Benha Journal of Applied Sciences (BJAS) print: ISSN 2356–9751
Vol. (6) Issue (6) Part (1) (2021), (133-140) online: ISSN 2356–976x
http://bjas.journals.ekb.eg

Ultrasonography Compared To Magnetic Resonance Imaging for the Diagnosis of the Temporomandibular Joint Disc Displacement

M.M.Refaat, M.I.Yousef, A.A.Torky and M.L.Sarow
Radiodiagnosis, Dept., Faculty of Medicine, Benha Univ., Benha, Egypt
E-Mail: Mariam_latef@yahoo.com

Abstract

Background: The most common cause of TMJ problems is disc displacement. Complementary imaging exams are needed since a clinical examination alone could not provide a diagnosis. Magnetic resonance imaging (MRI) is the gold standard modality, however because of its limited availability, lengthy scanning time, and expensive cost, it is difficult to use MRI as a screening technique. It has been proposed that USG may be used instead of X-rays to diagnose TMJ problems. Objective: Compare the accuracy of ultra sonography and magnetic resonance imaging in the diagnosis of temporomandibular joint disc displacement. Methods: Forty patients with temporomandibular disorders, both sexes, were included in this research. MRI was the gold standard for all patients' TMJs, followed by blinded operators performing high resolution ultrasound (HRUS) in both closed and open jaw positions to identify disc location. Ultrasonography findings were compared with MRI data to see which was more accurate. Results showed that HRUS had a sensitivity of 73.33 percent, specificity of 88.6 percent, and accuracy of 80 percent when used in a closed mouth position, but a sensitivity of 93.75 percent, specificity of 89.1 percent, and accuracy of 91.7 percent when used in an open mouth posture. When seen from the side, HRUS is 50% sensitive in the closed-mouth position and 100% specific in the open-mouth position, with an accuracy of 97.5 - 98.75 percent. TMJ disc displacement may be diagnosed with high-resolution ultrasonography (HRUS). There's much more to learn. To be sure of our findings, further studies with bigger sample numbers are needed.

Keywords: disc displacement, magnetic resonance imaging, musculoskeletal ultrasound, sonography, temporomandibular joint.

1. Introduction

There are two compartments in the temporomandibular joint because of the fibrocartilaginous disc that sits in between its glenoid fossa and condyle. The joint space is split into these two compartments. Displacement of the disc with respect to the condyle is the most frequent kind of TMJ dysfunction. [2] Disc displacement may occur anteriorly, anterolaterally, laterally, anteromedially, medially, or posteriorly, but the latter is very rare. [2] Displacement can occur in any of these directions. Rotational displacement refers to the combination of anterior and lateral or medial displacement, while lateral or medial displacement alone is very uncommon. A condition in which the articular disc moves anteriorly while the mouth is closed, and then returns (with a click) to its usual position when the mouth is opened is known as anterior disc displacement with reduction. Anterior disc displacement without decrease occurs when the disc remains anteriorly displaced throughout closure and opening positions. As a result, the jaw's range of motion may be drastically reduced, with the disc becoming a mechanical barrier that prevents the mandible from opening fully. Clinical examination alone could not determine the diagnosis of temporomandibular joint problems, therefore additional imaging tests are often needed to provide a certain and conclusive diagnosis. With its excellent soft tissue contrast and anatomical representation, MRI is widely regarded as the gold standard. Radiation-free and less technique-dependent are the primary benefits of MRI. Although MRI is a good screening tool, it's difficult to utilise because of the limited availability, high cost, and restricted usage in individuals with claustrophobia, pacemakers, and ferromagnetic metal implants that come with them. [6]

For the first time in 1991, Nabeih et al. utilised ultrasound (US) to examine the jaw joint. It has been recommended as an alternate diagnostic imaging modality for TMJ problems due to the fact that USG is less costly, non-invasive, and doesn't require specialised facilities or equipment. One of the biggest advantages of USG is that it allows for investigations to be done in "real time," thus the articular disc may be seen as the patient is opening their mouth. It's possible that this perspective on motion will aid the investigator in determining its exact location. [7,8]

2. Patient and methods

Patients' population;

Between October 2018 to May 2021, 40 consecutive patients of both sexes with symptoms and signs of TMJ disorders admitted to out-patient clinic, Benha university hospital as well as private centers, were included in the study. All patients prior to imaging were subjected to proper history taking and clinical examination. Inclusion criteria consisted of the presence of signs and symptoms of TMJ internal derangements. Exclusion criteria were contraindications for MRI such as claustrophobia, heart pacemaker and metallic foreign body carriers. We also excluded the patients in which the misaligned images or distortions due to motion artifacts made the interpretation of the MRI unreliable.

Imaging acquisition and interpretation

1- **Magnetic Resonance Imaging analysis (MRI)**

MRI was carried out with a 1.5 T (Siemens Aera closed MRI scanner machine, Germany) with dedicated, circular polarized transmit and receive TMJ coil. The MRI protocol included;

- T1 weighted fast spin echo, T2 weighted proton density and T2* weighted gradient echo / fat-saturated proton-density sequences in sagittal planes with the mouth closed and at maximal mouth opening.
- T2- weighted fast spine echo in coronal planes with thin 3 mm slices.

Sagittal scans were performed in a plane parallel to the mandibular ramus. Coronal scans were performed on a plane perpendicular to the mandibular ramus through the condylar fossa. Patients received an intermaxillary device to obtain maximal mouth opening.

The articular disc was identified as a biconcave hypointense structure. A normal disc position was defined when the disc posterior band is seen superior or at 12 o' clock position relative to the mandibular condyle at closed and maximum mouth opening Fig [1]. Anterior disc displacement with reduction was defined when the posterior band seen anterior to the condyle at closed mouth then reduced to its normal position during mouth opening Fig [2]. While anterior disc displacement without reduction is considered when the disc did not reduce to its physiological position during mouth opening Fig [3].

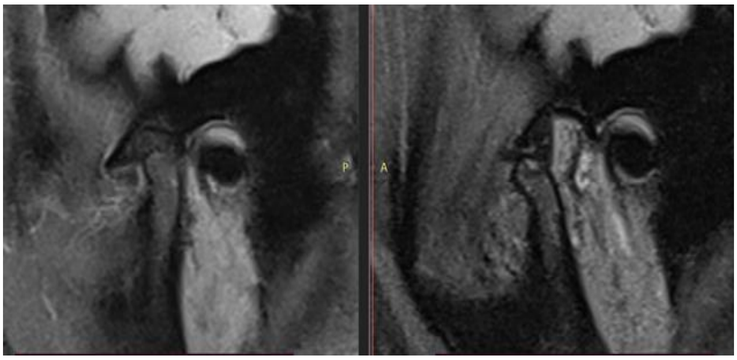

Fig (1) Sagittal proton density fat suppression MRI of a normal TMJ. Left with the mouth closed, the biconcave disc seen above the mandibular head. Right with mouth opening, the disc follows the condyle and is positioned above it.

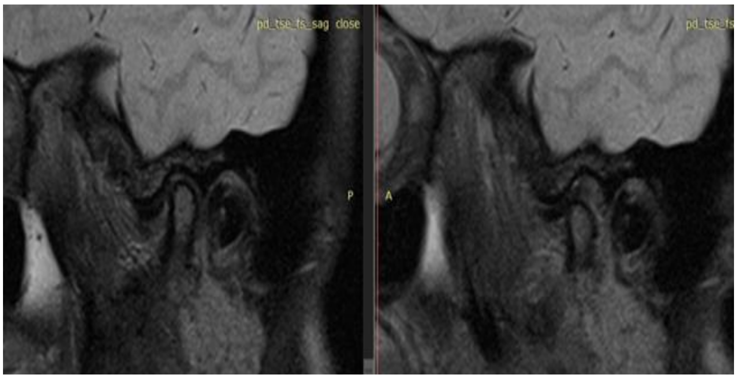

Fig (2) Sagittal proton density fat suppression MRI of anterior disc displacement with reduction. Left with the mouth closed, the disc is positioned anterior to the condyle. Right on maximal mouth opening, the disc resumes its normal position above the condyle

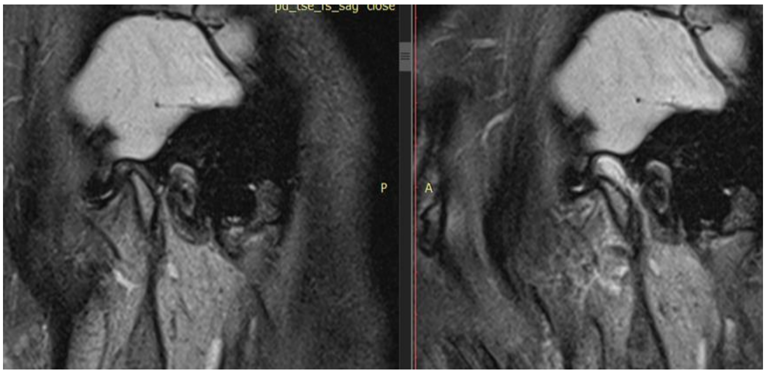

Fig (3) .Sagittal proton density fat suppression MRI of anterior disc displacement without reduction. Left with mouth closed, the disc is positioned anterior to the condyle. Right on maximal mouth opening, the disc remains in the abnormal anterior position.

2. High Resolution Ultrasonography (HRUS)

Patients are examined in the supine position using a high-resolution (5–17MHz) linear array transducer. HRUS investigation used a longitudinal to transverse scan performed at the closed-mouth and maximum mouth opening positions.

The probe was placed over the TMJ perpendicular to the zygomatic arch and parallel to the mandibular ramus then tilted out until the best visualization was obtained.

On sonography, the condyle and glenoid fossa were depicted as hyperechoic lines, whereas the disc was depicted as a central hyperechoic line surrounded by a shallow hypoechoic halo. A normal disc position was defined when the disc was placed over the manidibular head at closed and maximum mouth opening Fig [4]. Anterior disc displacement with reduction is considered when the disc was displaced anterior to the mandibular condyle with the mouth closed and recaptured it during opening Fig. [5]. While anterior disc displacement without reduction is considered when the disc did not return to its normal position during mouth opening Fig. [6].

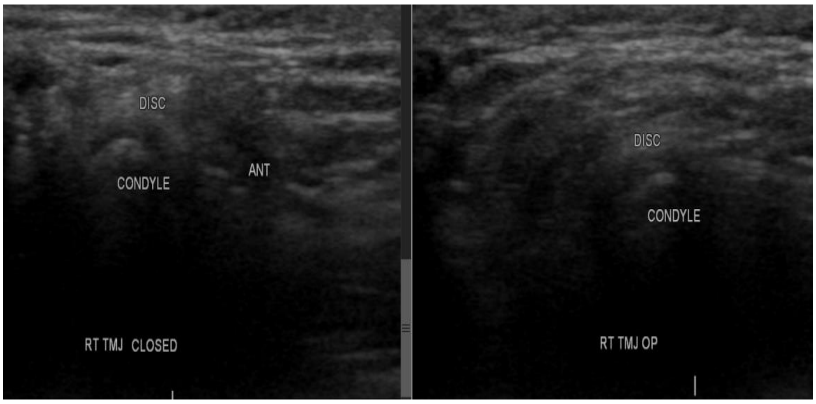

Fig. (4) Normal TMJ. Left figure with the mouth closed, the disc is shown over the mandible condyle. Right figure on mouth opening, the disc shown as a hyperechoic line surrounded by a hypoechoic halo, is also seen over the mandible condylar head.

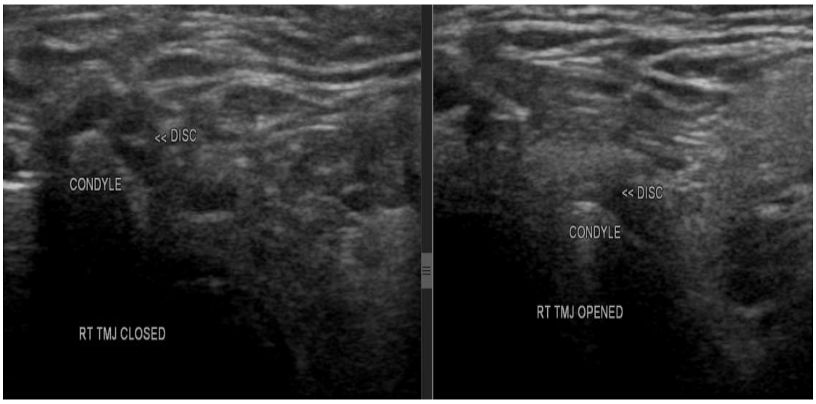

Fig. (5) Anterior displacement with reduction. Left, with the mouth closed, the disc (arrow) is displaced anteriorly. Right, at maximal opening, the disc (arrow) returns to the normal position.

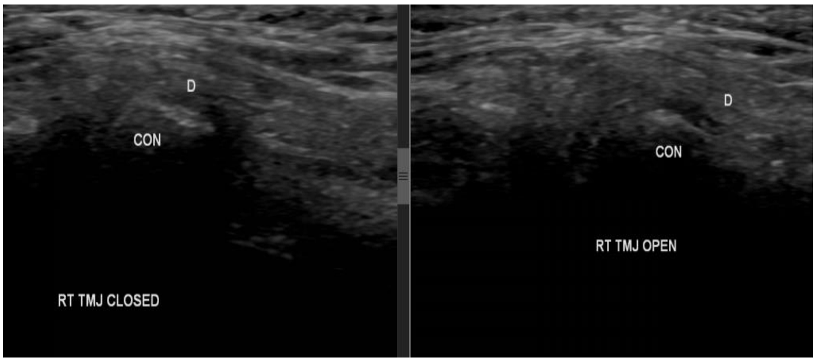

Fig. (6) Anterior displacement without reduction. Left, with the mouth closed, the disc is displaced anteriorly. Right, at maximal opening, the disc remains at the abnormal position, anterior to the condyle.

Statistical analysis

Ultrasonographic diagnosis of disc position was compared with MRI findings. The subcategories of disc displacement with and without reduction were grouped together in the statistical analysis. Statistical analysis of the data was done by using Statistical Package for Social Science (SPSS) version 22.0.

Qualitative variables were presented as number and percent. Quantitative variables were presented as mean ± SD (median). Chi square test was used for comparison between categorical data. The overall agreement between ultrasonography and MRI was evaluated using inter-rater reliability Cohen's Kappa test. The Kappa values were interpreted as following; values ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement.

Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value, Accuracy and area under curve assessment by ROC curve were calculated to evaluate the diagnostic performance of US in relation to MRI. A p value of < 0.05 was considered to be significant.

3. Results

40 consecutive patients with clinically diagnosed TMJ disorders participated in the study (80 joints; 10 male [25%] and 30 female [75%]; age range from 16 to 59 years with mean age, 33 years). Our study showed that TMJ disc displacement had a high predilection among females than males **Table (1).**

Magnetic resonance imaging depicted 35 normal disc position (43.75%), an anterior disc displacement in 41 of 80 TMJs (51.25%), an anteromedial disc displacement in 3 of 80 TMJs (3.75%), an anterolateral disc displacement in 1 of 80 TMJs (1.25%). There were no discs displaced in pure medial, lateral or posterior directions have been detected.

While HRUS shows a normal disc position in 43 of 80 joints (53.75%), an anterior disc displacement in 35 of 80 TMJs (43.75%), an anteromedial disc displacement in 2 of 80 TMJs (2.5%), an anterolateral disc displacement in 0 of 80 TMJs (0%). No discs displaced in pure medial, lateral or posterior directions **table (2) & fig (7).**

Table (1) Sex distribution of the study cases.

Sex	Frequency	Percent (%)
Female	30	75
Male	10	25
Total	40	100

Table (2) HRUS versus MRI in diagnosis of disc displacement.

Findings	MRI Finding	HR-US Finding
Normal	35 (43.75%)	43 (53.75%)
Anterior displacement	41(51.25%)	35 (43.75%)
Anteromedial	3 (3.75%)	2 (2.5%)
Anterolateral	1 (1.25%)	0 (0%)
Medial	0 (0%)	0 (0%)
Lateral	0 (0%)	0 (0%)
Posterior	0 (0%)	0 (0%)
Total	80 (100%)	80 (100%)

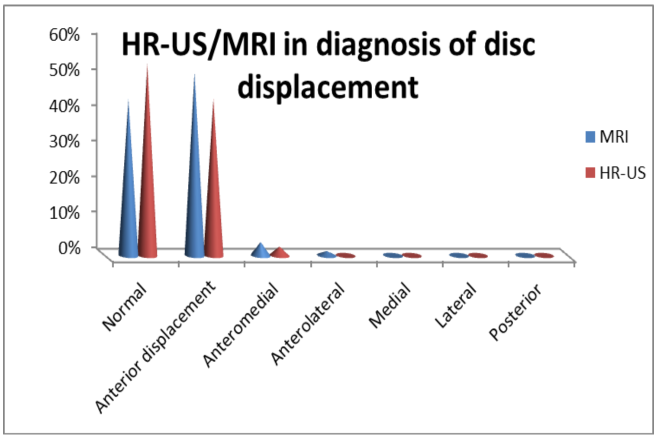

Fig. (7) HRUS versus MRI in diagnosis of disc displacement.

Diagnosis of TMJ disc position at sagittal /longitudinal view:-

MRI (sagittal view) shows 45 discs from 80 TMJs were diagnosed as anterior disc displacement at closed-mouth position, and 16 discs were diagnosed as anterior displaced at the maximum-mouth opening position (non-reducible). Longitudinal view HRUS shows 37 discs with anterior disc displacement in closed-mouth and 22 discs was diagnosed as anterior displaced at maximum-mouth opening position (non-reducible) **table (3).**

Disc position of the TMJ was correctly diagnosed on HRUS interpretations in 72 (90%) of the 80 TMJs in closed mouth positions, and in 71 (88.75%) of the 80 TMJs in maximum mouth opening positions. Considering the presence or absence of AD, ultrasonography confirmed 37 of 45 (82.2%) from MRI diagnosis of TMJs having anterior disc position.

Diagnosis of TMJ disc position at coronal /transverse view:-

MRI coronal view showed that 4 discs from 80 TMJs were diagnosed as medial and lateral disc displacement at the closed-mouth position, and 2 discs were diagnosed as displaced at the maximum-mouth opening position.

Transverse view HR-US shows medial and lateral disc displacement in closed-mouth position at 2 discs from 80 TMJs, and 1 disc was diagnosed as displaced at maximum-mouth opening position. So Ultrasonography confirmed 2 of 4 (50%) from MRI diagnosis of TMJs having anteromedial and anterolateral disc position **Table (4).**

This study showed that there was substantial agreement 80% and 90% between sagittal MRI and longitudinal view US in the diagnosis of anterior disc displacement at the closed and maximum open mouth positions respectively. While showed that there was substantial agreement 98.73% and 98.75% between coronal MRI and transverse view US in the diagnosis of antero-medial / antero-lateral disc displacement at the closed and open mouth positions respectively.

Therefore this study showed that the longitudinal HR-US assessment of TMJ yielded a sensitivity of 73.33% and a specificity of 88.6%, the positive and negative predictive values were respectively 89.2% and 72.1% and the overall accuracy of 80% in the diagnosis of anterior disc displacement at closed mouth position. While at maximum mouth opening HR-US showing a sensitivity of 93.75% and a specificity of 89.1%, the positive and negative predictive values were respectively 68.2% and 98.3% and the overall accuracy of 91.7%, with the MRI used as the gold standard for diagnosis **Table (5).**

As regarding the transverse HRUS, it showed a sensitivity of 50%, specificity of 100%, the positive and negative predictive values were 100% and 97.4% respectively and the overall accuracy of 97.5% at closed mouth views, while at maximum mouth opening HRUS showing a sensitivity of 50%, specificity of 100%, the positive and negative predictive values were 100% and 98.73% respectively and the overall accuracy of 98.75% for the diagnosis of antero-medial/lateral TMJ disc displacement **Tables (6).**

Table (3) Longitudinal view US versus sagittal MRI in detection of disc displacement at both closed and open mouth positions.

Mouth position	Disc position	MRI	US	X^2	p
Closed	**Anteriorly displaced**	45	37	1.6	0.21
	Normal	35	43		
Total	**Total**	80	80		
Open	**Anteriorly displaced**	16	22	2.72	0.26
	Reduced	29	20		
	Normal	35	38		
Total	**Total**	80	80		

Table (4) Transverse view US versus coronal MRI in detection of disc displacement at both closed and open mouth positions.

Mouth position	Disc position	MRI (coronal view)	US (transverse view)	X2	p
Closed	**Medially-displaced**	3	2	0.69	0.41
	Laterally-displaced	1	0		
	Normal	76	78		
	Total	80	80		
Open	**Medially-displaced**	2	1	0.692	0.71
	Laterally- displaced	0	0		
	Normal	76	78		
	Reducible	2	1		
	Total	80	80		

Table (5) Diagnostic performance test of longitudinal US for the diagnosis of anterior disc displacement using sagittal MRI as the gold standard method.

Item	TP	FN	TN	FP	Sensitivity	Specificity	PPV	NPV	Accuracy	AUC
US in closed mouth	33	12	31	4	73.33%	88.6%	89.2%	72.1%	80%	81%
US in Open mouth	15	1	57	7	93.75%	89.1%	68.2%	98.3%	91.7%	91.4%

TP =true positive, TN= true negative, FP = false positive, FN = false negative.

Table (6) Diagnostic performance test of transverse US for the diagnosis of Antero medial / lateral disc displacement using coronal MRI as the gold standard method.

Item	TP	FN	TN	FP	Sensitivity	Specificity	PPV	NPV	Accuracy	AUC
US in closed mouth	2	2	76	0	50%	100%	100%	97.4%	97.5%	75%
US in open mouth	1	1	78	0	50%	100%	100%	98.73%	98.75%	75%

TP =true positive, TN= true negative, FP = false positive, FN = false negative.

4. Discussion

Temporomandibular joint disorders are debilitating illnesses that afflict more women than men. This causes pain, which is by far the most frequent and significant complaint. Restricted mandibular mobility and joint sounds were among the other concerns (click sound). Conservative treatment or surgery can only be effective with an accurate diagnosis. [9] MRI is considered the gold standard in many investigations because of its excellent soft tissue contrast and anatomical representation, and its accuracy is about 95% when sagittal and coronal scans are assessed. MRI's major benefits are that it is radiation-free, takes less time, and is less reliant on a certain method. The drawbacks of this treatment include its high price, limited availability, and limited use in certain individuals. Alternative methods of visualising the TMJ have been developed as a result. In addition to being noninvasive, less costly, widely accessible, and producing quick findings with a reduced examination time, ultrasonography (US) has the added benefit of providing good tissue resolution and characterisation without exposing patients to radiation. The identification of anterior disc position was shown to be very accurate in a number of early studies. Emshoff et al., 1997[12], in the first study in which the accuracy of static ultrasonography demonstrated a poor sensitivity (range from 13 percent at maximum mouth opening position to 50 percent at closed mouth position) and a satisfactory specificity (from 65 percent at half-mouth opening position to 74 percent at maximum mouth opening position).

With longitudinal US view, our study shows that the prospective HRUS diagnosis of anterior disc displacement and MRI findings are in substantial agreement, with sensitivity of 73.33%, specificity of 88.63%, and accuracy of 80% at closed mouth position, and with a sensitivity of 93.75%, specificity of 89.13%, and accuracy of 91.75% at maximum mouth opening position.

According to our findings, the HRUS diagnosis of disc displacement has high accuracy with US interpretations using a 12-MHz probe, which has significantly improved diagnostic efficacy, as reported by Emshoff et al., 2002[13], Uysal et al., 2002[14], Jank et al., 2005 [15], Brandlmaier et al., 2003[16], and Bas et al., 2011[17].

Using 13MHz, Talmaceanu et al. found that the sensitivity was 72.58 percent, the specificity was 86.44%, and the accuracy was 78% in their 2020[10] research. Also, investigations by Habashi, et al., 2015[6] found a 74.3% sensitivity, an 84.2% specificity, and a 77% accuracy. Their findings are in agreement with those of our research and show that the diversity in results is due to the use of various US transducer resolutions, since high-resolution transducers (12-MHz) allow for greater imaging of the TMJ than low-resolution equipment. Another important aspect in the study's findings is the fact that ultrasonography is a technique reliant on the abilities of the operator.

Studies from the past have produced results that differ from ours, such as Nabieh et al., 1991[18], Stefanoff et al., 1992[19], and Emshoff et al., 1997[12], which used a transducer of 7.5-MHz and reported an accuracy rate of 31% while obtaining poor blurred images. All of these studies used transducers with higher frequencies. There may be a connection between the early unsatisfactory findings and the use of low-frequency transducers in the initial studies, which had poor tissue differentiation and penetration depth.

Many prior investigations have shown that HRUS has greater specificity than sensitivity. A study by Melchiorre and colleagues found that their sensitivity was greater than their specificity.

According to earlier research, HRUS findings obtained with the mouth closed were superior to those obtained with the mouth fully open. The disc may have migrated more deeply because the bony bones concealed it when the mouth was fully opened, according to one theory. Another explanation is that the ultrasonic waves deviate and do not reflect uniformly because of the two hard bone surfaces (articular eminence and condyle). [10]

The findings of our research vary from those of prior studies and their potential explanations, demonstrating greater accuracy identified at mouth opening position (91.7 percent) than that detected in closed-mouth position (80 percent). Varying research group samples, equipment with different transducer resolution, and that ultrasonography is a method dependent on the operator may all account for this unanticipated discrepancy.

It's surprising how few research agree with Emshoff et al., 2002[13], who found accuracy of 93 percent in open-mouth posture was greater than the 91 percent accuracy rate in closed-mouth.

Furthermore, no pure lateral or medial sideways disc displacement was found in our study sample, which is consistent with the majority of the existing research indicating that pure sideways disc displacement is very uncommon. Furthermore, disc displacement in the anteromedial and anterolateral directions is an uncommon occurrence. One joint showed anterolateral disc displacement, and three joints showed anteromedial disc displacement in this research (from a total of 80 TMJs).

We found significant agreement between HRUS (using transverse view) and MRI coronal images, despite the modest number of sideways disc displacements seen in this research. Because mediolateral disc displacement is such an uncommon occurrence, these findings can't be generalised to the general population; instead, further studies using larger samples are needed to corroborate them.

5. In conclusion

Increased and purer frequencies in sonographic units will enhance the units' capacity to represent the disc and improve the quality of the picture they produce. HRUS may be widely used in the future to diagnose internal derangement, if this finding holds true. More study with bigger sample sizes is also needed to validate our findings, investigate other technical elements and give information on TMJ internal problems depending on the population. This is also encouraged.

Conflict of interest

The authors have no conflict of interest to declare.

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