

Ultrasonography: A step forward in temporomandibular joint imaging. A preliminary descriptive study

Surej Kumar L.K.,
Georgie P. Zachariah,
Sumesh Chandran

Department of Oral and Maxillofacial
Surgery, PMS College of Dental Science
and Research, Thiruvananthapuram,
India

Abstract

Ultrasonography (USG) is a cost-effective and noninvasive imaging modality commonly employed for imaging the abdominal region and extremities. Currently, with the availability of higher frequency probes and higher resolution devices, USG imaging of the temporomandibular joint (TMJ) looks promising.

The aim is to evaluate and demonstrate the role of USG as an imaging modality of TMJ by visualizing the static and dynamic relationship of the joint, assessment of joint space and eliciting reproducibility at both open and closed mouth positions.

30 volunteers were selected based on the inclusion criteria in line with the research diagnostic criteria/temporomandibular disorders guidelines. High-resolution USG (≥ 12 MHz) of the right TMJ (chosen for uniformity) was done in the left decubitus position on ($n=30$) volunteers. The joint disc movement was directly visualized during opening and closing motions. The vertical joint space was assessed using the firmware and accurate reproducibility was checked. At the closed mouth position, the measured values ranged from 0.2 mm to 0.7 mm with a median of 0.05 cm and a mean of 0.4 ± 0.15 mm. At the position of maximal mouth opening, the measured values ranged from 0.9 mm to 1.5 mm with a median of 1.1 mm and a mean of 1.1 ± 0.17 mm. USG enables visualization of the dynamic relationship between joint structures, with particular importance to the condyle and disc position. The articular disc appears on the USG as a thin layer of hyperechogenicity surrounded by a hypoechoic halo, located between 2 hyperechoic lines viz, the condyle and the articular eminence. We recommend ultrasonographic imaging as a noninvasive diagnostic technique with relatively high specificity for patients with temporomandibular disorders.

Introduction

The temporomandibular joint (TMJ) is unique in both design and function. The main functions of the TMJ include mastication and speech. The right and left joints work synchronously and impairment of one member joint affects the other. The TMJ is a joint of glyngimoarthroidal variety.

Constant usage subjects the joints to an exhaustive degree of wear and tear, which at times lead to disorders of the joint to such a magnitude that will hamper the day-to-day functions of the patient. This makes improvements in diagnostic imaging necessary. Even in today's world of ameliorating scientific technology, there are limitations in studying joint movements in real time. Since long, inexpensive and non-invasive alternatives have been searched for TMJ imaging. The gap between TMJ disorder and proper treatment is often the inability to afford diagnostic imaging techniques. It is an obligation to society to bridge this gap by finding out newer cost-effective and noninvasive techniques. An expanse of diagnostic imaging modalities exist, with advantages and limitations to each; the cost of imaging and invasiveness being the prime limitation.

Ultrasonography (USG) is a cost-effective and noninvasive imaging modality commonly employed for imaging the abdominal region and extremities. Paramount studies on the use of USG for diagnostic imaging of the TMJ was first carried out in 1991 using a 3.5 MHz Probe.¹ USG has been suggested as an alternative diagnostic method in the imaging of TMJ disorders since 1992.² Currently, with the availability of higher frequency probes and higher resolution devices, the scope of TMJ imaging using USG looks promising.

Materials and Methods

This study was aimed at evaluating the role of ultrasonography (>12 Mhz) as an imaging modality of the TMJ. The objectives of the study included visualizing the static and dynamic relationship of the condyle; glenoid fossa and articular disc and assessing of the height of the joint space in both open mouth and closed mouth positions. The study population consisted of volunteers who were willing to participate in the study. The participants were screened and those without any symptoms or history of temporomandibular disorders were included in the study. The 30 selected volunteers were informed about the study and informed consent was obtained. The study was subject to institutional board review

Correspondence: Georgie P. Zachariah, PMS College of Dental Science and Research, Thiruvananthapuram, India.
E-mail: georgiepz@gmail.com

Key words: Temporomandibular joint; Ultrasonography; Condyle.

Conflict of interest: the authors declare no potential conflict of interest.

Funding: none.

Received for publication: 7 February 2019.

Revision received: 29 April 2019.

Accepted for publication: 21 May 2019.

This work is licensed under a Creative Commons Attribution NonCommercial 4.0 License (CC BY-NC 4.0).

©Copyright S.K.L.K et al., 2019
Licensee PAGEPress, Italy
Clinics and Practice 2019; 9:1134
doi:10.4081/cp.2019.1134

and was passed. The ultrasonographic evaluation was performed on the selected volunteers. The right TMJ was chosen for uniformity. A single radiologist experienced in ultrasonography of the head and neck region interpreted the images obtained.

Clinical assessment

All clinical assessments were performed by the investigators, according to the research diagnostic criteria/temporomandibular disorders guidelines. The examination included patient history, evaluating presence or absence of joint pain, evaluating presence or absence of joint sounds, palpation of intra-oral and extra-oral masticatory muscles, and the range of mandibular motion.

Ultrasonographic imaging analysis

USG examination was carried out with a general electricals (GE) ultrasound and colour doppler machine (Model no DX 300/Simplex) and instrument with a linear array probe which operated at 11-15 MHz (high-resolution USG ≥ 12 MHz). Sonograms were obtained by a single radiologist experienced in USG of the head and neck region. For USG examination, the right TMJ was chosen. All examinations were carried out in the left decubitus position. The transducer was first placed over the TMJ perpendicular to the Zygomatic arch and was tilted out between axial (Figure 1) and longitudinal views (Figure 2) until the best visualization was achieved. Images were obtained at both closed mouth

and maximal mouth opening positions. The distance between the highest point of the condyle and the point of maximum concavity on the glenoid fossa was measured using the inbuilt firmware of the ultrasonography machine in both closed mouth and maximal mouth opening positions (Figure 3). The process was repeated again by the same radiologist on the same machine and the values were reproducible accurately in all 30 samples. During the examination, it was possible to visualize the joint disc move directly during the opening and closing motions.

The articular disc appears on the USG image as a thin layer of hyperechogenicity surrounded by a hypochoic halo. It was located between the condyle and articular eminence, which appeared as hyperechoic lines.^{3,4}

Results

The ultrasonographic imaging (USI) diagnoses were compared with the clinical diagnosis, which showed total agreement. It is to be noted that clinically normal individuals were chosen from amongst the volunteers for the study. The linear measurements obtained were then statistically described.

The data was collected from 30 volunteers (93.3 % male and 6.7% female) with a mean age of 23.2±5.0 SD years. Out of the study population, 36.7% of the individuals were among the age group 18-21 years, 43.3% of the individuals were among the age group, 22-25 years, 20.0% of the individuals were among the age group, greater than 25 years (Table 1). The USI diagnoses showed 100% agreement with the clinical diagnoses. It is to be noted that the selected volunteers included only those with a normal TMJ clinically. Descriptive statistics such as mean, median, minimum, maximum and standard deviation were calculated for measured values at both closed mouth and maximal opening positions. At the closed mouth positions, the measured values ranged from 0.2 mm to 0.7 mm with a medial value of 0.05 cm and the mean was calculated to be 0.4 mm with standard deviation to be 0.15 mm (Table 2). At the position of maximal mouth opening, the measured values ranged from 0.9 mm to 1.5 mm with a medial value of 1.1 mm and the mean was calculated to be 1.1 mm with standard deviation to be 0.17 mm (Table 3).

Discussion

Detailed clinical, physical and physio-

logical examinations are considered the golden standard for diagnosis of TMJ disorders. The National center for devices and radiological Health of the Food and Drug Administration (USA), in 1979 recommended that the imaging examination must be capable of providing the desired information of the internal anatomy or physiology and the radiographic information sought, even if negative or normal, is expected to be significantly useful in the medical management of the patient.⁵ Thus, imaging would only be performed when it is known that it would contribute to: i) a proper diagnosis, ii) treatment with better prognosis. Unless imaging contributes to these, then the cost to benefit will be low. The diagnosis of temporomandibular disorders (TMD) can be very difficult because it is mainly based on patient's symptoms rather than objective assessment. Most investigations have suggested that TMJ abnormalities cannot be reliably assessed by only clinical examination. Magnetic resonance imaging (MRI) is the preferred examination for TMJ soft tissue pathology in many institutions.

Imaging techniques include plain panoramic radiography, conventional and

computerized tomography (CT) scan, cone beam CT, magnetic resonance imaging (MRI), radionuclide imaging and arthrography.⁶ The main disadvantage of conventional radiography is that they provide a static view of the hard tissues and superimposition of adjacent anatomic structures makes such visualization difficult.⁶ Diagnostic accuracy is reduced in case of panoramic radiography when compared to intraoral radiography.^{6,7} In 1996, a study centered around radiographic techniques reported acceptable reliability and specificity – but low sensitivity – for bony changes of the condyle and low reliability and accuracy for



Figure 1. Ultrasonographic image of the temporomandibular joint in open and closed mouth positions with the transducer placed longitudinally (vertically).

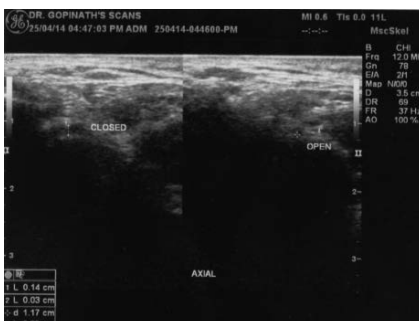


Figure 2. Ultrasonographic image of the temporomandibular joint in open and closed mouth positions with the transducer placed axially (horizontally).



Figure 3. Measurements.

Table 1. Distribution of samples according to age.

Age	Count	Percent
18-21	11	36.7
22-25	13	43.3
>25	6	20.0

Table 2. Values recorded at the closed mouth position.

Closed mouth position	
Mean	0.04
Standard deviation	0.015
Median	0.05
Minimum	0.02
Maximum	0.07

Table 3. Values recorded at the open mouth position.

Opened mouth position	
Mean	0.11
Standard Deviation	0.017
Median	0.11
Minimum	0.09
Maximum	0.15

the temporal component.⁸ Arthroscopy involves the surgical invasion of the joint with attendant surgical risks as well as the significant likelihood of altering its normal function by its mere presence.⁹ CT examination produced excellent image for osseous morphology and pathology.¹⁰ The radiation dose involved for a CT examination range between magnitudes of 10-20 mSv (comparable to that of a PET scan) while a dental xray is of the magnitude 0.005 mSv. This comparison throws light to the magnitude of radiation involved and hence contra-indicated for a pregnant patient. If the imaging modality gives negligible data on soft tissues, then the risk to benefit ratio will be low in CT in assessment of the TMJ. MRI is considered as the imaging tool of choice to visualize the hard and soft tissues of the temporomandibular region and currently the most non-invasive method to visualize the disc- relation. Owing to the equipment cost, cryogenes for the magnet, as well as staffing required, MRI is currently an expensive imaging tool.^{10,11} and requires the patient to travel to a special facility.⁹ With magnetic resonance imaging, the patient's head position is abnormal, which can influence mandibular motion.⁹ MRI is most specific and sensitive for the interpretation of soft tissue and inflammatory conditions of the joint.

However, MRI is an expensive imaging method and contraindicated in certain patients, such as those with pacemakers, metal vascular clips and any metal particle in the body. Because of the small magnet bore diameter, other relative contraindications include claustrophobia, patient obesity, or an inability to be motionless during the examination. For the aforesaid reasons, this method cannot be classified as a routine examination. Since 1992, several investigators have advocated ultrasonography as a noninvasive, low-cost, and easy to perform technique for the visualization of the disc-condyle relation.^{2,3,9} It is relatively non invasive and is being put to use by many branches of medicine. The main advantage of this technique is the possibility of visualizing the dynamic relationship between joint structures, with particular importance to the condyle and disc position. Moreover there are no specific contra indications for ultrasonography and can be safely put to use during pregnancy. In 1991, preliminary studies reported the visualization of the TMJ and disc with USI using a 3.5MHz transducer.¹ In 1992, further studies² evaluated the TMJ disc in asymptomatic volunteers with a 5MHz transducer and reported successful results. After these preliminary studies, several reports have been published about the sensitivity, specificity and accuracy

of the USI in depicting the TMJ condyle – disc position. Most reports compared the diagnostic value of USI with MRI findings.³ Therefore the capability of USI to detect clinically normal joints is higher than MRI.¹² Joint effusions can be detected indirectly by measuring the distance between the two articular surfaces/measuring capsular width.⁴

In the review article¹³ published in 2016 USG technique can be used in oral and maxillofacial region for the examination of bone and superficial soft tissue, detection of major salivary gland lesions, TMJ imaging, assessment of fractures and vascular lesions, lymph node examination, measurement of the thickness of muscles and visualization of vessels of the neck. It has the potential to be used in the evaluation of periapical lesions and follow up of periapical bone healing. Also, it may be used for the evaluation of periodontal pocket depth and for the determination of gingival thickness before dental implantology.

In a case control study published in 2017,¹⁴ the following conclusions were made. Ultrasonography, which has shown high specificity, can supplement clinical evaluation in patients with TMJ disorders and can be used as a potential diagnostic tool for identifying internal derangement of the TMJ with reduction. Auscultation is mandatory in the examination of TMJ for clicking sound.

In the systematic review and metanalysis¹⁵ published in 2018 it was concluded that US can be a good imaging tool to supplement clinical examination findings in patients with suspected Differential diagnosis. Combined static and dynamic examinations using high-resolution US should be preferred.

This study used a GE ultrasound and colour doppler machine (Model no DX 300/Simplex) and instrument with a linear array probe which operated at 11-15 MHz (high-resolution ultrasonography ≥ 12 MHz) in contrast to the probes used in expeditious studies. With the use of the aforesaid machinery and probe, we were unable to delineate the upper and lower joint compartments and can be ascertained as a major shortcoming of this study. The position of the disc could be appreciated and observed in real-time and joint space could be measured, in contrast to MRI wherein the disc/joint movement is visualized as a series of static images recorded with the patient's head in an unnatural position which is found to influence the movement of the joint structures.

According to literature, USI seems to be more specific than sensitive for the detection of TMJ disc displacement.^{3,12} In 1997,

Emshoff *et al.*¹⁶ used a small diameter 7.5 MHz transducer and reported a sensitivity of 41% and a specificity of 70% for static USI in locating disc displacement and a sensitivity of 31% and a specificity of 95% for dynamic USI compared with MRI. In 2001, Hyashi *et al.*¹⁷ evaluated 23 patients with a 10 MHz transducer and reported 63% sensitivity, 100% specificity, and 72% accuracy of disc displacement.

Our knowledge and regard in the diagnosis and treatment of patients with diverse types of TMJ disorders has grown as research has identified structural abnormalities and disease mechanisms associated with some of these disorders. Although there has been remarkable progress in the imaging of the TMJ, no single imaging modality studied can accurately show all changes in the hard and soft tissues of the joint. MRI provides the most accurate information about the soft tissues of the joint, whereas CT scan provides the most accurate information about hard and soft tissue changes. Ultrasonography provides information about soft tissues and hard tissue boundaries and is encouraging from the economic point of view.⁵

The aim of the study was to evaluate and demonstrate the role of ultrasonography as an imaging modality of TMJ by visualizing the static and dynamic relationship of the condyle, glenoid fossa and articular disc and assessing of the height of the joint space (distance between the highest point of the condyle and the point of maximum concavity on the glenoid fossa) at both open mouth and closed mouth positions. Such type of measurements can be put to use in indirectly detecting joint effusions and in evaluating arthritis, where the joint spaces will be increased and decreased respectively.^{4,18} A comparison between the right and left TMJs is required for further evaluation, which did not come under the purview of this study.

One of the major shortcomings of the USI is the insufficiency of the technique to detect disc displacements in the medio-lateral plane as well as in detecting sideways and rotational components. Disc perforations cannot be visualized as USG imaging is carried out in a plane perpendicular to the occurrence of perforation. Three-dimensional imaging is not possible with conventional high-resolution ultrasonography, unless accompanied by a 3D image reconstruction hardware and software. Another disadvantage of the technique is that the accuracy depends on the operator training. Results described herein are a result of a few research groups and further results of larger groups are needed for better comparisons.

Conclusions

As a concluding note, we recommend USI as a noninvasive diagnostic technique with relatively high specificity. It could be a useful diagnostic method in patients with TMD. With ultra higher resolution devices (>15 MHz), in contrast to probes operating at 12-15 MHz such as what we have used in this study, better visualization of joint structures, delineation of the upper and lower joint compartments and more reliable results with higher sensitivity and accuracy may be achieved.

References

1. Nabeih YB, Speculand B. Ultrasonography as a diagnostic aid in temporomandibular joint dysfunction. A preliminary investigation. *Int J Maxillofac Surg* 1991;20:182-6.
2. Stefanoff V, Hausamen JE, van den Berghe P. Ultrasound imaging of the TMJ disc in asymptomatic volunteers. *J Cranio-Maxillofac Surg* 1992;20:337-40.
3. Manfredini D, Guarda-Nardini L. Ultrasonography of the temporomandibular joint: a literature review. *Int J Oral Maxillofac Surg* 2009;38:1299-36.
4. Kundu H, Basavaraj P, Kote S, et al. Assessment of TMJ disorders using ultrasonography as a diagnostic tool: a review. *J Clin Diagn Res* 2013;7:3116-20.
5. Sinha VP, Pradhan H, Gupta H, et al. Efficacy of plain radiographs, CT scan, MRI and ultrasonography in mandibular joint disorders. *Natl J Maxillofac Surg* 2012;3:2-9.
6. Petersson A. What you can and cannot see in TMJ imaging – an overview related to the RDC/ TMD diagnostic system. *J Oral Rehabil* 2010;37:771-8.
7. Rushton VE, Horner K. The use of panoramic radiology in dental practice. *J Dent* 1996;24:185-201.
8. Dahlström L, Lindvall AM. Assessment of temporomandibular joint disease by panoramic radiography: reliability and validity in relation to tomography. *Dentomaxillofac Radiol* 1996;25:197-201.
9. Braun S, Hicken JS. Ultrasound imaging of condylar motion: a preliminary report. *Angle Orthod* 2000;70:383-6.
10. Bag AK, Gaddikeri S, Singhal S, et al. Imaging of the temporomandibular joint: an update. *World J Radiol* 2014; 6:567-82.
11. Matsuda S, Yoshimura Y, Lin Y. Magnetic resonance imaging assessment of the temporomandibular joint disc displacement. *Int J Oral Maxillofac Surg* 1994;23:266-70.
12. Bas B, Yulmaz N, Gökçe E, Akan H. Diagnostic value of ultrasonography in temporomandibular disorders. *J Oral Maxillofac Surg* 2011;69:1304-10.
13. Evirgen Ş, Kamburoglu K. Review on the applications of ultrasonography in dentomaxillofacial region. *World J Radiol* 2016;8:50-8.
14. Siva KU, Moturi K, Padma Rayalu K. The role of ultrasound in diagnosis of temporomandibular joint disc displacement: a case-control study. *J Maxillofac Oral Surg* 2018;17:383-8.
15. Su N, van Wijk AJ, Visscher CM, et al. Diagnostic value of ultrasonography for the detection of disc displacements in the temporomandibular joint: a systematic review and meta-analysis. *Clin Oral Investig* 2018;22:2599-614.
16. Emshoff R, Bertram S, Rudisch A, Gassner R. The diagnostic value of ultrasonography to determine the temporomandibular joint disc position. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1997;84:688-96.
17. Hayashi T, Ito J, Koyama J, Yamada K. The accuracy of sonography for evaluation of internal derangement of the temporomandibular joint in asymptomatic elementary school children: comparison with MR and CT. *AJNR Am J Neuroradiol* 2001;22:728-34.
18. Byahatti SM, Ramamurthy BR, Mubeen M, Agnihothri PG. Assessment of diagnostic accuracy of high-resolution ultrasonography in determination of temporomandibular joint internal derangement. *Indian J Dent Res* 2010; 21:189-94.