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High-resolution ultrasonography in assessing temporomandibular joint disc position

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Abstract

Aims: The purpose of this study was to determine the diagnostic value of high-resolution ultrasonography (US) in temporomandibular joint (TMJ) disc displacements. **Materials and methods:** A number of 74 patients (148 TMJs) with signs and symptoms of TMJ disorders, according to the Research Diagnostic Criteria for Temporomandibular Disorders, were included in this study. All patients received US and magnetic resonance imaging (MRI) of both TMJs 1 to 5 days after the clinical examination. MRI examinations were performed using 1.5 T MRI equipment (Siemens Avanto, Siemens, Erlangen). Ultrasonographic examination was performed on a Hitachi EUB 8500 (Hitachi Medical Corp., Tokyo, Japan) scanner with L 54 M 6.5-13 MHz linear transducer. **Results:** MRI depicted 68 (45.95%) normal joints, 47 (31.76%) with disc displacement with reduction, 33 (22.3%) with disc displacement without reduction and 34 (22.97%) with degenerative changes. US detected 78 (52.7%) normal joints, 37 (25%) with disc displacement with reduction, 33 (22.3%) with disc displacement without reduction and 21 (14.19%) with degenerative changes. Compared to MRI, US showed a sensitivity of 93.1%, specificity of 87.88%, accuracy of 90.32%, a positive predictive value of 87.1% and a negative predictive value of 93.55% for overall diagnosis of disc displacement. The Youden index was 0.81. **Conclusions:** Based on our results, high-resolution ultrasonography showed high sensitivity, specificity and accuracy in the diagnosis of TMJ disc displacement. It could be a valuable imaging technique in assessing TMJ disc position. The diagnostic value of high-resolution ultrasonography depends strictly on the examiner's skills and on the equipment used.

Keywords: temporomandibular joint; disc displacement; magnetic resonance imaging; ultrasonography

Introduction

Various imaging techniques have been indicated for the diagnosis of temporomandibular joint (TMJ) pathology, including conventional radiography, artrograhpy, computed tomography (CT), and magnetic resonance imaging (MRI) [1,2]. High-resolution ultrasonography (US) is not a commonly used imaging technique for TMJ pathology [3]. One of the main limitations of US consists of the difficulty of assessing the disc due to the presence of the bony structures (mandibular condyle and zygomatic process of the temporal bone). Another important issue is that US examination is unable to visualize the medial part of the condyle. On the other hand, being a real time investigation, US provides information regarding disc position during mandibular movements, compared to other TMJ imaging techniques [4-6].

The TMJ is a synovial joint located anterior to the external auditory meatus, consisting of two bones (mandib-

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ular condyle and the glenoid fossa of the temporal bone), an articular disc, internal and external ligaments [7]. The disc, a fibrocartilaginous biconcave structure, consists of an anterior band, posterior band and a thin intermediate zone. This small articular element is difficult to be visualized at US examination; therefore, well trained operators are required. Posteriorly, the disc is attached to the temporal bone by the retrodiscal tissue (bilaminar zone), highly vascularized and innervated. Anteriorly, the superior belly of lateral pterygoid muscle inserts into the disc [8-10].

The temporomandibular disorder (TMD) is defined by the American Academy of Orofacial Pain (AAOP) as a complex term that covers a number of clinical problems that include the masticatory muscles, the TMJ, and the associated structures. The AAOP classifies the TMD in two groups: muscular and articular. The most frequent type of TMD is represented by internal derangements which define an abnormal position of the disc on the condyle [11]. Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), is a symptom-based-system, which defines clearly the subtypes of TMD [12], allowing a classification according to the two different degrees of displacement of the disc relative to the condyle: 1) disc displacement with reduction (DDwR), when the disc is displaced anteriorly, medially, or laterally to the condylar head. The displaced disc with mouth-closed reduces during mouth opening, usually with a clicking sound. The mandible deviates to the affected side, and then, when the click occurs, returns to the midline. The mandibular range of motion is not limited, though intermittent locking can occur; and 2) disc displacement without reduction (DDwoR), or also named “closed-lock”, in which the displacement of the disc is not reduced during mouth opening. The mandible deviates to the affected side and the mandibular range of motion is limited. Pain occurs in most patients [12-15].

Panoramic and transcranial radiographs show only bone changes of TMJ (asymmetries, tumors, fractures, degenerative disease in late stages), but they are limited due to the overlap of the zygomatic arch and base of the skull. Cone beam CT is useful in the detection of morphological TMJ changes, but is not able to visualize the soft tissue structures [16].

MRI is considered to be the reference standard in visualizing the disc-condyle relationship and the soft tissue structures of TMJ [1,2,17]. The accuracy of the MRI in revealing the disc position is 95% compared to autopsy studies [18]. Its disadvantages are the high cost, low availability, and restricted use in patients with claustrophobia, pacemakers, and in patients with ferromagnetic metal implants [3].

US was first used for TMJ exploration in 1991, by Nabeih et al, using a 3.5 MHz transducer [19]. It is a non-invasive, dynamic, inexpensive imaging technique which can be useful in diagnosing articular disc displacements. Variable levels of sensitivity were reported in detection of disc displacement, therefore further studies are required [2-5,20-24]. It is a technique that depends widely on the operator.

The aim of this study was to determine the sensitivity, specificity, diagnostic accuracy, and positive and negative predictive values of US in the detection of TMJ disc displacements, compared to MRI. An important goal of this research was to determine whether US could be a routine imaging technique in assessing the presence or absence of TMJ disc displacement.

Materials and methods

Patients

Between May 2015 and October 2016, 74 consecutive patients (148 TMJs) were included in a prospective study. Inclusion criteria were patients with signs and symptoms of TMD, according to RDC/TMD [12]. Exclusion criteria were patients with contraindications to MRI (claustrophobia, metal prosthesis, pacemakers) and patients with masticatory muscle disorders. The clinical evaluation was performed in the Department of Cranio-Maxillofacial Surgery in Cluj-Napoca. All patients underwent US and MRI examinations of both TMJs, 1 to 5 days after the clinical examination. The results were interpreted by two radiologists blinded on both clinical and imaging findings, one for MRI imaging and one for high-resolution US. The research protocol was analyzed and approved by the Ethics Committee of the University. Informed consent was obtained from each participant included in this study.

Clinical examination

The diagnosis of TMD was based on the patient’s history and physical examination. The clinical evaluation was performed by an oral surgeon and included a comprehensive examination of TMJ, masticatory, and cervical muscles. Occlusion analyze, both static and dynamic was performed. Signs and symptoms associated with articular TMD could be represented by pain, presence of articular sounds, abnormal mandibular movement, jaw locking, and ear discomfort. The diagnostic decision tree was done according to RDC/TMD.

Ultrasonography

US examination was performed on a Hitachi EUB 8500 (Hitachi Medical Corp., Tokyo, Japan) machine with L 54 M 6.5-13 MHz linear transducer. The images were obtained using the 13 MHz frequency, by the same examiner, experienced in head and neck ultrasound for 9 years. The examiner was blinded to clinical findings and

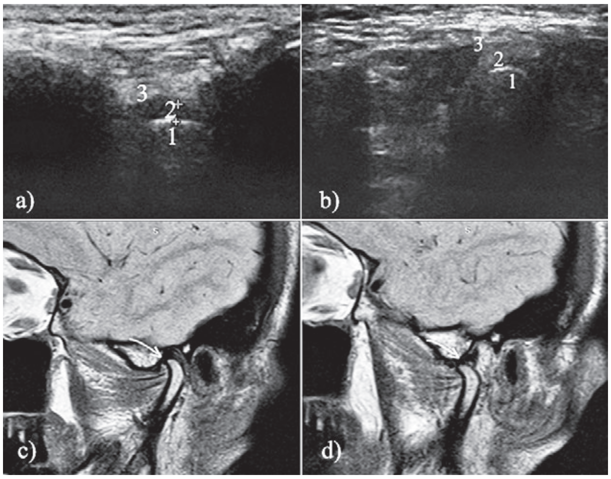

Fig 1. High-resolution US of a normal TMJ: mouth-closed (a), mouth-opened (b). 1 – mandibular condyle; 2 – articular disc, situated with the intermediate part between the anterosuperior zone of the mandibular condyle and the posterosuperior part of the articular eminence; 3 – articular eminence. Sagittal proton density MRI of the same TMJ: mouth-closed (c), mouth-opened (d). The disc (arrow) is in a correct position.

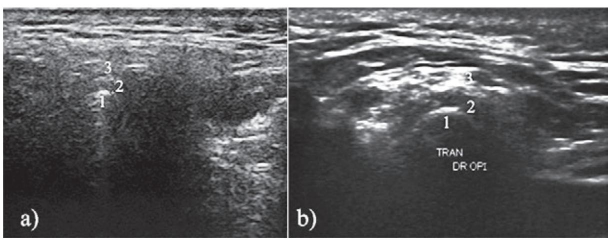

Fig 2. High-resolution US of an anterior disc displacement: mouth-closed (a), mouth-opened (b). 1 – mandibular condyle; 2 – articular disc, represented by a hyperechoic line, located anteriorly to the posterosuperior part of the articular eminence; 3 – articular eminence.

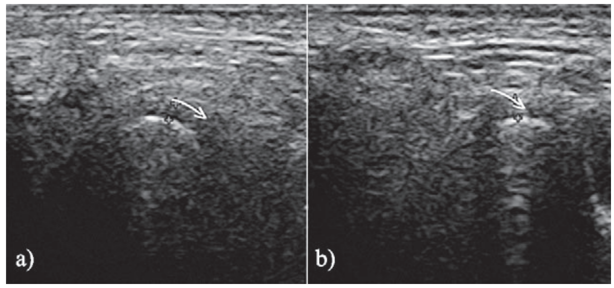

Fig 3. High-resolution US of an anterior disc displacement with reduction: mouth-closed (a), mouth-opened (b). The arrow shows the displaced disc at mouth-closed position which returns to its normal position at maximal mouth opening.

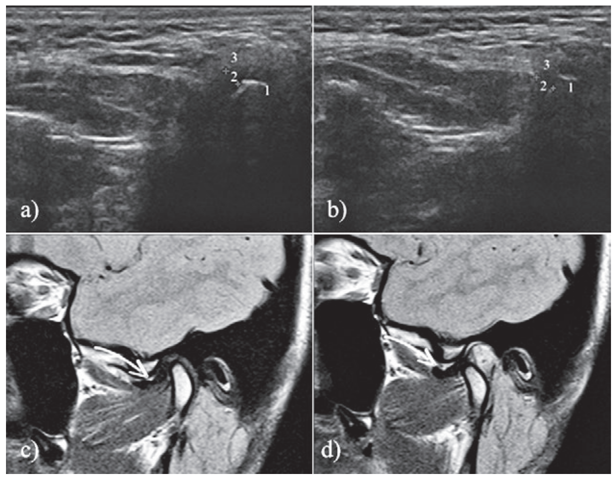

Fig 4. High-resolution US of an anterior disc displacement without reduction: mouth-closed (a), mouth-opened (b). 1 – mandibular condyle; 2 – articular disc, which is displaced anteriorly both at mouth-closed and mouth-opened position; 3 – articular eminence. Sagittal proton density MRI of the same patient with anterior disc displacement without reduction: mouth-closed (c), mouth-opened (d). Note the displaced disc (arrow) at mouth-closed that does not return to its normal position at maximal mouth opening.

MRI results. All the examinations were conducted in a dark room, with the patient in a supine position.

The probe was placed in the anatomical position of the TMJ, perpendicular to the zygomatic arch and parallel to the mandible ramus. Both transverse and longitudinal scans were performed. Once the transducer was placed in the right position and the TMJ was visualized, the probe was tilted out until the best view was obtained. Bilateral images were stored, both with the mouth closed and maximal mouth opening positions. During the examination also the dynamic movement of the disc was assessed.

At US examination, the non-displaced disc normally appears as a thin hyperechoic line surrounded by a hypoechoic halo (fig 1 a,b) [3]. In the closed-mouth position, the disc is placed between two hyperechoic lines, represented by the condylar surface and articular eminence (between the anterosuperior zone of the mandibular condyle and posterosuperior part of the articular eminence). If the disc is located anteriorly to the anatomical position, the aspect is interpreted as anterior disc displacement (fig 2a). Opened-mouth US examination reveals the normal position of the disc between the mandibular condyle and the articular eminence. Again, the anterior position of the disc is diagnosed as anterior disc displacement (fig 2b).

If the disc is anteriorly displaced when the mouth is closed and returns in the anatomical position when the mouth opens, the diagnosis is DDwR (fig 3). If the disc remains displaced at opened-mouth position, the US diagnosis is DDwoR (fig 4).

Magnetic resonance imaging

All MRI examinations were performed using 1.5 T MRI equipment (Siemens Avanto, Siemens, Erlangen). The MRI assessment was performed by a radiologist blinded on both clinical and US findings. Bilateral MR imaging of the TMJs were performed using the same protocol. The data were collected on a 205/256 matrix, with a field of view of 120 mm and a flip angle of 150 degrees. The MRI protocol included T2 weighted and proton density (PD) sequences in sagittal and coronal planes, using a 3 mm slice thickness with mouth closed and at maximal mouth opening (fig 1 c,d).

An axial localizing image was used to direct the long axis of the condyle in the closed-mouth position. Sagittal images were obtained perpendicular to the long axis of the condyle, and coronal images were obtained parallel to the long axis [17] (fig 4 c,d).

At MRI examination, a pathologic condition is considered to be present relative to the intermediate zone of the meniscus (as a point of reference) and its interposition between the condyle and the temporal bone [1]. Normal disc position, evaluated in the sagittal plane, is with the junction of posterior band aligned approximately at 12 o'clock, position relative to the condyle. Disc displacement was diagnosed when the posterior band was in an anterior, posterior, medial or lateral position with regard to the condylar surface [1-3,18].

Statistical analyses

Categorical data was presented as counts and percentages, while skewed continuous data was presented as median and range. We assessed the distribution and the normality of the data with quantile-quantile plots, strip charts and Kolmogorov-Smirnov tests. The diagnostic characteristics of the tests (sensitivity, specificity, positive and negative predictive values, accuracy and Youden index) were computed along with 95% confidence intervals (CI). We computed the exact binomial confidence limits for sensitivity, specificity and positive and negative predictive value. Positive and negative likelihood ratios were also assessed. All analyses were performed with R environment for statistical computing and graphics, version 3.2.3 [25].

Results

From 74 patients 60 patients were female; the age was between 13-69 years (median 29).

Clinical examination detected 64 (43.24%) normal joints, 45 (30.41%) with disc displacement with reduction, 30 (20.27%) with disc displacement without reduction and 10 (6.76%) with degenerative changes.

MRI depicted 68 (45.95%) normal joints, 47 (31.76%) with disc displacement with reduction, 33 (22.3%) with disc displacement without reduction and 34 (22.97%) with degenerative changes.

US detected 78 (52.7%) normal joints, 37 (25%) with disc displacement with reduction, 33 (22.3%) with disc displacement without reduction and 21 (14.19%) with degenerative changes.

The estimated sensitivity, specificity, accuracy, Youden index, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+) and negative likelihood ratio (LR-) of US compared to MRI are shown in table I.

The estimated sensitivity, specificity, accuracy, Youden index, PPV and NPV of clinical diagnosis compared to MRI are shown in table II.

Discussions

For an accurate diagnosis of internal TMJ disorders, the clinical examination is crucial, but not enough, therefore additional investigations are required. MRI is considered to be the reference standard in visualizing the soft tissue of TMJ [1-5]. US has been suggested by several studies as a useful diagnostic tool but the diagnostic value reported had contradictory results.

Not all clinically assessed disc displacements were confirmed by MRI. Articular joint sounds could be common among adult population and could represent a transient condition of TMJ [13].

We found a significant sensitivity, specificity and accuracy of high-resolution US in the diagnosis of disc displacements, but low sensitivity for degenerative changes, compared to MRI. US allowed a good visualization of the disc with mouth closed, but also during maximal mandibular range of motion. In some cases, where the overlying structures were very thick, the visualization of the disc was difficult, but by asking the patient to open and close the mouth several times, the disc could be visualized. Since the obtained specificity was slightly lower than sensitivity, further studies are recommended to reduce the proportion of false-positive interpretations.

A difficulty in our study, seen also in other papers [4], was to obtain high US quality images of TMJ, especially at mouth-opened position, due to the overlying bony structures. It was necessary to adjust continuously the transducer orientation in order to assess the correct disc position.

In 4 cases with disc displacements not diagnosed by US, the discs were medially displaced and in these conditions, the condyle did not allow the visualization of the disc. In other 5 cases, the disc displacements were minor and were not recognized by US. Our belief is that continuously training for interpretation of the US findings

Table I. High-resolution US findings compared to MRI findings

Statistical value	Disc displacement	Degenerative changes
Sensitivity %	93.1 (95 % CI 77.23-99.15)	38.24 (95 % CI 22.17-56.44)
Specificity %	87.88 (95 % CI 71.8-96.6)	92.98 (95 % CI 86.64-96.92)
PPV %	87.1 (95 % CI 70.17- 96.37)	61.9 (95 % CI 38.44-81.89)
NPV %	93.55 (95 % CI 78.58- 99.21)	83.46 (95 % CI 75.84-89.46)
LR +	7.68 (95% CI 3.05-19.35)	5.45 (95% CI 2.47 – 12.04)
LR –	0.08 (95% CI 0.02 – 0.3)	0.66 (95% CI 0.51 – 0.87)
Accuracy %	90.32 (95 % CI 80.12-96.37)	80.41 (95 % CI 73.09-86.47)
Youden index	0.81 (95 % CI 0.49-0.96)	0.31 (95 % CI 0.09-0.53)

PPV – positive predictive value, NPV – negative predictive value, LR+ positive likelihood ratio, LR – negative likelihood ratio, CI – confidence interval

Table II. Clinical findings compared to MRI findings

Statistical value	Disc displacement	Degenerative changes
Sensitivity %	82.5 (95% CI 72.38 – 90.09)	29.41 (95% CI 15.1 – 47.48)
Specificity %	86.76 (95% CI 76.36 – 93.77)	100 (95% CI 95.25 – 100)
PPV %	88 (95% CI 78.44 – 94.36)	100 (95% CI 58.72 – 100)
NPV %	80.82 (95% CI 69.92 – 89.1)	82.61 (95% CI 75.24 – 88.53)
Accuracy %	84.46 (95% CI 77.6 – 89.89)	83.78 (95% CI 76.84 – 89.33)
Youden index	0.69 (95% CI 0.49 – 0.84)	0.29 (95% CI 0.1 – 0.47)

PPV – positive predictive value, NPV – negative predictive value, CI – confidence interval

could lead to the diagnosis even of these minor disc displacements.

A review published in 2009 by Manfredini D et al [4] showed an accuracy of 54-100% for diagnosing disc displacement and 56-93% for degenerative changes and the authors concluded that US is a useful imaging technique, but a better standardization is required and normal parameters must be set. Another review published in 2013 by Kundu H et al [5] found a sensitivity ranging from 41% to 90% in the diagnosis of disc displacement.

The heterogeneous results of the reviews may be due to the fact that they depend on the skills of the examiner, on the equipment used (different US frequencies), and the difficulty of visualizing the articular disc because of the surrounded anatomical structures. In our study, the examiner has been experienced in head and neck ultrasound for 9 years and quality US equipment was used.

Jank et al [23] showed also a high sensitivity of 90%, specificity of 84% and accuracy of 88% for disc displacements, with patient at rest and suggested that US is suited to detect disc displacements. Habashi et al [3] found the estimated sensitivity, specificity and accuracy for diagnosis of disc displacement based on high-resolution ultrasonography to be 74.3%, 84.2% and 77.7%, respectively. It was concluded that ultrasonography is a potential imaging technique for the diagnosis of TMJ disc displacement. Another study developed by Emshoff et al [20] evaluated the sensitivity and specificity of US in TMD. In detecting the disc position, US had a sensitivity of 31% and a specificity of 95%.

Compared to these studies, we found better statistical parameters, probably due to the higher number of patients and the use of a better US equipment. Using high-resolution US (13 MHz in our study), the diagnostic efficacy of US in the diagnosis of TMJ disc displacement can be significantly increased.

In a previous prospective study, US yielded a sensitivity, specificity and an accuracy of 92% each, in the detection of disc displacements at closed-mouth position [21]. The same study design and inclusion criteria were used. Our results showed similar statistical values.

Landes et al [26] found a concordance of 83 % between US and MRI in the diagnosis of TMJ disc displacements. In their work, the US examination was performed with the patient in vertical position, which is different from the MRI position. This could influence assessing the correct position of the TMJ disc. In our study, both US and MRI were performed with the patient in a supine position.

One article published by Emshoff et al [27] calculated the intra-observer and inter-observer agreement of US in TMJ pathology. Intra-observer agreement ranged between 87-93% and inter-observer agreement ranged between 82-90%.

Some authors suggested the use of indirect signs for disc displacements, such as lateral capsule-condyle distance [5]. These measurements can only be used if the disc is displaced in an antero-lateral direction. According to different studies, antero-lateral disc displacement is less frequent than antero-medial disc displacement [13,15,17].

We have not compared our results with the studies that have used only static high-resolution US.

This study presents some limitations. One important limitation is that each imaging examination was performed by a single radiologist. No intra-observer and inter-observer agreement was done. Another limitation is that the accuracy of MRI (reference standard) is not 100%, therefore the statistical values obtained might be slightly different from the reality. Also, the results of both US and MRI are influenced by the examiner's experience.

In our opinion, the clinical examination is the most important step in the diagnosis of TMJ pathology. There is still no evidence when and which imaging technique should be indicated for TMD patients. We recommend the use of US when a disc displacement is clinically presumed because of its high diagnostic accuracy, low cost and accessibility. The new US techniques increase the capacity to detect the TMJ disc displacement.

US did not reach the diagnostic value of MRI, but it could be an acceptable alternative imaging technique in assessing the TMJ disc position and treatment follow up. The protocol we recommend, based on our results, is to first perform the clinical examination, then the US. If any uncertainty should arise at the US examination, MRI is the following option to be taken into consideration.

Conclusions

High-resolution US showed high sensitivity, specificity and accuracy in the diagnosis of TMJ disc displacement with or without reduction, compared to MRI. Based on our results, high-resolution US can be considered a helpful diagnostic tool in assessing TMJ disc position. The diagnostic value of high-resolution ultrasonography depends strictly on the examiner's skills and on the equipment used and must be always correlated with the clinical findings.

Conflict of interest: none

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