i dobrovoljaca bez pomaka diska: disk je u zglobova pacijenata bez pomaka diska pozicioniran više anteriorno nego u zglobova asimptomatskih dobrovoljaca bez pomaka diska.