Assessment of articular disc displacement of temporomandibular joint with ultrasound

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Abstract

Purpose To assess pattern of articular disc displacement in patients with internal derangement (ID) of temporomandibular joint (TMJ) with ultrasound.

Materials and methods Prospective study was conducted upon 40 TMJ of 20 patients (3 male, 17 female with mean age of 26.1 years) with ID of TMJ. They underwent high-resolution ultrasound and MR imaging of TMJ. The MR images were used as the gold standard for calculating sensitivity, specificity, accuracy, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (PLR), and negative likelihood ratio (NLR) of ultrasound for diagnosis of anterior or sideways displacement of the disc.

Results The anterior displaced disc was seen in 26 joints at MR and 22 joints at ultrasound. The diagnostic efficacy of ultrasound for anterior displacement has sensitivity of 79.3 %, specificity of 72.7 %, accuracy of 77.5 %, PPV of 88.5 %, NPV of 57.1 %, PLR of 2.9 and NLR of 0.34. The sideways displacement of disc was seen in four joints at MR and three joints at ultrasound. The diagnostic efficacy of ultrasound for sideways displacement has a sensitivity of 75 %, specificity of 63.6 %, accuracy of 66.7 %, PPV of 42.8, NPV of 87.5 %, PLR of 2.06, and NLR of 0.39.

Conclusion We concluded that ultrasound is a non-invasive imaging modality used for assessment of anterior and

sideways displacement of the articular disc in patients with ID of TMJ.

Keywords Ultrasound · Temporomandibular · Disc · Displacement

Riassunto

Scopo Valutare i pattern della dislocazione del disco articolare nei pazienti con squilibrio interno (ID) dell'articolazione temporo-mandibolare (ATM) con l'ecografia.

Materiale e metodi E' stato condotto uno studio prospettico su 40 ATM di 20 pazienti (3 maschi, 17 femmine, con età media di 26,1 anni) con ID della TMJ. Tutti sono stati sottoposti ad ecografia ad alta risoluzione e RM della TMJ. La RM è stata utilizzata come il gold standard per il calcolo di sensibilità, specificità, accuratezza, valore predittivo positivo (PPV), valore predittivo negativo (NPV), rapporto di probabilità positivo (PLR) e rapporto di probabilità negativo (NLR) dell'ecografia nella diagnosi di dislocazione anteriore o lateralmente del disco.

Risultati Il disco appariva dislocato anteriormente in 26 ATM con la MR e in 22 con l'ecografia. L'efficacia diagnostica dell'ecografia nella diagnosi di dislocazione anteriore aveva sensibilità del 79,3 %, specificità del 72,7 %, accuratezza del 77,5 %, valore predittivo positivo del 88,5 %, NPV di 57,1 %, PLR di 2,9 e NLR di 0,34. Il dislocamento laterale del disco è stato osservato in 4 casi con MR e 3 con ecografia. L'efficacia diagnostica dell'ecografia per lo spostamento laterale aveva sensibilità del 75 %, specificità del 63,6 %, accuratezza del 66,7 %, PPV di 42,8, NPV di 87,5 %, PLR di 2.06 e NLR di 0,39.

Conclusioni Abbiamo concluso che l'ecografia è una metodica di imaging non invasiva che può essere utilizzata per la valutazione delle dislocazioni anteriori e laterali del disco articolare nei pazienti con ID di TMJ.

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Introduction

Internal derangement (ID) of the temporomandibular joint (TMJ) is defined as displaced disc that interferes with smooth joint movement and causes some types of dysfunction to the individual. The displaced disc is commonly anterior; however, sideways displacement has been reported [1, 2]. MR imaging is the most accurate imaging modality for accurate localization of disc position and its pattern of displacement and considered as the gold standard for assessment of TMJ but it is expensive, not readily available [3–6].

Sideway displacement of disc of TMJ is a painful process and an exact diagnosis is required for a successful therapy, either by conservative treatment or by surgery. Sideway displacement is commonly associated with variable degree of anterior disc displacement and it is therefore classified as either antero-medial or anterolateral displacement. Few studies have been discussing the value of MR imaging at coronal plane in diagnosis of sideways displacement of TMJ [7–10].

Ultrasound was used in assessment of different joints of the body such as hip and knee joints [11–13]. High-resolution ultrasound was used for assessment of the anterior disc displacement of TMJ [14–28]. All these studies discuss the anterior displacement of the TMJ without assessment of sideways displacement of the disc.

The aim of this work was to assess pattern of articular disc displacement in patients with ID of TMJ with ultrasound.

Patients and methods

A prospective study conducted on 22 consecutive patients presented with ID of TMJ according to the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) classification [29] was included in the study. Two patients excluded from the study due to claustrophobia from MR imaging. The final patients included in this study were 20 patients (3 male and 17 female, age ranged from 15 to 57 years; mean age 26.1 years). They presented with facial pain ($n = 22$), clicking ($n = 20$), restricted lateral movement ($n = 12$), deviated mandibular movement ($n = 5$), and crepitus ($n = 3$). All patients underwent ultrasound examination and MR imaging of TMJ. We obtained institutional board approval and informed consent obtained from the patients.

Ultrasound examination was performed by one radiologist expert in head and neck imaging since 20 years (AA). Ultrasound examination carried out at Xario (Power vision 6000; Toshiba, Japan) with a real-time linear array high-frequency (12 MHz) transducer. The ultrasound examination was performed in longitudinal scan at maximum

mouth opening position and in the transverse scan at the closed-mouth position. The probe placed over the TMJ perpendicular to the zygomatic arch and parallel to the mandibular ramus and tilted out until the best visualization of the articular disc achieved.

All MR images were obtained using a 1.5-T scanner (Symphony; Siemens AG Medical systems, Forchheim, Germany) using a 3-in.-diameter bilateral TMJ surface coil. MR imaging was performed in the sagittal and coronal planes. T1-weighted images were obtained in closed- and open-mouth positions (TR/TE of 600/15 ms). In the coronal plane, T1-weighted images were obtained in the closed-mouth position (TR/TE of 800/15 ms). All images were obtained with a section thickness of 3 mm an inter-slice gap of 1 mm, one excitation, a field-of-view of 12–14 cm and an acquisition matrix of 256×224 .

On ultrasound images, the condylar surface and articular eminence appeared as hyper-echogenic lines, while the articular disc identified as a thin hypo-echogenic band between the two lines. The relationship between the articular disc and the condyle assessed. The disc position classified into normal when anterior border of the disc located superior to the condyle, anteriorly displaced when the anterior border of the disc presents anterior to the condyle, medially displaced when the disc boundary shifted medial to boundary of the condyle, laterally displaced when the disc boundary shifted lateral in comparison to the boundary of the condyle. On MR imaging, the normal and displaced disc position categorized according to previous criteria [30].

The statistical analysis of data was done using Statistical Package for Social Science version 20 (SPSS Inc., Chicago, Ill, USA). Qualitative variables presented as number and percent. Sensitivity, specificity, accuracy, positive predictive value (PPV), negative predictive value (NPV), positive Likelihood ratio (PLR) and negative Likelihood ratio (NLR) of ultrasound for assessment of disc displacement of TMJ were calculated.

Results

MR imaging depicted a normal disc position in 10 joints (25 %), anterior disc displacement in 26 joints (65 %), and sideways disc displacement in 4 joints (10 %). Ultrasound showed normal disc position in 15 joints (37.5 %), anterior disc displacement in 22 joints (55 %) and sideways displacement in 3 patients (7.5 %) (Table 1).

At MR imaging, 26 articular discs diagnosed as anteriorly displaced. Ultrasound revealed anterior displacement of 22 joints (Fig. 1) and missed anterior displacement of 4 joints. Ultrasound revealed sensitivity of 79.3 %, specificity of 72.7 %, PPV and NPV were, respectively, 88.5 and

Table 1 Direction of disc displacement of TMJ at MR and ultrasound

Disc position	MR (%)	Ultrasound (%)
Anterior displacement	26 (65)	22 (55)
Antero-medial displacement	3 (7.5)	2 (5)
Anterolateral displacement	1 (2.5)	1 (2.5)
Normal position	10 (25)	12 (30)

Fig. 1 Anterior disc displacement of TMJ. **a** Longitudinal sonogram obtained in maximal open-mouth position shows anterior displacement of hypo-echoic disc (*arrow*) in relation to hyper-echogenic band of mandibular condyle. **b** Sagittal MR imaging in open-mouth position shows disc (*arrow*) superior to condyle

57.1 % and the overall accuracy was 77.5 %. Positive and negative likelihood ratios were, respectively, 2.9 and 0.3 with a *P* value of 0.64 at closed-mouth position.

At MR imaging, four discs were diagnosed as sideways displacement at coronal T1-weighted images and at

Fig. 2 Sideways disc displacement of TMJ. **a** Transverse sonogram obtained in open-mouth position shows lateral shift of the hypo-echoic disc (*arrow*) in relation to the hyper-echogenic condyle of the mandible. **b** Coronal MR image in closed-mouth position shows the disc (*arrow*) lateral to the condyle

ultrasound three discs were diagnosed as sideways displacement (Fig. 2). The sideways displacement on MR imaging was antero-medial disc displacement in two joints (5 %) and anterolateral disc displacement in another two joints (5 %). The ultrasound missed sideways displacement in one joint. On ultrasound, the displacement was antero-medial disc displacement in two joints (5 %) and anterolateral disc displacement in another only one joint (2.5 %). The diagnostic efficacy of ultrasonography for assessment of sideways displacement of the disc has a sensitivity of 75 %, specificity of 63.6 %, overall accuracy

of 66.7 %, PPV of 42.8 %, NPV of 87.5 %, and NLR of 0.39 with a *P* value of 0.8.

Discussion

In this study, high-resolution ultrasound examination is an accurate method for the detection of normal articular disc. The normal disc appeared as hypo-echogenic band between the hyper-echogenic bands of the mandibular condyle and the articular eminence. Few studies reported that ultrasound differentiate between the articular disc and capsule, and the two hyper-echogenic lines are related to the condylar head and articular eminence cortices and the hypo-echoic area between them produced by the articular disc [26, 28]. Other studies added that the disc was surrounded by hard tissues of the condyle and temporal bone. Therefore, significant difference exists in the acoustic properties of the disc and its surrounding structures, resulting in a considerable reflection of ultrasound waves and formation of sharp image [11–14].

In this study, ultrasound is an effective method for diagnosis of anterior displacement of the articular disc. Several studies discuss the role of ultrasound in assessment of anterior disc displacement [14–18]. Meta-analysis of diagnosis efficacy of ultrasound in assessment of anterior disc displacement reported that diagnostic efficacy of disc displacement with reduction had a sensitivity of 0.76, a specificity of 0.82, a positive likelihood ratio of 3.80, a negative likelihood ratio of 0.36, a diagnostic odds ratio of 10.95, an area under the curve of 0.83, and a *Q** of 0.76. They added that the detected results were not influenced by the types of ultrasonography, image dimensions, types of transducer, and ultrasonic image of the disc (*P* = 0.05) [15].

In this study, sideways displacement was detected in 10 %. Previous studies reported that the incidence of sideways displacement is rare (4 %) because the medial and lateral surfaces of the articular disc are firmly supported by their ligaments [6]. The difference in the results was attributed to different machine and difference experience of the sonographer as well as different and small number of patients in this study.

Anterolateral displacement probably related to the weakness either lax or completely torn of the lateral disc attachment. The lateral capsular attachment easily stretched due to high pressures focuses on the lateral attachment during chewing. The disc displaced antero-medially because of the vector of pull of lateral pterygoid muscle. In this study, there are two cases with antero-medial displacement and one patient with anterolateral displacement.

Few studies described that the coronal plane of MR imaging is the ideal plane for assessment of the integrity of

the congruency of the disc in the medial–lateral dimension and detection of sideways displacement [7–10]. In this work, coronal section of MR as transverse section at ultrasound in the opened mouth is the best plane for assessment of the sideways displacement.

In the present study, MR imaging diagnosed four patients with sideways displacement and ultrasound diagnosed three patients with sideways displacement were detected in 10 % of joints at MR imaging. However, only 7.5 % was detected on ultrasound. One of the major shortcomings of US is the insufficiency of the technique to detect disc displacements laterally or medially.

In the present study, one patient with side way displacement misdiagnosed at axial section of ultrasound examination and well presented at coronal section of MR imaging. This attributed to the presence of overlying soft tissue in the medial aspect of the joint space that may interfere with ultrasound beam for better detection of the medial aspect of the disc.

In this study, we used high-frequency probe for ultrasound examination (12 MHz) of the articular disc of TMJ. Applications of higher frequency ultrasound probe (18 MHz) and advancements in ultrasound probe technology continue; more detailed imaging and improvement in tissue differentiation will improve the image quality and may contribute to a better diagnosis [11–14]. Application of three-dimensional ultrasound examinations [31] increases the diagnostic validity of ultrasound in diagnosis of sideways as well as the anterior disc displacement and improves the relationship of the articular disc with bony condyles.

There are few limitations to this study. First, the patient population studied is small. Further studies upon large sample of patients to confirm results were recommended. Second, there is no analysis of associated changes in the retro-discal soft tissue, lateral pterygoid muscles and articular bony surfaces at ultrasound examination. Further studies were recommended for assessment of associated soft tissue and bony changes in patients with sideways displacement of patients with ID of TMJ.

Conclusion

We concluded that ultrasound is a non-invasive imaging modality used for assessment of anterior and sideways displacement of the articular disc in patients with ID of TMJ.

Conflict of interest The authors (Abdel Razek A, Al Belasy F, Ahmed W, Haggag M) have no conflict of interest.

Informed consent All procedures followed were in accordance with the ethical standards of the responsible committee on human

experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). All patients provided written informed consent to enrolment in the study and to the inclusion in this article of information that could potentially lead to their identification.

Human and animal studies The study conducted in accordance with all institutional and national guidelines for the care and use of laboratory animals.

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