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Ultrasound Imaging of Temporomandibular Joint Disorder - Review

Dr. M. Shanthi

Department of Oral Medicine and Radiology, SRM Kattankulathur Dental College and Hospital,
SRM University, Potheri, Tamil Nadu, India

Abstract: ***The temporomandibular joint is a ginglyoarthrodial joint where ginglyo represents hinging movement and arthrodial is gliding movement.[1] Plain-film radiography and tomography are basic hard tissue imaging techniques for assessment of the TMJ; however, in patients with TMJ symptoms, evaluation of the soft tissues is frequently necessary, but these techniques are rarely definitive. With the development of other modalities such as arthrography, CT, MRI and, most recently, ultrasound, the understanding of the anatomy and the diagnosis of the TMJ disorders has been improved.[2] Ultrasound is defined as sound wave having a frequency greater than 20 kHz (acoustic = 20-20, 000 Hz). Two primary forms of ultrasound include diagnostic and therapeutic. Diagnostic. This technique allows evaluation of all the components of the TMJ: the condylar head, the glenoid fossa of the temporal bone, the disc, the joint capsule, the articular ligaments and the insertions of tendons.[3] This review will be compiling the various role of ultrasonography in various temporomandibular joint disorders.***

Keywords: US-Ultrasound, HR-US-High resolution ultrasound, ID-Internal derangement, JIA- Juvenile idiopathic arthritis, DDWR-Disk displacement with reduction, DDWOR-Disk displacement without reduction, DC-Degenerative changes.

1. Introduction

TMJ ultrasonography is a non-invasive, readily available and relatively cheap dynamic "real time" examination, featuring soft joint tissues. The first reports of TMJ sonography date back to year 2000. It uses currently available types of ultrasonic equipment with a linear scanning transducer of 7.5–12 MHz frequency, which makes it possible to depict the narrow space of the jaw joint and the position of the joint disc and it reveals fluid or ligament adhesion. [47]The joint disc is scanned on the screen as a thin homogenous hypo, as far as the iso echo strip contiguous to the condyle border. The condyle bone borders and articular eminence show as a hyper echo line. During the examination it is possible to directly observe the joint disc move when the mouth is opening and closing. Studies comparing the results of MRI and sonography showed 70–85 % agreement. An ultrasonographic system using the high frequency and conveyors with a large diameter has been recently invented. The sonographic waves, generated by this system, are able to penetrate easily through the small aperture between the glenoid fossa and the condyle.

1.1 Normal Sonographic Features of Temporomandibular Joint.[43, 12, 18, 33, 35, 41]

Esther Goldenberg Birmansome et al carried out study with the purpose of establishing ultrasonographic criteria that could be used for diagnosing disc displacement. Most studies were based on the identification of the disc and its position relative to the condyle found difficulty in observing the disc itself in all the exams accomplished by them, suggesting that the position of that structure should be evaluated by other anatomical landmarks, independently of its direct visualization. These landmarks, as seen in the sonograms, have been considered as indirect ultrasonographic signs of the disc position.

Landes *et al.* (2000), Hayashi *et al.* (2001) proposed an indirect sign to evaluate the anterolateral position of the disc, which was the distance between the articular capsule and the lateral surface of the mandibular condyle.[42] During TMJ ultrasonographic examination, they concluded that the measurement of the distance between the most lateral point of the articular capsule and the most lateral point of the mandibular condyle (lateral capsule-condyle distance) can be used to assess the lateral position of the disc, whereas the measurement of the distance between the most anterior point of the TMJ capsule and the most anterior point of the mandibular condyle (anterior capsule-condyle distance) can be used to assess the anterior position of the disc. The normal values for these distances obtained in the present study can be used in future studies as normal reference values.

li jen liao et al [41] conducted study to measure the width of the temporomandibular (TM) joint capsule and the thickness of the masseter muscle with total of 84 joints were included. The mean (± standard deviation) TM joint capsular width was 1.9 ± 0.4 mm; MM thickness at rest was 9.0 ± 1.9 mm; and MM thickness during occlusion on maximal force was 11.8 ± 2.8 mm with an increased ratio of 33 ± 25%. No significant differences were found with regard to the laterality in TM joint capsular width. The use of ultrasound technology for imaging the temporomandibular joint does appear promising. The technique is relatively easy, it provides real-time dynamic imaging that may be recorded and studied at a later time, it is noninvasive, and it does not interfere with normal function.

1.2 Sonographic Imaging of Temporomandibular Joint Disorders

1.2.1 Internal Derangement [39, 40, 41]

Internal derangements of the TMJ represent a spectrum of progressive pathologic alterations due to abnormal disc-condylar function. It arises from breakdown of the normal rotational function of the disc on the condyle. **Sujatha et al**

conducted study on a Patients with pain, clicking, deviation, and tenderness were included in the study as a symptomatic group.. Maximum mandibular range of motion (Open and Closed) was performed during High Resolution Ultrasound of TMJ in 100 consecutive patients, (50 symptomatic and 50 asymptomatic cases, a total of 400 joints, with 200 joints in the right and left closed and open mouth position;36 males and 64 females; age range, 16 - 50 years; mean age 27.56 years Sonography confirmed the diagnosis by showing internal derangement in 34 (68%) of the symptomatic group and the remaining 16 (32%) patients failed to show any derangement. The results obtained showed a sensitivity of 64%, specificity of 88%, positive predictive value of 84%, and a negative predictive value of 71%, with an accuracy of 76%.

Brandlmaier et al, used 12·5 MHz ultrasonography (US) to assess the presence or absence of temporomandibular joint (TMJ) internal derangement (ID). In 48 consecutive patients with TMJ disorders they found that US showing a sensitivity of 0·58 and 0·75, and a specificity of 0·92 and 0·84 for disc displacement with and without reduction, the data revealed US to be marginal in detecting the presence, but sensitive in detecting the absence of the respective types of a TMJ ID detecting the absence of the respective types of a TMJ ID. In addition, with a positive predictive value of 0·83 and 0·71, and a negative predictive value of 0·81 and 0·87 for disc displacement with and without reduction, the results indicate that US may be insufficient in establishing a correct diagnosis for the presence or absence of the respective types of TMJ ID.

Carlos Fernando de Mello Junior et al conducted study and found that the sensitivity and specificity of high-resolution ultrasonography in the assessment of intracapsular temporomandibular disorders. The authors have studied 38 patients (76 joints) with complaint of temporomandibular disorder. All the patients underwent ultrasonography and magnetic resonance imaging and the results were compared. Among 24 joints demonstrating disc displacement at magnetic resonance imaging of patients at rest, 7 were confirmed at ultrasonography; in, the discs could not be visualized; and in 4, no sonographic abnormality was observed. In 48 joints, the articular discs could not be visualized at ultrasonography of patients at rest. Among them, 41 exhibited normal positioning at magnetic resonance imaging, and 7 exhibited anterior disc displacement. Morphological changes of the mandibular condyle were visualized in 13 joints at magnetic resonance imaging, and in 2 at ultrasonography. The authors concluded that ultrasonography offers high sensitivity and specificity in the diagnosis of the articular disc location with the patient at rest, either to analyze anatomical position or to analyze disc displacement. On the other hand, it does not offer significant results to analyze articular discs in patients with open mouth as well as to analyze disc/condyle morphological changes.

Juvenile Idiopathic Arthritis [39, 40]

Juvenile idiopathic arthritis (JIA) is a term that indicates a childhood disease characterized primarily by arthritis persisting for at least 6 week. **Siegfried Jank et al** made a significant correlation between duration of rheumatoid arthritis and clinical symptoms of TMD. The study demonstrated a correlation between the duration of JIA and destructive changes of the TMJ and disc dislocation in the maximum open-mouth position. These results imply that high-resolution US could be used as a screening method for the evaluation of the TMJ in patients with JIA.

Melchiorre *et al*. have found it useful for the diagnosis of TMJ pathology in adult patients with RA. In a study with JIA patients**, Jank *et al***. found that high-resolution US was able to detect TMJ pathology before clinical symptoms appeared. **Weiss *et al***. who compared US and MRI in children with newly diagnosed JIA

Chronic Polyarthritis [30, 37, 39, 40]

Zanger et al conducted a study in 40 patients with chronic polyarthritis. High resolution ultrasound (HR-US) assessed destructive changes, effusion, and disc dislocation. The results of the clinical investigation and the HR-US investigation were compared using the χ^2 test. The statistical calculation of the correlation between the HR-US results and the clinical TMJ investigation by the χ^2 test showed a significant correlation between TMJ sounds, destructive changes and disc dislocation. A significant correlation between TMJ joint effusion, TMJ pathology and TMJ pain was detected using the χ^2 test.

Internal Disorders of TMJ [33]

Carlos Fernando de Mello Junior et al evaluated the sensitivity and specificity of high-resolution ultrasonography in the assessment of intracapsular temporomandibular disorders. The authors have studied 38 patients (76 joints) with complaint of temporomandibular disorder. All the patients underwent ultrasonography and magnetic resonance imaging results were compared. Among 24 joints demonstrating disc displacement at magnetic resonance imaging of patients at rest, 7 were confirmed at ultrasonography; in 13, the discs could not be visualized; and in 4, no sonographic abnormality was observed. In 48 joints, the articular discs could not be visualized at ultrasonography of patients at rest. Among them, 41 exhibited normal positioning at magnetic resonance imaging, and 7 exhibited anterior disc displacement. Morphological changes of the mandibular condyle were visualized in 13 joints at magnetic resonance imaging, and in 2 at ultrasonography.

Masticatory muscle disorders [53]

Yoshiko Ariji conducted study to examine ultrasonographic appearances in female patients with temporomandibular disorder (TMD) associated with myofascial pain in comparison with healthy volunteers. The thickness of the masseter muscle in 25 female patients with TMD was measured at rest and at maximum contraction using ultrasonography. The visibility and width of the internal echogenic bands of the masseter muscle were also assessed and the muscle appearance was classified as 1 of 3 types: type I, characterized by the clear visibility of the fine bands; type II, thickening and weakened echo-intensity of the bands; type III, disappearance or reduction in number of the bands. There were significant differences in the thickness at rest and the increase ratio by contraction between the patient and control groups. The distribution of muscle types showed a significant difference between the 2 groups. The

ultrasonographic features of the masseter muscle in TMD patients with myofascial pain were clarified and they might be related to muscle edema.

Osteoarthrosis [17]

According to **Brandlmaier and S. Bertram et al** a study was designed to study was to determine whether 12·5 MHz ultrasonography (US) could be used to assess the presence or absence of temporomandibular joint (TMJ) condylar osteoarthrosis. In 40 consecutive patients with TMJ disorders, 80 TMJs were investigated by US to analyse the condylar morphology.. With US showing a sensitivity of 87%, and a specificity of 20%, the data revealed US to be sensitive in detecting the presence, but insufficient in detecting the absence of osteoarthrosis. In addition, with a positive predictive value of 88%, and a negative predictive value of 18%, the results indicate that US may be valuable in diagnosing the presence, but insufficient in diagnosing the absence of osteoarthrosis..

Temporomandibular joint disc displacement with reduction [36, 37]

According to **Swaroop Telkar and Mubeen K. Khan** study was to evaluated to find out the effect of occlusal splint therapy by determining the cross-sectional dimension of masseter muscle using ultrasound in patients with temporomandibular joint disc displacement with reduction. Twenty-seven patients aged between 20 and 40 years were included in the study. A detailed history was obtained, and a comprehensive clinical examination was carried out.) Ultrasonographic measurements of the masseter muscle in patients with temporomandibular joint disc displacement with reduction can be a useful tool to assess the effectiveness of occlusal splint therapy. Such conservative measures can significantly reduce masticatory muscle tenderness, especially of the temporalis and masseter.

Efficacy of Ultrasound in Temporomandibular Joint [35, 39]

Emshoff *et al* were the first to compare ultrasonography diagnosis with that of MRI of the TMJs. They used a MHz transducer positioned horizontally; consequently, the images obtained were in the transverse plane, and evaluated the TMJs by both static and dynamic ultrasonography. They reported a low sensitivity of the procedure, but a high specificity, especially in the dynamic evaluation (95-100%), which can suggest ultrasonography in the identification of normal disc position in patients with signs and symptoms of TMJ disorders.

Another study by **Emshoff *et al*** improved the values of sensitivity, specificity and accuracy of the exam to 90-96%, 94- 91%, and 91-93% respectively, at closed-mouth and maximum- mouth opening positions. **Landes *et al*** suggested the use of ultrasonography for measurement of mandibular range of motion obtaining 83% agreement with axiographic results. They also reached values of sensitivity, specificity and accuracy close to 90% for the diagnosis of disc displacement with reduction (DDWR), compared to MRI, using both horizontal and vertical positioning of the transducer.

In 2001, **Jank *et al*** introduced the use of a high resolution transducer of 12 MHz to better visualize the TMJ structures. Differently from most of the previous reports, where the disc was described as hyperechoic, the authors considered it as a hypoechoic structure in the glenoid fossa surrounded by a hyperechoic rim. Their results, comparing ultrasonography diagnoses with diagnoses based on MRI, achieved a sensitivity, specificity and accuracy at closed-mouth position of 78%, and a sensitivity, specificity and accuracy of 61%, 88% and 77%, respectively, at maximum-mouth opening position.

7.5 Mhz transducer, was used by **Uysal *et al*** who found perfect agreement between MRI and ultrasonography diagnoses. **Brandlmaier *et al*** confirmed the diagnostic value of ultrasonography to detect the absence, but not the presence of ID of the TMJ, because of its high specificity and lower sensitivity for the diagnosis of DDWR and DDWOR, and the low reliability of the procedure in the diagnosis of osteoarthrosis, in agreement with a previous study. **Tognini *et al*** assumed the presence of joint effusion when the distance between the lateral pole of the condyle and the lateral part of the articular capsule was greater than 3 mm, while **Manfredini *et al,*** in another study, used a cut-off value of 2 mm. **Melchiorre *et al*** described levels of sensitivity, specificity and accuracy for the diagnosis of disc-related diagnoses (including displacement, structural and morphological changes) that were very low: 69.6%, 30% and 57.6% respectively, despite the fact that they performed a static and dynamic assessment of the TMJ.. **Jank *et al,*** reported that using the high-resolution transducer, reached very high levels of accuracy both in the evaluation of disc displacement (DD), joint effusion and degenerative changes (DC) of the TMJ.. According to the **Landes *et al*** using a 3-D ultrasonography for the diagnosis of DC of the condyle and the articular eminence, disc degeneration, and DD.

Limitation of Ultrasound in TMJ [12, 13, 34, 35, 38, 39, 40]

Limits to the use of ultrasonography for the diagnosis of TMJ disorders are related to the difficulty in the visualization of the articular disc, that is allowed only through the small gap between the zygomatic process of the temporal bone (above) and the head of the condyle (below). It is very difficult to obtain satisfactory images especially when the condyle rotates and translates from the mouth-closed position to the mouth-open position.

Another limitation can be represented by the difficulty of interpreting the images which are blurred and not clear; therefore the need of well trained and calibrated operators can be important to obtain reliable results.

2. Summary and Conclusion

TMJ ultrasonography is a non-invasive, readily available and relatively cheap dynamic “real time” examination. It is commonly used in many branches of medicine and applied even in diagnosing functional temporomandibular defects. Its great advantage mainly consists in the possibility of depicting dynamic joint structures, particularly the condyle line and the joint disc position.The various diseases such as Masticatory muscle disorders, Temporomandibular Joint

Disorders, Chronic Mandibular Hypomobility can be analysed with the help of ultrasound.

The specificity and sensitivity of temporomandibular joint in ultrasound is high. It is considered the main diagnostic approach, apart from the various higher imaging modality.

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