Assessment of TMJ Disorders Using Ultrasonography as a Diagnostic Tool: A Review

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ABSTRACT

Temporomandibular disorders affect nearly 10-70% of population. Hence, a proper diagnosis of temporomandibular disorders using appropriate diagnostic aids is required. Thus, the purpose of this review was to check the use of ultrasonography as a diagnostic aid in the detection of TMJ disorders. A literature review was performed in Pub Med Central and Cochrane library using Mesh Terms – 'ultrasonography' and 'TMJ disorders'. Out of the total 113 titles appeared, 38 were related to the research question. Further search criteria were applied to the articles, out of which 11 articles fulfilled the criteria and were selected for the review. Two articles which were hand searched were also included. Sensitivity of ultrasonography in detecting TMJ disorders in a majority of articles ranged from 41%-90% in disc displacement, when MRI was taken as the gold standard. In case of TMJ Effusion and Condylar effusion, sensitivities ranged from 20-80% and 83% respectively. It was also seen that sensitivity increased with increase in frequency of transducer. In the available literature, it was found that ultrasonography was an acceptable diagnostic tool for detection of disc displacement, condylar erosion and articular effusion.

Keywords: Ultrasonography, Temporomandibular joint disorders, Magnetic resonance imaging, Articular disc

INTRODUCTION

Temporomandibular Joint diseases (TMD) and disorders refer to a complex and poorly understood set of conditions, manifested by pain in the area of the jaw and associated muscles and limitations in the ability to make the normal movements of speech, facial expression, eating, chewing, and swallowing [1]. According to the Clinical Diagnostic Criteria for Temporomandibular Joint Disorders (CDC/TMD) scale; the most important symptoms of TMD are clicking, crepitation and reduction or closed lock of mouth opening movements [2-4]. These disorders affect the quality of life, having a prevalence of 10% to 70% in the population [5]. Clinical studies usually report a greater incidence of TMJ dysfunction in females, especially in women who are 20 to 40-year-old [5,6].

The proper management of the patients suffering from TMJ disorders begins with a thorough diagnosis [7]. Along with the clinical examination, imaging the TMJ is necessary to confirm the disorder suspected by the physician and to decide on the best form of management [8,9]. The most commonly used imaging methods include Computed Tomography, Arthrography and Magnetic Resonance imaging (MRI). MRI is described as the gold standard in the literature [9-13]. Despite its many advantages, it suffers certain drawbacks, being expensive, having necessity of advanced equipment, longer time needed to use it for TMJ images, its restricted use in patients with claustrophobia, pacemakers and metallic prosthesis [14].

Visualization of the TMJ and disc with USI was first reported by Nabeih and Speculand with a 3.5-MHz transducer in 1991 [15] and in 1992, Stefanoff et al., evaluated the TMJ disc in asymptomatic volunteers with a 5-MHz transducer and reported successful results [16].

Since 1992, ultrasonography has been suggested as an alternative diagnostic method in the imaging of TMJ disorders, because it is less expensive, it does not require special facilities and thus, it can be easily used in a dental setting. Also, it can be used to view the joint in a continuum without invasion, discomfort, alteration of the patient's normal head posture, or interference with condylar motion [17,18].

High Resolution ultrasonography (HR-US) has shown better results. A great advantage of HR-US is that the investigation can be performed as well "real-time", which means that the articular disc can be viewed during the mouth opening movement. This view of moving could help the investigator to detect its position more clearly than in a static investigation [9,19].

Study of Bas et al., has shown that USI provided a sensitivity of 69% in the detection of internal derangements, while high resolution ultrasonography (HR-US) showed a sensitivity between 65-95% in the determination of TMJ disorders [20-23].

Principle

The principle of ultrasonography is based on the fact that ultrasonic sound waves emitted by a device (transducer), travel through TMJ, and are partly reflected on transiting through dissimilar anatomical structures. The reflected sound waves are then read by the same emitting device and are translated into images [24,25].

Interpretation of Ultrasonography in Assessment of Tmj Disorders

The TMJ region consists of several diverse structures that reflect sound waves differently. Bone tissue, represented by the head of the condyle and the articular eminence, is generally hypoechoic (low reflection of sound waves) and it appears black in ultrasonography images; however, the margin of the bone is hyperechoic (high reflection of sound waves) and it appears white in ultrasonography images. The connective tissues, represented by the joint capsule and the retrodiscal tissue and muscular tissue, represented by the lateral pterygoid and masseter muscles, are isoechoic (intermediate reflection of sound waves) and they appear heterogeneously grey in ultrasonography images. However, the surface of the joint capsule, as well as the surface of muscles, highly reflect the sound waves, thus generating a hyperechoic (white) line. Empty space and water, like the superior and inferior joint spaces, are hypoechoic and they appear black in ultrasonographic images. However, these anatomic cavities are virtual, because the opposing surfaces are in contact and are usually not detectable, unless an effusion is present [25].

The difficulty in visualizing the TMJ using ultrasound contributes to

the limited accessibility of the deep structures, especially the disc, due to the absorption of sound waves by the lateral portion of the head of the condyle and the zygomatic process of the temporal bone [26].

On the sonogram, the disk is visualized as a thin homogenous, hypo-to-isoechoic band. The bony landmark of the mandibular condyle and the articular eminence are visualized as hyperdense lines.

In evaluating the findings of the closed mouth position, the position of the disk is considered to be normal if the intermediate zone of the disk is located between the anterosuperior aspect of the mandibular condyle and the posteroinferior aspect of the articular eminence. Disks with the intermediate zone located anterior to this position are considered to be displaced in anterior direction (internal derangement).

In evaluating the findings of the open mouth, the position of the disk is considered to be normal if the intermediate zone of the disk is located between the condyle and the articular eminence. If the disk was displaced in anterior direction, then it is considered to be an internal derangement.

Joint effusions can be detected indirectly by measuring the distance between the two articular surfaces/ capsular width [21,25,27].

MATERIAL AND METHODS

Search criteria

Inclusion criteria

i   Studies evaluating the use of ultrasonography in the diagnosis of TMJ disorders were undertaken.

ii   TMJ disorders which were selected in the review were disc displacement, internal derangement, condylar erosion and joint effusion.

iii Use of MRI as a gold-standard.

iv   Inclusion of sensitivity, specificity, accuracy, positive predictive value and negative predictive value as outcome variables.

v   Ultrasonography, HR-US, 3-Dimensional and 2-Dimensional Ultrasonography was included.

vi   All the original research articles were included.

Exclusion criteria

i   Review articles, case reports, case series and pilot studies.

ii   Participants without diagnostic tests such as ultrasonography and MRI

iii Studies on young children.

Search strategy

A literature review was performed in Pubmed Central and Cochrane library. MESH Terms – 'ultrasonography', 'TMJ disorders' were combined in the search. With this combination, a total of 113 abstracts appeared. Out of these 113 abstracts, 38 titles/abstracts were related to the research question. Further, search criteria (inclusion and exclusion criteria's) were applied to the articles, out of which 11 articles, which fulfilled the criteria, were selected for the review. Also, 2 handsearched articles were included in the review.

RESULTS

Mello JR CF et al., conducted a study in 2011 on 38 patients to assess sensitivity of ultrasonography in diagnosis of ADD closed mouth cases and found the sensitivity to be as high as 83% (High) [10].

Jank et al., introduced high-resolution ultrasonography for better visualization of TMJ and conducted a study on 66 patients. It showed a high sensitivity of 61% in open mouth position and of 78% in closed mouth position [17].

Bas et al., found sensitivity of ultrasonography to be 69% and

specificity to be 80% using 10MHz transducer [20].

Byahatti et al., conducted a study on 100 patients with a 12 MHz transducer using dynamic ultrasonography. Sensitivity in closed mouth position was found to be 80%, while in the open mouth position, it was found to be 76% [21].

Emshoff et al., conducted a study on 29 patients who were aged between 19 to 62 years. Accuracy was found to be 91% (closed mouth position) and it was 93% in open mouth position. The high PPV, combined with the recognized high sensitivity (90-96%), suggested that HR-US was a useful modality for the diagnosis of DD [22].

Another study was conducted by Emshoff et al., on 208 patients who were aged 13 to 78 years. The sensitivity, specificity and diagnostic accuracy were 80-68% (closed mouth-open mouth), 87-93% (closed mouth-open mouth) and 82-82% (closed mouth-open mouth), which were lesser than those which were seen in a previous study [23].

Emshoff et al., conducted a study in 1997 on 17 patients who were aged between 16 to 60 years of age, who presented with signs of TMD. They reported a low sensitivity (31% in static US and 41% in dynamic US), but a high specificity, especially in dynamic US (95%) [28].

In 2012, Bonafe et al found the estimated sensitivity to be 22.5% in closed mouth position, which was lower than that was seen in previous studies. The specificity in closed mouth position was 96.6% [29].

A different approach was suggested by Landes et al., using 3-D sonography for the diagnosis of DD of TMJ. Sensitivity obtained for closed mouth was 62%, for open mouth it was 43% and specificity obtained for closed mouth was 62% and for open mouth, it was 85% [30].

Kaya et al., assessed the diagnostic value of ultrasonography in the evaluation of anterior disc displacement. Sensitivity of US was 91% in ADD, it was 70% in ADD with reduction, it was 50% in ADD without reduction, and it was 53% in effusion [31].

Ozkan et al., found that the reproducibility, inter and intra-observer agreements of TMJ US were low and the authors advocated including two interpreters in the future studies [32].

Manfredini et al., conducted a study on 69 patients and found that the diagnostic accuracy of US for depicting effusions was good. US sensitivity was high for values which were below the cut off value of 1.950, while specificity was high for values which were above 2.150(TPR-71% and FPR-11.8%) [33] [Table/Fig-1].

Another study conducted by Emshoff et al., showed more precise outcomes on use of dynamic US instead of static US [34].Cut-off value was 2 mm in this study, whereas according to Tognini et al., joint effusion was seen when the distance between the lateral pole of condyle and lateral part of the articular capsule was greater than 3mm [35].

DISCUSSION

The present review describes ultrasonography as a quite sensitive diagnostic aid in the diagnosis of TMJ disorders. It has become one of the most recommended methods in recent decades because of its non-invasiness, inexpensiveness, and ability in evaluating the integrity and correlation of the hard and soft tissues of the TMJ through static and dynamic assessments. Results in all the articles varied with the techniques used. Firstly, variations occurred among all the articles in the resolution of the transducer. Sensitivity was found to be directly proportional to the resolution of the transducer. Increase in resolution increased the sensitivity of US. Emshoff et al., used a transducer of 7.5 MHz, with which the sensitivity was found to be 41-50% and specificity was 70% [28], while in other studies where the transducer used was of 10MHz or more, sensitivity was

Study	Sample size	Patient characteristic	Transducer (MHz)	Type of US	Gold standard	Target	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Positioning
Emshoff et al., [28]	17	M/F- 3/14, mean age-33.8 years	7.5	Static and dynamic	MRI	DD	Static-41% Dynamic- 31%	Static- 70% Dynamic-95%	Static- 61% Dynamic-88%	Static- 51% Dynamic-55%	Horizontal
Bonafe et al., [29]	40	Mean age- 41.5 years	5 to12	Static	MRI	Articular sounds for DD	Closed mouth-22.5%, open mouth-no sensitivity	Closed mouth-96.6%, open mouth-98.2%	Closed mouth-81.8%, open mouth-0	Closed mouth-64.4%. open mouth-91.4%	Horizontal
Bas et al., [20]	91	M/F-17/74, mean age-25years	10	Static	MRI	ID	69%	80%	92%	42%	Transverse and longitudinal
Landes et al., [30]	68	M/F-44/24, age-14 to 77 years	8 to 12.5	2D &3D Sonography Static	MRI	DD	Closed mouth-62%, open mouth-43%	Closed-62%, open mouth-85%	Closed-49%, open-41%	Closed-67%, open-86%	Horizontal
Kaya et al., [31]	52	M/F -5/47, mean age-28.30+ 10.76	7.5	Static and dynamic	MRI	ADD	ADD-91%,ADD with reduction-70%,ADD without reduction-50%, effusion-53%	ADD,ADD with reduction, ADD without reduction & effusion-16%, 38%, 89%, 63% respectively	ADD,ADD with reduction, ADD without reduction & effusion-89%, 63%, 67% & 72%	ADD,ADD with reduction, ADD without reduction & effusion-20%, 47%, 80% & 50%	Horizontal and longitudinal
Ozkan et al., [32]	28	M/F9/19, Mean age- 32.82 years	12	Static	MRI	DD	TPF-Closed mouth-57.1%, open mouth-71.4%	FPF-Closed mouth-78.6%, open mouth-71.4%	Closed mouth-72.7%, open mouth-71.4%	Closed mouth-64.7%, open mouth-71.4%	Transverse
Mello JR et al., [10]	38	M/F9/29, Mean age 33.13 years	12.5	Static	MRI	DD, Articular effusion	ADD-Closed mouth83.3% ADD open mouth-0 Articular effusion 20%	ADD closed mouth-100% ADD open mouth-100% Articular effusion 100%	ADD closed mouth-100% ADD open mouth-nil Articular effusion 100%	ADD closed mouth92.9% ADD open mouth90.8% Articular effusion 94.7%	Oblique axial
Byahatti et al., [21]	100	M/F64/36, Mean age- 27.56years	12	Dynamic	-	ID	64%	88%	84%	71%	
Manfredini et al., [33]	69		8-20	Static and dynamic	MRI	TMJ EFFUSION	83.9%, 71%	26.3%, 11.8%	-	-	Horizontal & Vertical
Emshoff et al., [34]	48		12.5	Dynamic	MRI	ADD&CE	CE-83% DDWR-82% DDWOR -83-93%	CE-63% DDWR-95% DDWOR-91-96%	-	-	Vertical
Emshoff et al., [22]	29	M/F-6/23, Mean age 29years	12	Static	MRI	ID	-	-	Closed mouth-97%, open mouth 88%,	Closed mouth 81%, open mouth97%	-
Emshoff et al., [23]	208	M/F-49/159, Mean age 38.5years	12	Static	MRI	DD	Closed mouth-80% open mouth-68%	Closed mouth 87% Open mouth 93%	-	-	-
Jank et al., [17]	66	M/F15/51, Mean age-38.2years	12	Static	MRI	DD	Closed mouth-78% Open mouth-61%	Closed mouth-78% open mouth-88%	Closed mouth- 87% open mouth-79%	Closed mouth- 65% open mouth-77%	Horizontal & Vertical

[Table/Fig-1]: Summarizes the main features of the study

found to be 61-90% (Landes et al., Byahati et al., Manfredni et al., Okezon et al.,) [21,30-33]. To use ultrasonography for the diagnosis of a TMJ disorder, a clear understanding of disc displacement is necessary. Disc displacement (an abnormal location of the TMJ disc) is the most common category of TMD. ADD is the most common condition and it usually is divided into two categories: ADD with reduction and ADD without reduction.

Each category has special features. In ADD with and without reduction, the TMJ disc localizes anterior to its normal position when the mouth closes. However, in the open-mouth position, the disc returns to the normal position in ADD with reduction, whereas the disc remains anteriorly displaced in ADD without reduction [5].

Therefore, the diagnosis should be based on the closed- and open mouth positions. Significant differences were seen in the values of sensitivity, specificity, diagnostic accuracy in closed and open

mouth positions. In the study of Emshoff et al., sensitivity was found to decrease from closed to open mouth position, while specificity increased from closed to open mouth position [28]. Diagnostic accuracy was more in the open mouth rather than closed mouth position, but in both the positions, the results obtained were acceptable. Similar results were found in studies of Landes et al., and Jank et al., [17,30]. In study of Mello Jr CF et al., sensitivity was as high as 83.3% in closed mouth position, but it was low in open mouth position [10]. Such a finding can be attributed to the medial displacement of the articular disc after opening the mouth, as the mandibular condyle and the glenoid cavity do not allow appropriate ultrasound propagation, thus impairing the visualization of the articular disc. Another variation was seen in the visualization of Disc. Disc was visualized as hyperechoic in studies of Emhoff et al., [28], as hyperechoic with a hypoechoic halo in

studies of Manfredini et al., and as a hypo to isoechoic band, as was seen by Byahatti et al., Landes et al., Jank et al., and Bonafe et al., [17,21,29,30]. This may be attributed to different structural, morphological and positional abnormalities in the patients who were examined. The position of the transducer also varied from horizontal (parallel to the zygomatic arc) to vertical (parallel to the ramus of the mandible), thus giving a different image of the TMJ in a transverse or a coronal / sagittal plane. In reality, the planes of the images are rarely true transverse, coronal or sagittal, but they are almost always inclined, because the transducer is tilted during the examination, in order to achieve a better visualization of the different components of the TMJ, especially the disc. This consideration does not apply in 3-D ultrasonography, where the TMJ can be evaluated in different planes within the scan volume. 3-D ultrasonography has also been found to have an acceptable sensitivity and accuracy [30]. Ultrasonography has good diagnostic accuracy in disc displacement as well as in joint effusion. As far as predictive values are concerned, ultrasonography showed acceptable predictive values in all the articles.

Interpretation of the US images highly depends on the operator, as the images can be blurred and not clear. Thus, well-trained and calibrated operators are required, to get reliable results. In the present review, only in one article, intra-observer and inter-observer variability was calculated, which had two different investigators. Intra-observer agreement for the detection of disc position ranged between 87-93% and inter-observer agreement ranged between 82-90%. These results are within acceptable limits and they suggested high reliability of the procedure when it was performed by trained and calibrated operators. Except for study of Byhati et al., [21], in all the other studies, ultrasonography diagnosis was compared to MRI diagnosis, as it has been so far described as the gold standard and the most accurate and reliable method in diagnosis of TMJ disorders. Using 1.5T imager accuracy, sensitivity and specificity were found to be near 95% in the evaluation of disc position, when both sagittal and coronal views were considered.

The difficulty in visualizing articular disc is one of the limitations of ultrasonography. The disc is visualized only through the small gap between the zygomatic process of the temporal bone (above) and the head of the condyle (below). It becomes difficult to obtain satisfactory images, especially when the condyle rotates and translates from the mouth-closed position to the mouth-open position. Hence, it becomes necessary to constantly adjust the position of the transducer, for a better visualization of the disc. Furthermore, only the lateral part of the TMJ can be reached, while the medial part remains hidden by the mentioned structures. As a consequence, medial displacements of the disc are likely to be overlooked.

Despite the possibility of obtaining images of the TMJ in different planes, the use of 3-D ultrasonography does not seem, at the moment, to increase the reliability of the examination.

CONCLUSION

Ultrasonography, with its acceptable sensitivity in the diagnosis of disc derangement and joint effusion and its added advantages over MRI (non invasiveness, in being an inexpensive procedure, its use in dental settings, its use in patients with pacemakers and metallic implants and in patients having claustrauphobia), can be suggested as a diagnostic aid in evaluation of TMJ disorders.

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