"ASSESSMENT OF DISC POSITION IN INTERNAL DERANGEMENT OF TEMPOROMANDIBULAR JOINT USING ULTRASONOGRAPHY AS A DIAGNOSTIC TOOL - A PROSPECTIVE STUDY IN NORTH KARNATAKA REGION"

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LIST OF ABBREVATIONS

TMJ	:	Temporomandibular joint
MRI	:	Magnetic Resonance Imaging
TMD	:	Temporomandibular Disorders
CT	:	Computed Tomography
US	:	Ultrasonography
ADD	:	Anterior disc displacement

ABSTRACT

Introduction

Temporomandibular disorders are clinically manifested by orofacial pain, limited mouth opening, clicking and popping sounds of temporomandibular joint area, pain at the muscles of masticatory muscles and other surrounding structures. They can be broadly classified as muscular disorders, internal derangement, inflammatory diseases and osteoarthritis; internal derangement being the most important. The diagnosis of internal derangement is important and hence the suitable imaging modality is necessary to identify the disease. Currently many modalities such as CT scans, MRI, ultrasonography and arthroscopy have been used to identify the TMDs. MRI being the gold standard for TMJ imaging, has its own drawbacks as it is time consuming and expensive because of which many patients withdraw treatment midway. Hence, high resolution ultrasonography can be used a effective diagnostic tool to detect internal derangement as it is cost effective and less time consuming than MRI.

Aim

To assess the position of disc in internal derangement of temporomandibular joint using ultrasonography as a diagnostic tool and thereby give a co-relation between clinical and ultrasonographic findings and provide an ultrasonographic classification of internal derangement of TMJ.

Materials and methods

Patients who reported to Department of Oral and Maxillofacial Surgery, KLE VKIDS were initially subjected to a thorough clinical examination followed by an orthopantomogram. After which, they were subjected to an ultrasonographic examination to locate the disc position.

Results

A total of 70 subjects participated in this study. Significant difference was noted among the control and study groups based on their clinical parameters. A co relation was drawn between clinical and ultrasonography findings. Using clinical finding as a gold standard, sensitivity, specificity and disease prevalence were noted based on the clinical and ultrasonography parameters. The sensitivity, specificity and disease prevalence were compared between ultrasonography and MRI and was found to have values in the similar range.

Conclusion

To conclude, ultrasonography can be used as a diagnostic tool to detect internal derangement of TMJ as it is cost effective and less time consuming as compared to MRI.

Keywords:

Temporomandibular joint, Temporomandibular joint disorders, Ultrasonography, Internal derangement.

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INTRODUCTION

TMJ is referred as a ginglymo-diarthrodial joint located between the glenoid fossa and condyle of the mandible. [1] The articular disc of this joint divides it into two synovial cavities. In the superior compartment, gliding or translatory movement between the disc and the glenoid fossa is noted whereas in the inferior compartment rotary or hinge movement occurs between the disc and condyle. [2] The articular disk is avascular and comprises of thick anterior and posterior bands, along with a thin middle zone.[3]

The joint has various muscles and ligaments to facilitate movements such as chewing, swallowing, breathing, phonation and facial expressions. The main muscles involved are the temporalis, masseter, and medial and lateral pterygoid muscles that allows for different movements of the jaw. The TMJ is also maintained by three ligaments: the temporomandibular, stylomandibular, and sphenomandibular ligaments which supports the joint and prevent excessive movements that could lead to injury or dysfunction. [4] [3]

There are many pathologies related to TMJ such as temporomandibular disorders (TMD), infections, tumours, traumatic injuries, and developmental abnormalities in growth[5] affecting up to 28% of the population. Any disruption in the coordinated

functioning of muscles, bones, and joints can give rise to TMD. TMD is also associated with psychological symptoms such as depression and anxiety. [6]

The National Institute of Dental and Craniofacial Research divides TMD into the following:

1. Myofascial pain: This is prevalent type of TMD that is pain in the face and the muscles responsible for different movements.

2. Internal derangement: Pathology referred to as abnormal position of the disc.

3. Degenerative joint disease: This contains conditions like osteoarthritis or rheumatoid arthritis affecting the TMJ.

The diagnosis and management of TMD is important as the leading reason of pain in the maxillofacial region, continue to pose significant challenges for clinicians recently and also a thorough knowledge of the TMJ anatomy is found crucial as it lays a groundwork for effectively detecting and managing temporomandibular disorders in clinical practice. [7]

The commonly noticed disorder, internal derangement is defined as any interference in the smooth joint movement.[8] The internal derangements are classified by Wilke from Grade 1 to 5 as early to late stage by clinical evaluation and patient complaints.

Dimitrolius has classified the internal derangement from category 1 to 5 along with the treatment from arthroscopy of the joint to alternative surgical modalities. Research findings suggest that a while 16% to 31% of asymptomatic individuals exhibit disc displacement, its occurrence is more frequent in symptomatic patients. [(9)] In cases of a displaced disc, reduction (or "recapture") often occurs during mouth opening, presenting with audible and palpable click. However, as the condition progresses, the disc may become nonreducible, resulting in restricted movements without an audible click. Contributing factors to internal derangement include trauma, malocclusion, bruxism, stress, and underlying osseous abnormalities. [(10)]

Many studies show that the identification of temporomandibular disorders (TMD) cannot independently rely on clinical examinations indicating that a radiographic examination would be required to attain accurate diagnosis and management of the condition. Although there appears to be increasing uncertainty among practitioners regarding the appropriate utilization of imaging and the timing for each modality's application; diagnostic imaging assumes paramount importance in seeing the anatomical changes within the TMJ, aiding in the classification of TMD, evaluating treatment efficacy, facilitating therapeutic interventions, and guiding surgical management. [(10)(11)]. Currently the modalities used for imaging are plain radiographs, orthopantomogram, CT scans, ultrasonography, MRI and arthroscopy.

Plain radiographs are useful in depicting degenerative diseases and condylar position; however, it has limitations such as lack of 3-Dimensional images and superimposition of images. Panoramic radiography is used to rule out bony deformities, however it doesn't show the functional movement of TMJ and has low specificity and sensitivity when compared to CT. [13] Computed tomography (CT) shows multi-planar reconstruction of TMJ structures, facilitating the acquisition of 3 dimensional images .The highest disadvantage is its high cost and radiation exposure. [14] [15] MRI is now the best technique for soft tissue imaging in diagnosing disc displacements, TMJ dysfunction, rupture of retrodiscal tissue, joint effusion. [16]

The utilization of ultrasonography for TMJ examination was initially introduced in 1991 by Naabeih et al., It is a real time investigation which is non-invasive, inexpensive and records both static and dynamic positions which helps to visualize the disc position and effusion. Currently high-resolution ultrasonography is praised for its diagnostic accuracy and its interpretation by a well-trained and experienced radiologist.

Hence, this study highlights the importance of ultrasonography in the Indian community for identifying internal derangement of TMJ while MRI being the gold standard is being advised for most of the temporomandibular disorders. But due to its high cost and extensively long examination time it becomes tedious to the patients and many withdraw from going forward with MRI scans leaving many TMJ disorders

untreated and neglected. Ultrasonography is much affordable and less time consuming than MRI offering added advantage of evaluation of the joints both in static and dynamic positions which gives a real time evaluation of the disc position. Hence this modality (ultrasonography) could be used among the population as a diagnostic tool.

AIM AND OBJECTIVES

AIM :

- To establish data of normal anatomy of TMJ using ultrasonography.
- To assess the position of disc in internal derangement of TMJ using ultrasonography as a diagnostic tool.
- To correlate clinical and ultrasonographic data to establish the degree of derangement.

OBJECTIVES:

- To understand the normal anatomy of temporomandibular disc on ultrasonography.
- To assess the position of disc in internal derangement of TMJ.
- To assess other abnormalities (cysts, condylar abnormalities, joint effusion, arthritis).

NULL HYPOTHESIS

The use of ultrasonography in Temporomandibular disorders gives negligible diagnostic results.

RESEARCH HYPOTHESIS

The use of ultrasonography in Temporomandibular disorders gives significant diagnostic results.

REVIEW OF LITEARTURE

1. In 2022, Saul N Freidman et al conducted a study which introduced an advanced ultrasound (US) technique for diagnosing internal derangement of TMJ and suggested it as diagnostic screening tool. This technique involved positioning the US probe parallel to the articular disc, utilizing clock face references, as opposed to traditional axial and coronal views. This was further verified by comparing it directly with MRI. 61 subjects underwent both US screening and MRI evaluation for internal derangement. Results showed that ultrasonography screening indicated a sensitivity of 79% and specificity of 100%. The study's findings suggested that ultrasonography can serve as a reliable screening method for identifying TMD when administered by an experienced operator. When abnormalities are detected during TMJ assessment, patients should proceed to undergo MRI for validation, particularly if surgical intervention is being considered. [(11)]

2. In 2009, Kurtulus Kaya et al studied the agreement between ultrasonography and MRI findings in diagnosing ADD in TMJ, both with and without

reduction. 52 subjects with TMJ pain underwent examinations with both US and MRI. The study evaluated the agreement between the two methods and determined the a sensitivity, specificity, and accuracy of US in diagnosing ADD. Results showed a high sensitivity (91%) but low specificity (16%) for US in detecting ADD, with an overall accuracy of 82%. For ADD with reduction, US had a sensitivity of 70%, specificity of 38%, and accuracy of 57%. For ADD without reduction, US had a sensitivity of 50%, specificity of 89%, and accuracy of 76%. In summary, the study found that US is sensitive in detecting ADD and reliable in identifying the absence of ADD without reduction. However, it was less effective in demonstrating ADD, whether with or without reduction, compared to MRI. [(12)]

3. In 2014, R Emshoff et al carried out a study to investigate whether ultrasonography could be a viable alternative for assessing disk displacement in patients with TMD, considering the limitations of arthrography and MRI. Seventeen patients underwent static and dynamic ultrasonography of 100 TMJ positions, followed by MRI for comparison. The results indicated that static ultrasonography had a sensitivity of 0.41 and specificity of 0.70, while dynamic ultrasonography had a sensitivity of 0.31 and specificity of 0.95. While dynamic ultrasonography was sensitive in detecting the absence of disk

displacement, both modalities were marginal in accurately detecting its presence or absence. Although dynamic ultrasonography showed promise in detecting normal disk position, neither static nor dynamic ultrasonography was deemed sufficient for diagnosing disk displacement accurately. (13)

4. In 2006 Ansgar Rudisch et al the efficacy of ultrasonography in finding disk displacement and condylar erosion of the temporomandibular joint (TMJ) was evaluated, using corresponding cryosections as a "gold standard". High resolution US of the TMJ was performed with a high frequency 12 MHz transducer on 30 preserved autopsy specimens. Succeeding sonography, the autopsy specimens were deep-frozen and cut in paracoronal planes corresponding to the sonographic images. High resolution -US diagnoses were compared with cryosectional findings in a blinded fashion. High resolution -US detected 19 (95%) of 20 instances of condylar erosion and 16 (73%) of 22 instances of disk displacement. There were one false-positive finding for condylar erosion and two false-positive findings for disk displacement. The accuracy of HR-US evaluating condylar erosion and disk displacement rated 93% and 73%, respectively. In conclusion, condylar erosion was reliably assessed by High resolution-US, but the evaluation of disk position was less accurate. (14)

5. In 2005, F Tognini et al assess the efficacy and reliability of ultrasonography in diagnosing temporomandibular joint (TMJ) disc position abnormalities compared to magnetic resonance imaging (MRI). Total of 82 TMJs were examined using both ultrasonography and MRI, conducted by blinded operators. Ultrasonography demonstrated good accuracy in detecting disc position abnormalities, with a sensitivity of 65.8% and specificity of 80.4%. Positive and negative likelihood ratios were 3.35 and 0.42, respectively, and the diagnostic odds ratio was 7.97. The predictive positive and negative values were 77.1% and 70.2%, respectively, with an overall agreement between the two techniques of 73.1%. Ultrasonography was effective in detecting normal disc position and abnormalities in disc-condyle relationship but was less useful in distinguishing between disc displacement with and without reduction. [15]

6. In 2011, Burcu Bas et al assess the ultrasonographic imaging (USI) in temporomandibular disorders (TMD). A total of 182 temporomandibular joints (TMJs) from 91 patients were examined using both USI and magnetic resonance imaging (MRI), following clinical diagnosis of TMJ disc derangement. Results showed that MRI had a sensitivity of 85%, specificity of 62%, and an accuracy of 80% in detecting internal derangements compared to clinical diagnosis. USI demonstrated a sensitivity of 69%, specificity of 80%,

and an accuracy of 71%. While USI had a higher specificity, MRI showed higher sensitivity. The study concludes that USI, as a non-invasive and dynamic imaging method, is reliable for evaluating disc position in TMJ disc derangements. It suggests that higher-resolution devices (≥12 MHz) may offer better visualization of joint structures and improved sensitivity and accuracy in diagnosis. (16)

7. In 2020, Kader Azlag Pekince et al evaluate the use of ultrasonographic imaging in diagnosing temporomandibular joint (TMJ) internal derangements. Fifty-five patients with TMJ disorders underwent both ultrasonographic and magnetic resonance imaging (MRI) scans bilaterally. Diagnostic accuracy of ultrasonographic imaging was assessed using MRI as the gold standard. Results showed that the diagnostic accuracy of ultrasonographic imaging for detecting TMJ disc displacement was 0.81. The study concludes that ultrasonographic imaging, as a non-invasive and reproducible method capable of acquiring dynamic images, is successful in evaluating TMJ disc displacement. (17)

8. In 2023 Ahmet Faruk Erturk et al explore the utility of ultrasonography in imaging temporomandibular disorders (TMD) patients, as there is limited prospective clinical research on this application. 320 patients were initially screened, with 100 participating in the study. Results indicated that women were more likely to experience muscle pain and headaches compared to men.The study suggests that US can serve as an adjunctive tool in diagnosing TMD, especially for assessing muscle and joint pain. However, it may not provide sufficient detail for patients requiring advanced surgical interventions, in which case referral to magnetic resonance imaging (MRI) may be necessary. The findings from this study contribute to the understanding and diagnosis of TMD, offering valuable reference values for clinicians. [18]

9. In 2009 D. Manfreidini et al the clinical usefulness of ultrasonography (US) for the diagnosis of temporomandibular joint (TMJ) disorders. A systematic search in the National Library of Medicine's Database was performed that assessed the accuracy of US with respect to MRI, computerized tomography (CT), clinical assessment or autopsy specimens for the diagnosis of TMJ disk displacement, effusion and osteoarthrosis. US accuracy was 54-100% for

diagnosing disk displacement, 72-95% for joint effusion and 56-93% for osteoarthrosis. US remains potentially useful as an alternative imaging technique for monitoring TMJ disorders, particularly the presence of intrarticular effusion. (19)

10. In 2007, Marcello Melis et al evaluate the reliability of ultrasonography in the diagnosis of temporomandibular joint (TMJ) disorders. A review of the literature was performed, searching for all articles published between 1966 and 2006, and examining the ones which met the selection criteria. Ultrasonography sensitivity ranged from 13-100% for the evaluation of disc displacement (DD), from 70.6-83.9% for the evaluation of joint effusion (JE), and from 70-94% for the evaluation of condylar erosion (CE). Specificity ranged from 62-100% for the evaluation of DD, from 73.7-100% for the evaluation of joint effusion, and from 20-100% for the evaluation of condylar erosion. Accuracy ranged from 51.5-100% for the evaluation of disc displacement, from 72.2-95% for the evaluation of joint effusion, and from 67-94% for the evaluation of condylar erosion. (20)

11. In 2000 C. Landes et al evaluate the efficacy of sonographic examination compared to MRI and axiography in assessing temporomandibular joint (TMJ) function in 55 patients with TMJ disorders. Patients underwent clinical assessment, axiography, sonography, and some also underwent MRI. Sonographic and axiographic measurements of condylar movement were compared using statistical analysis. Sonographic examinations were also compared to MRI for diagnosing disc displacement and other pathologies. Results showed that sonography was significantly faster than axiography, with good agreement in measuring condylar movement for opening and protrusion. However, sonography had limitations in visualizing the medial aspect of the joint, medial disc dislocation, and condylar slope angulation. In conclusion, sonography proved to be a fast and reliable method for assessing TMJ function and diagnosing various pathologies, offering advantages such as real-time imaging and non-invasiveness. However, it may not fully replace MRI for comprehensive evaluation, especially in cases requiring visualization of specific structures not

12. In 2018, U Siva Kalyan et al assessed the utility of ultrasound of temporomandibular joint (TMJ) internal derangement and its role as a diagnostic tool for TMJ clicking. A case-control study was conducted,

involving 25 patients with TMJ clicking (study group) and 25 asymptomatic patients (control group). Bilateral ultrasound scanning of the TMJ was performed in both groups, to measure the lateral and anterior part of capsule to condyle distances (LCCD and ACCD). Results showed that the mean LCCD and ACCD in the control group were 1.3630 mm and 1.4850 mm, respectively. In the study group, 56% of subjects showed deviation towards one side. Clicking was observed in all subjects during mouth opening. The frequency of negative and non-negative deviations in LCCD and ACCD from the control group was noted. Conclusion: Auscultation is crucial for assessing TMJ clicking. Ultrasound, with high specificity, can complement clinical evaluation in TMJ disorders and serve as a potential diagnostic tool for identifying internal derangement with reduction in the TMJ. [(22)]

13. In 2010, Sujatta M Byahatti et al did an assessment of ultrasonography in evaluating internal derangements of the temporomandibular joint (TMJ) in both open and closed mouth positions. The sample was collected from the Outpatient Department of Oral Medicine and Radiology at GDC, Bangalore. Symptomatic patients with pain, clicking, deviation, and tenderness were included, along with an asymptomatic group.HR-US was performed during maximal mandibular range of motion in 100 patients (50 symptomatic and 50 asymptomatic), total of 400 joints. Sonography confirmed internal

derangement in 68% of symptomatic patients and detected it in 10% of asymptomatic patients. Statistical analysis showed a sensitivity of 64%, specificity of 88%, positive predictive value of 84%, negative predictive value of 71%, and accuracy of 76%.The study concludes that dynamic HR-US, being non-invasive, can provide valuable information about TMJ internal derangement, particularly in the mandibular closed mouth position. [23]

14. In 2005, S Jank et al conducted a pilot study to compare values for ultrasonography (HR-US) in diagnosing degenerative changes, effusion and disk displacement using MRI as a reference. Over a period of 6 months, 100 patients with TMJ disorders (200 TMJs) were investigated by an experienced radiologist with HR-US and magnetic resonance imaging (MRI). The results of the current study imply that HR-US is a valuable diagnostic imaging method of the TMJ which can be used as an alternative method to a MRI-investigation, but is yet not able to replace it. Further studies have to be done to reduce false-negative results. [24]

15. In 2023, Chenyang Li et al established a quantitative ultrasonographic method for diagnosing anterior disc displacement (ADD) of the temporomandibular joint (TMJ) and to evaluate its diagnostic efficacy. Using magnetic resonance

imaging (MRI) as the reference standard, 75 joints were classified into normal disc position (NDP) or ADD groups. Longitudinal scans of the lateral articular compartment were conducted, and various variables such as the width of the lateral joint space (LJS), upper lateral joint space (ULJS), lower lateral joint space (LLJS), and position of the lateral articular disc edge (ADE) were investigated. The study identified LJS and ULJS as significant predictors of ADD and developed a diagnostic model using stepwise logistic regression. The optimal cut-off value for diagnosing ADD using this model was determined to be 0.800, with a sensitivity of 82%, specificity of 96%, positive predictive value (PPV) of 97.6%, negative predictive value (NPV) of 72.7%, and an accuracy of 86.7%. The study concluded that the quantitative ultrasonographic diagnostic method demonstrated promising efficacy in diagnosing ADD and has the potential for use in screening for ADD in clinical practice. [25]

16. In 2014, Ahmed Abdel Khalek et al assessed the pattern of articular disc displacement in patients with internal derangement (ID) of the temporomandibular joint (TMJ) using ultrasound. Forty TMJs from 20 patients with TMJ ID underwent high-resolution ultrasound and magnetic resonance imaging (MRI), with MRI serving as the gold standard for

comparison. Results showed that ultrasound detected anterior displaced discs in 22 joints and sideways displaced discs in 3 joints, compared to 26 and 4 joints, respectively, detected by MRI. Diagnostic efficacy of ultrasound for anterior displacement exhibited a sensitivity of 79.3%, specificity of 72.7%, accuracy of 77.5%, positive predictive value (PPV) of 88.5%, negative predictive value (NPV) of 57.1%, positive likelihood ratio (PLR) of 2.9, and negative likelihood ratio (NLR) of 0.34. For sideways displacement, ultrasound showed 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. In conclusion, ultrasound proved to be a non-invasive imaging modality capable of assessing anterior and sideways displacement of the articular disc in patients with TMJ ID. [26]

17. In 2015, Hadeel Habashi et al found the effectiveness of sonography in diagnosing temporomandibular joint (TMJ) disk displacement compared to magnetic resonance imaging (MRI) with the mouth closed and during maximal mandibular range of motion. Thirty-nine consecutive patients with TMJ disorders underwent both sonography and MRI, with 78 joints assessed in total. The MRI identified normal joints, those with anterior disk displacement with and without reduction, and degenerative disease, which

were compared to sonographic findings. Both studies were independently interpreted by blinded operators. Results showed that sonography had an overall sensitivity, specificity, and accuracy of 74.3%, 84.2%, and 77.7%, respectively, for diagnosing disk displacement. Conclusions suggest that dynamic high-resolution sonography shows promise as an imaging method for diagnosing TMJ disk displacement and degenerative diseases. Further research is recommended to establish dynamic high-resolution sonography as the primary diagnostic tool for TMJ disk displacement. [27]

18. In 2018, B H Hechler et al did a systematic review of articles on ultrasound (US) and magnetic resonance imaging (MRI) of the temporomandibular joint (TMJ) in juvenile idiopathic arthritis (JIA) to answer the question "What is the sensitivity and specificity of US as compared to MRI in diagnosing acute and chronic joint changes in patients with JIA?" Six of these articles were specific to JIA patients. The heterogeneity of these articles made comparison difficult. Of the acute and chronic changes assessed (disk displacement, joint effusion, bony deformity), only joint effusion was appropriately assessed by multiple authors, with US having a sensitivity of 0-72% and specificity of 70-83% as compared to MRI. This systematic review found that dynamic imaging with high-resolution US improves sensitivity and specificity compared to

static, low-resolution US. Additionally, there is evidence to suggest that US imaging following a baseline MRI can increase US sensitivity and specificity and may have a future role in disease surveillance. [28]

19. In 2023, Ingrid Tonni et al the performance of ultrasonography and MRI in assessing the Lateral Periarticular Space (LPAS) of Temporomandibular Joints (TMJs) in patients with Juvenile Idiopathic Arthritis (JIA).In the study, 29 children with JIA and 28 healthy children were assessed. The LPAS width was found to be significantly greater in the JIA group compared to the healthy group. Additionally, within the JIA group, TMJs with moderate/severe enhancement on MRI showed a significantly greater LPAS width compared to those with mild enhancement. A positive significant correlation was observed between MRI and US measurements of LPAS width in the JIA group. The Bland-Altman method indicated a good level of agreement between MRI and US measurements in this group. In conclusion, while US cannot replace MRI in evaluating TMJ in patients with JIA, it could serve as a supplementary imaging method alongside MRI for assessing TMJ disease. [29]

20. In 2019, Surej Kumar L K et al evaluated the ultrasonography as an imaging modality for the temporomandibular joint (TMJ), focusing on visualizing static and dynamic joint relationships, assessing joint space, and ensuring reproducibility in both open and closed mouth positions. Thirty volunteers were selected based on inclusion criteria aligned with research diagnostic criteria/temporomandibular disorders guidelines. High-resolution USG (≥12 MHz) was performed on the right TMJ of each volunteer in the left decubitus position. At the closed mouth position, 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 maximal mouth opening, 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 facilitated visualization of dynamic joint structures, particularly the condyle and disc position. The articular disc appeared as a thin layer of hyperechogenicity surrounded by a hypoechoic halo between two hyperechoic lines—the condyle and the articular eminence. The study recommends ultrasonographic imaging as a noninvasive diagnostic technique with relatively high specificity for patients with temporomandibular disorders. [30]

21. In 2019, Dora Zulema R Diaz Et al compare TMJ images in individuals with and without temporomandibular disorder (TMD) using high-resolution

ultrasonography (HRUS). The lateral capsule-mandibular condyle distance was measured to confirm clinical diagnosis according to the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD). The sample comprised 17 women and 15 men, aged 19-39 years, divided into TMD (n = 20) and Asymptomatic (n = 12) groups. HRUS was used to evaluate TMJ images in closed- and open-mouth positions. Morphological changes, including joint effusion, condylar erosions, and irregularities, were observed in some TMD group participants. However, the lateral capsule-mandibular condyle distance a did not differ between sides or groups among participants with intra-articular disorders with or without pain. In conclusion, HRUS allowed visualization of TMJ structures but did not confirm clinical diagnosis by DC/TMD. [31]

22. In 2015 X Y Dong et al did evaluation of ultrasonography in detecting ADD of the temporomandibular joint (TMJ). They conducted a meta-analysis of 11 studies involving 1096 subjects, assessing both ADD with reduction (ADDWR) and without reduction (ADDWoR). HR-US demonstrated acceptable performance, particularly for ADDWoR, offering a new method for rapid diagnosis with advantages of simplicity and low cost. However, more high-quality studies are required to further evaluate its diagnostic efficacy. [32]

23. In 2019 Fabiana Tolentino Almeida et al capability of ultrasound in assessing temporomandibular joint (TMJ) alterations, specifically disc displacement (DD), joint effusion (JE), and condylar changes (CC), using 3D imaging modalities as reference standards. A comprehensive search was conducted, resulting in the inclusion of 28 studies. The review found that ultrasound showed acceptable capability for screening DD and JE in patients with temporomandibular disorders (TMD). However, further studies comparing ultrasound with computed tomography (CT) or cone beam computed tomography (CBCT) are needed to assess its capability for detecting condylar changes. [33]

24. In 2018, Tomasz Klatkiewicz et al ultrasound imaging used as a diagnostic tool for temporomandibular joint disorders (TMDs) compared to other imaging modalities. A search of publications from 2006 to March 2017 yielded 8 relevant studies from the US National Library of Medicine database. These studies were analyzed based on sensitivity, specificity, accuracy, positive predictive value, and negative predictive value in diagnosing articular disc displacement, joint effusion, and condylar abnormalities. The results

showed that ultrasound imaging had a sensitivity of 75.6%, specificity of 69.1%, accuracy of 76.1%, positive predictive value of 72.2%, and negative predictive value of 65.6% for diagnosing articular disc displacement. The study concluded that while ultrasound imaging holds promise as a diagnostic tool for TMDs due to its accessibility and non-invasiveness, standardization of the method and further research are necessary to confirm its effectiveness. (34)

25. In 2020, Daniel Talmaceanu et al saw ultrasonography compared to MRI for evaluating temporomandibular disorders (TMD). Fifty consecutive patients with TMD symptoms were included in the study, undergoing both US (13 and 20 MHz) and MRI examinations of both temporomandibular joints (TMJs). Regarding degenerative changes, 13 MHz US had a sensitivity of 58.33%, specificity of 92.11%, PPV of 70%, NPV of 87.5%, and diagnostic accuracy of 84%, whereas 20 MHz US showed similar results with a sensitivity of 58.33%, specificity of 93.42%, PPV of 73.68%, NPV of 87.65%, and diagnostic accuracy of 85%. The Cohen's Kappa coefficient for intra- and inter-observer agreement was high for both disc displacement and degenerative disorders. In conclusion, high-resolution US demonstrated potential as a useful imaging technique for diagnosing TMJ disc displacements. (35)

26. In 2019, Dilek Yılmaz et al evaluate ultrasound compared to MRI for assessing temporomandibular joint (TMJ) disorders in patients. Fifty patients underwent clinical examination and bilateral TMJ imaging using high-resolution ultrasound and 1.5 Tesla MRI. Diagnostic accuracy of ultrasound was compared to MRI for assessing disc displacement and joint effusion. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated for ultrasound measurements. Results showed that ultrasound had high sensitivity, specificity, PPV, NPV, and accuracy for assessing disc position and effusion compared to MRI. In conclusion, ultrasound can serve as a valuable adjunct to traditional imaging modalities for assessing TMJ disorders. (36)

27. In 2022, Małgorzata Pihut et al saw the impact of ultrasound in identifying and treatment planning of temporomandibular disorders (TMD) in patients. A total of 110 patients were assessed using the Research Diagnostic Criteria for TMD questionnaire, axis I and II, to create an initial treatment plan. All patients underwent ultrasound examinations of the temporomandibular joints to obtain detailed information on joint pathologies. The results showed various

morphological changes within the joint structures across all treatment groups. In conclusion, the study highlights the importance of ultrasound examinations in diagnosing and planning treatment for TMD patients. Further research is recommended to confirm these findings and validate the effectiveness of ultrasound diagnostics for temporomandibular disorders. [37]

28. In 2018 Daniel Talmaceanu et al ultrasonography (US) in detecting temporomandibular joint (TMJ) disc displacements. A total of 74 patients (148 TMJs) with signs and symptoms of TMJ disorders were included. Each patient underwent both US and magnetic resonance imaging (MRI) of both TMJs shortly after clinical examination. MRI revealed various findings, including normal joints, disc displacement with reduction, disc displacement without reduction, and degenerative changes. US detected similar findings, with high sensitivity, specificity, and accuracy compared to MRI. The study concluded that high-resolution ultrasonography demonstrated high diagnostic performance in detecting TMJ disc displacement, making it a valuable imaging technique for assessing TMJ disc position. However, the diagnostic value of US depends on the skills of the examiner and the quality of the equipment used. [38]

29. In 2002, R Emshoff et al. analyse errors in the interpretation of ultrasonography images of the temporomandibular joint (TMJ) and compare them with diagnostic magnetic resonance imaging (MRI) findings. The prospective interpretation of TMJ HR-US images showed sensitivity, specificity, and accuracy of 80%, 87%, and 82%, respectively, for images at the closed-mouth position, and 68%, 93%, and 82%, respectively, for images at the maximum mouth-opening position. In conclusion, the study suggests that high resolution ultrasonography of the TMJ is a valuable imaging technique for assessing disk displacement due to its high diagnostic accuracy and low observer variation. However, it notes that some errors observed during prospective analysis did not occur during retrospective analysis, indicating potential areas for improvement in the interpretation process. [(22)]

30. In 2018, Naichuan Su et al commented on value of ultrasonography (US) in detecting disc displacements (DDs) in temporomandibular joints (TMJs) compared to magnetic resonance imaging (MRI). Researchers conducted a thorough search of Pubmed and EMBASE databases to identify diagnostic accuracy studies assessing the value of US for diagnosing DDs, using MRI as

the reference standard. Meta-analyses were then performed to analyse the data. Results from 16 studies were included in the meta-analyses. The findings indicated that for diagnosing DD at closed mouth position (DD-CM) and DD at maximum mouth-opening position (DD-MMO), US had added values of 22% and 41% for positively ruling in these conditions, and 30% and 20% for negatively ruling them out, respectively. Clinically, US can serve as a valuable imaging tool to complement clinical examination findings in patients suspected of having DDs. The study suggests that combined static and dynamic examinations using high-resolution US should be preferred for optimal diagnostic accuracy. [39]

31. In 2013, Hansa Kundu et al checked the use of ultrasonography as a aid in the understanding of TMJ disorders. A literature review was performed in Pub Med Central and Cochrane library using Mesh Terms – 'ultrasonography' and 'TMJ disorders'. 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. (40)

32. In 1991, Y.B. Nabeih et al 25 patients presenting with temporomandibular joint dysfunction were examined by both ultrasonography and arthrotomography. Anterior displacement of the meniscus was associated with deeper location of the condylar head within the glenoid fossa whilst a perforated meniscus produced a bilobed image. This study has provided a preliminary look at ultrasonography of the TMJ and has shown promise for further work. The present images are not ideal for clinical use but they show the possible potential for non-invasive diagnosis which might be provided by higher resolution ultrasound equipment than that used in this study. (41)

33. In 1998 Mitsuru Motoyoshi et al applied for diagnosis of TMJ disorders using an ultrasonic diagnostic imaging system. Patients with a normal TMJ (male, 24 y 1 month) and a symptomatic TMJ (female, 20 year 2 months) were selected for imaging. The ultrasonic diagnostic imaging system showed a transverse cross-section and no hard tissue images. However a difference between the kinematic images of the normal and symptomatic TMJ was

observed during jaw opening. Irregularity in the striated pattern of the soft tissue surrounding the condyle was observed in the image of the symptomatic TMJ. In order to make a precise diagnosis using ultrasonic imaging, it may be useful to understand the kinematics of the soft tissue surrounding the TMJ during jaw opening and closing. (42)

34. In 2023 P R Thapar et al explored the potential of ultrasonography as a chairside tool for diagnosing disc displacement in TMD. A search of databases yielded 17 relevant articles published from January 2000 to July 2020. Studies meeting inclusion criteria were evaluated for sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) regarding disc displacement diagnosisThe review suggests ultrasonography may offer clinically acceptable accuracy in diagnosing disc displacement, aiding TMD treatment. However, further training in ultrasonography operation and interpretation is needed to facilitate its integration into dental practice. Standardization of evidence and additional research are warranted for stronger validation. (43)

35. In 2015, Chalkoo et al compared ultrasonography with MRI in the diagnosis of temporomandibular joint (TMJ) internal derangements. The study was conducted on 11 subjects with a chief complaint of TMJ discomfort, who were diagnosed as having TMJ internal derangement according to clinical diagnostic criteria (CDC) for temporomandibular disorders (TMD). A control group of eight subjects who had no sign of TMJ internal derangement were also examined. Imaging modalities (MRI and HR-USG) were performed on all the subjects (cases and controls). Strong agreement was found between MRI and HR-USG in the diagnosis of TMJ internal derangements ($k = 0.918$, $P < 0.001$). [44]

36. In 2018, M Borahan et al evaluate the efficacy of ultrasonography in TMJ disorders. Material and Method: The retrospective ultrasonography images of 20 patients (female, male) who had been referred to Marmara University, Faculty of Dentistry, Oral Diagnosis and Radiology Clinic with a complaint related to Temporomandibular joint (TMJ) were evaluated in terms of condylar surface irregularities, joint space reduction and joint effusion. Results: A total of 20 patients (% 70 female, %30 male, mean age: 33,75) and 40 TMJ were evaluated and in % 15 erosive – degenerative changes, in % 82,5 condylar surface flattening and in % 27,5 increased joint capsule width was

observed. Conclusion: Ultrasonography is a non-invasive technique suitable for visualization of TMJ and evaluation of TMD in routine clinical practice. (45)

37. In 2021, M M Refaat et al Compare ultrasonography and MRI in temporomandibular joint disc displacement. Methods: Forty patients with temporomandibular disorders, both sexes, were included in this research. 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. 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. (46)

38. In 2018, M Shanthi et al conducted a study. The TMJ is a ginglyo-diarthrodial joint where ginglyo represents hinging movement and arthrodial is gliding movement.1 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. Ultrasonography 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 compiled the various role of ultrasonography in various temporomandibular joint disorders. [47]

39. In 2018, Shuang Ba et al. 160 subjects with TMD participated in this study. The subjects were randomized into two groups to receive US therapy or no therapy. Patients in the US group were given US therapy once a day for 5 days per week for 2 consecutive weeks. However, 6 months after the therapy, US group had a recurrence rate of 2.63%. US therapy can significantly reduce the pain, and improve the functionality of the temporomandibular joint and mouth opening limit for TMD patients, and is therefore recommended for TMD patients. [48]

40. In 2007, L J Periera et al did a study where 217 subjects aged 12–18 underwent assessment using the and a questionnaire. The minimum and maximum scorers were divided into control and TMD groups, respectively. Ultrasound static images and tomograms were used to measure joint spaces

and condylar position at mandibular rest. Results showed no correlation between ultrasound measurements and CMI scores, and no significant differences between groups. [49]

MATERIALS AND METHODS

STUDY DESIGN:

A prospective study.

SOURCE OF DATA:

The study was conducted both in the Department of Oral and Maxillofacial Surgery , KLEVKIDS (clinical examination) and in the Department of Radiology, KLE Dr. PRABHAKAR KORE HOSPITAL & Medical Research Centre , Belagavi, Karnataka (ultrasonography) with due permission of the institutional ethical committee. The procedure was explained to all the patients and an informed consent was signed by them.

INCLUSION CRITERIA:

- Both male and female patients willing to participate in the study.
- Patients with clinical signs or symptoms related to TMJ disorders.

EXCLUSION CRITERIA:

- Infection, inflammation with the joint.
- Cardiac pacemaker or other implantable devices.

LABORATORY DETAILS:

- Ultrasonography
- Orthopantomography

MATERIALS AND ARMAMENTARIUM

• GE LOGIQ P9 Ultrasound system
• 8 MHz hockey stick transducer probe
• Ultrasound gel
• System control panel
• System monitor
• Printer
• System power supply

METHODOLOGY

All the subjects in this study were first examined clinically followed by Orthopantomography (OPG) and Ultrasonographic investigations.

1. In the clinical examination, each patient was assessed based on:

- Pain,
- Mouth opening,
- Clicking sound/Crepitus,
- Deviation of mouth,
- Muscle tenderness,
- Range of jaw motion,
- Aggravating and Relieving factors

2. Following this the patient was advised for an OPG (Orthopantomogram) which would indicate any obvious bony deformities in the area of concern.

3. Subsequently an ultrasonography examination was carried out with a GE LOGIQ P9 ultrasonography machine with a 8MHz frequency hockey stick transducer probe.

4. All the sonograms were obtained by a single trained radiologist experienced in ultrasonography of the head and neck region. All trials were conducted in a dark room with patients in a supine position. First the joint was palpated both in open and close mouth position. Once the joint was palpated, the transducer probe was placed over the joint with liberal amount of gel.

5. The probe was angled approximately parallel to the right disc in the sagittal plane initially at an angle 50º-60º down from the horizontal as measured from the anterior side of the probe followed by 0º angulation and finally an anterior angle of 50º-60º up from the horizontal as measured from the anterior side of the probe. The same procedure was repeated on the opposite side. Dynamic video clips of movement were obtained by swivelling the probe or by keeping the probe just off the horizontal, which varies from patient to patient.

6. Initially 25 patients without any clinical sign and symptoms were subjected to ultrasonography using ultrasonography machine with a 8MHz frequency hockey stick transducer probe. This data was used to establish the normative data regarding the position of disc in healthy joints. Next 25 patients who have clinical sign and symptoms was subjected for ultrasonography. This data was used to establish the position of disc in affected TMJs. All images and videos were saved for further reference.

7. All the ultrasonograms were analysed by the radiologist and drawn-out conclusions on ultrasonographic differences between normal and pathological cases. A co relation between clinical and ultrasonographic findings were established to determine the severity as:

    - Mild
    - Moderate
    - Severe

8. The patients with abnormal disk position (internal derangement) were then advised for treatment depending on the severity. There are 4 treatment methods according to Weinberg & Shankland classification (1982): Palliative, Causative, Adjunctive and Definitive treatment plans based on which patient management was taken care of.

Detailed clinical examination of all subjects on the basis of pain, mouth opening, deviation, range of jaw motion, clicking sound/ crepitus, aggrevating/ relieving factors are recorded.

All patients are advised for an OPG to find for any obvious bony deformities.

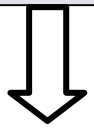
Patients are then subjected to Ultrasonography using GE LOGIQ P9 ultrasonography machine with a 8MHz frequency hockey stick transducer probe .

The patient is headed to dark room for ultrasonography of TMJ after explaining the whole procedure. Make the patient lie down in supine position .

The radiologist will palpate the joint both open and close mouth position. Take the transducer probe with liberal amount of ultrasound gel.

Position the hockey stick probe over the TMJ. Initially closed mouth position is recorded until the best visualization is achieved. Once it is done, patient will be asked to open his/her mouth gradually. Dynamic video clip is recorded.

All the images of open and close mouth positions are thoroughly analysed and ultimately a correlation is established between clinical and ultrasonographic findings



Patients with internal derangement may be advised treatment based on Weinberg & Shankland classification 1982. Palliative, Causative, Adjunctive, Definitive. Patients will be followed up for next 6 months for resolution of signs and symptoms.

Image 1: Ultrasonography machine

Image 2: Hockey stick probe used to detect the temporomandibular region on ultrasonography

STUDY VARIABLES

PAIN

Patients were provided with a Visual Analogue Scale with a score of 0-10 and were instructed to choose a score that best describes the degree of pain.

SCORE	INTENSITY OF PAIN
▪ 0	No pain
▪ 1-3	Mild pain
▪ 4-7	Moderate pain
▪ 8-10	Severe pain

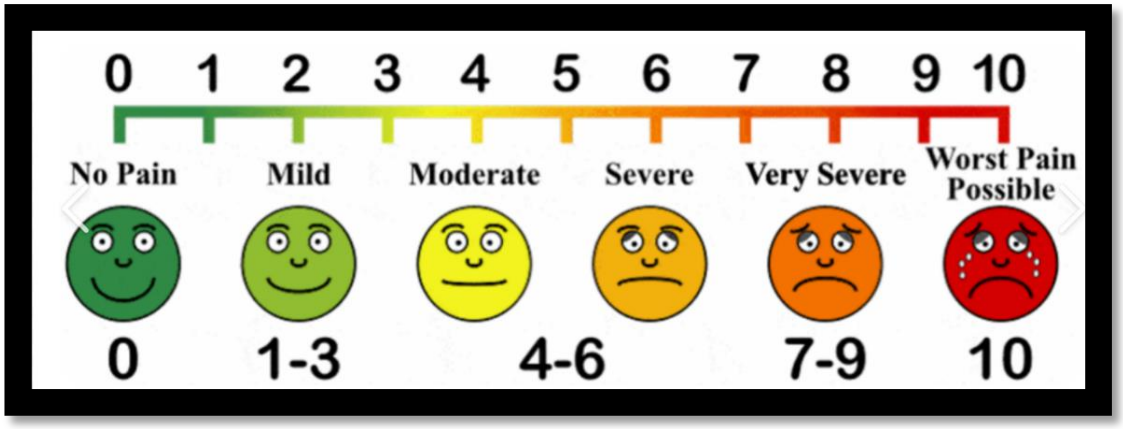


Image 3: Visual Analogue Scale

MOUTH OPENING

It is the measurement of interincisal distance attained during the active mouth opening by the subject. It was measured using a vertical ruler. Opening of less than 35 mm was considered abnormal in an adult. There was no upper limit of normal, but few patients can exceed 60 mm comfortably. The corresponding values of every subject will be recorded.

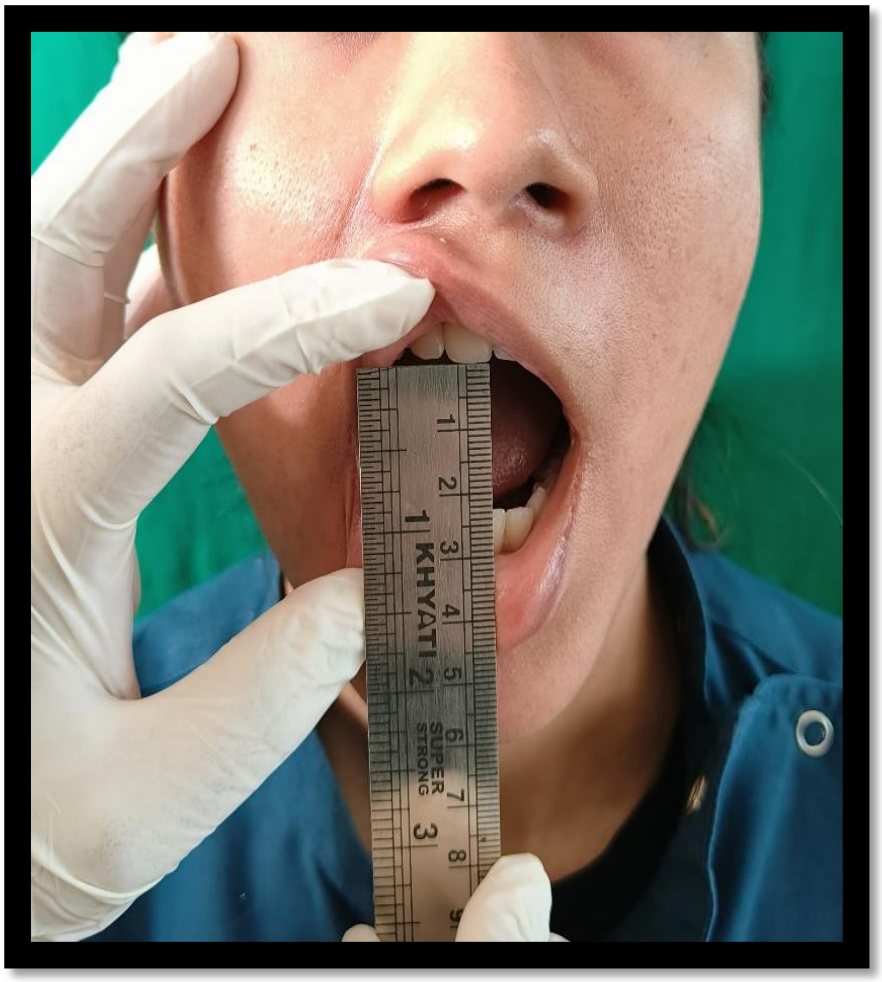


Image 4: Mouth opening recorded using measurement scale

CLICKING SOUND, CREPITUS

On palpation:

The examiner's middle and index fingers were positioned over the lateral pole and slightly in front of the condyle and the patient was instructed to open and close their mouth during the examination, and using very light pressure, listen carefully for audible TMJ noises.

On auscultation:

A stethoscope was placed over the anterior zygomatic bone, and listened for joint noise. The patient was instructed to, close, protrude, right, and left lateral movements with their teeth apart as the examiner listens for joint sounds. The findings were recorded.

Image 5: Palpation of the temporomandibular joint area for clicking/popping sounds at closed and open mouth positions.

RANGE OF JAW MOTION

For **lateral** movements, the patient was instructed to move their jaw fully to one side with the teeth only slightly apart, and hold that position. This distance was measured and repeated the same movement to the opposite side.

To measure the **protrusive** jaw motion, the patient was instructed to move their jaw as forward as possible and this distance was recorded.

Image 6: Range of jaw motion recorded at maximum lateral position.

DEVIATION OF MOUTH

The opening pattern of mouth was observed for deviation. The mandible often deviates towards the affected side during opening because of muscle spasm or mechanical locking by a displaced meniscus.

The pattern was observed and noted to record this parameter.

MUSCLE TENDERNESS

The masticatory muscles were palpated and searched for areas of tenderness or sustained contraction;

1. **Masseter** muscle at its attachments to the zygomatic arch and angle of the mandible,

2. **Temporalis** both in the temporal fossa and intraorally along the ascending ramus of the mandible,

3. **Medial pterygoid** bimanually, placing one finger externally at the medial aspect of the angle of the mandible and the other finger orally in the lingual vestibule in the retromolar region.

4. **Lateral pterygoid** is accessible to the examining finger intraorally posterior to the maxillary tuberosity. All the findings were recorded.

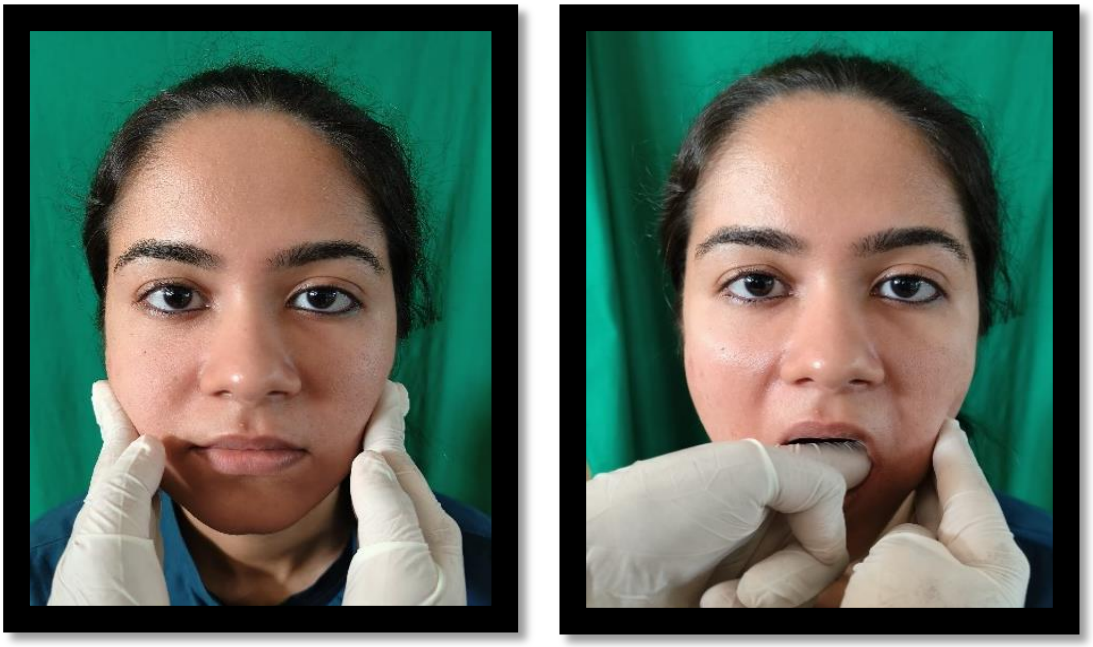


Image 7: Palpation of masseter muscle.

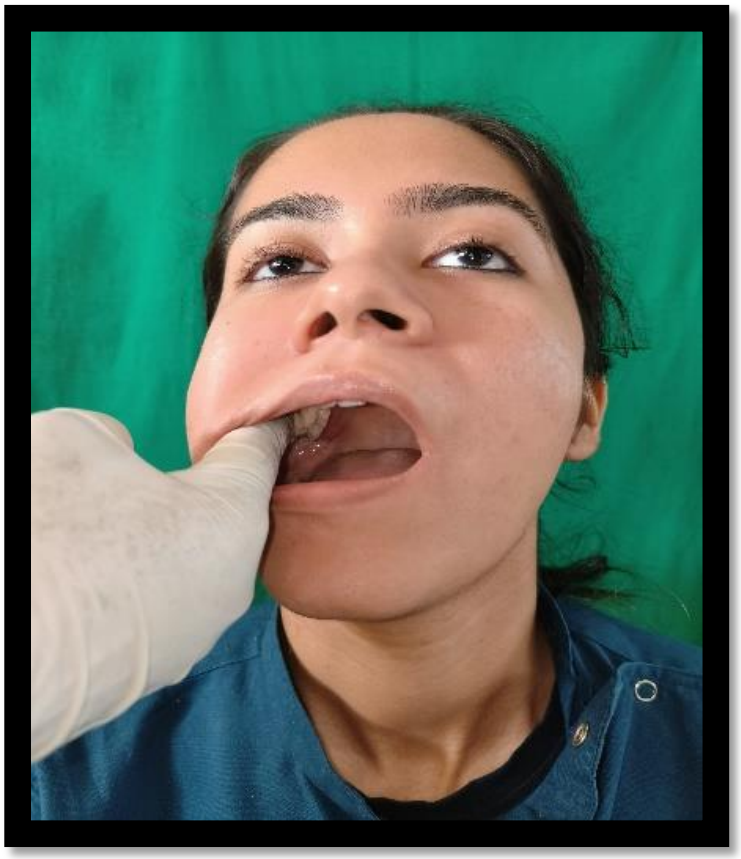


Image 8 : Palpation of lateral pterygoid muscle.

AGGREVATING / RELIEVING FACTORS

Any aggravating or relieving factors observed were noted.

Aggravating: On eating, parafunctional habits, trauma,

Relieving: Medication, non-pharmacological methods (massage, stretching, heat / ice)

ORTHOPANTAMOGRAM

OPGs with their respective reports of all subjects were used for further evaluation to find out if any obvious bony deformities were present.

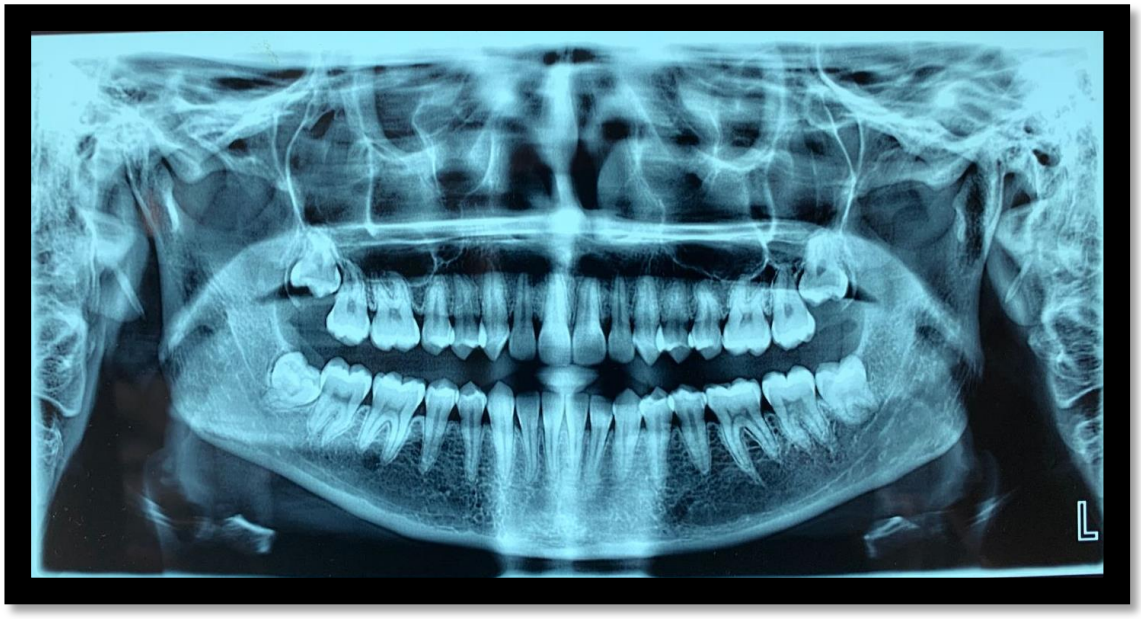


Image 9: Orthopantomogram

DISC DISPLACEMENT

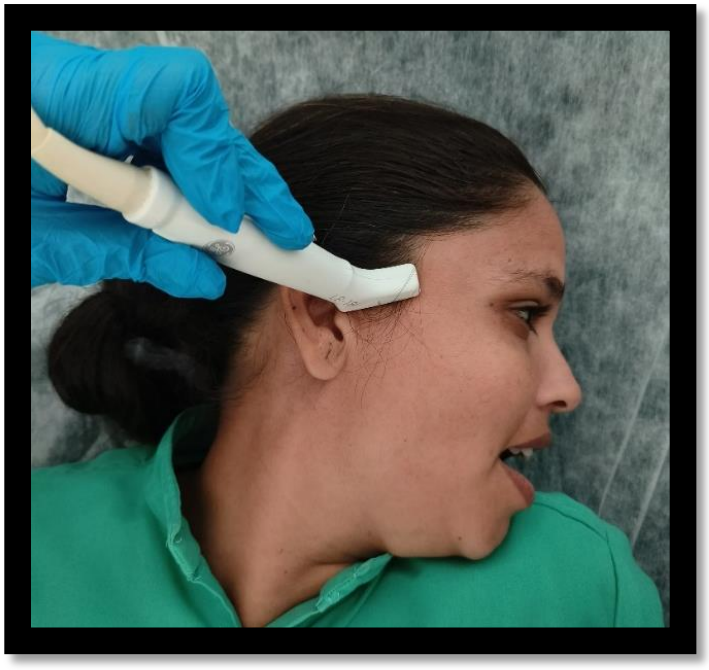


Image 10: Position of probe on skin surface to locate the disc on ultrasonography (open mouth)

Image 11: Position of probe on skin surface used to locate the disc on ultrasonography (closed mouth)

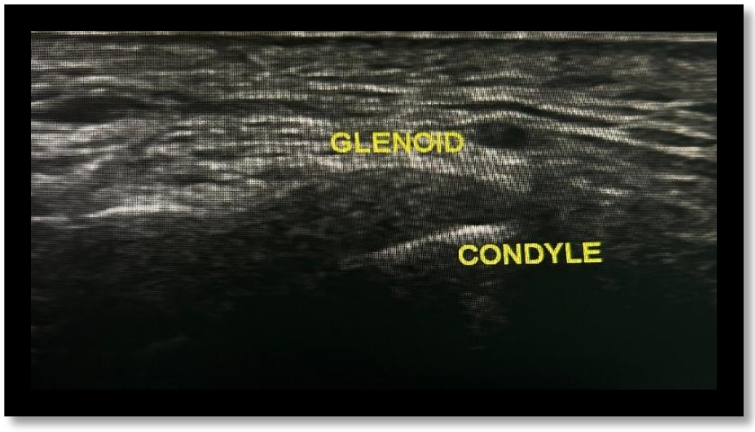


Image 12: Ultrasonography showing glenoid fossa and condyle

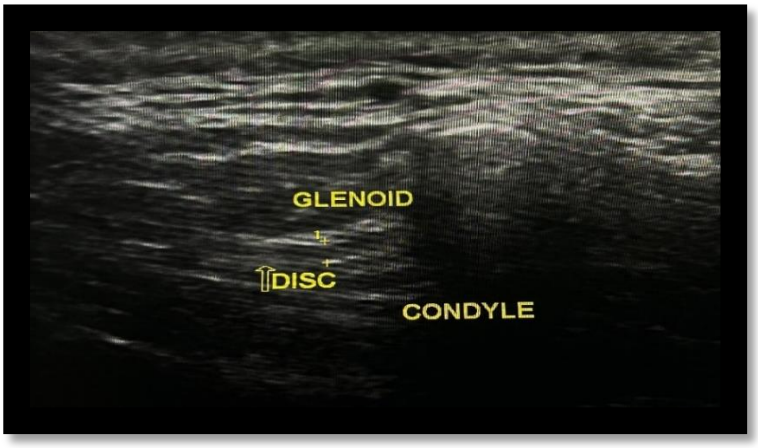


Image 13: Ultrasonography showing normal disc position with joint space measurement

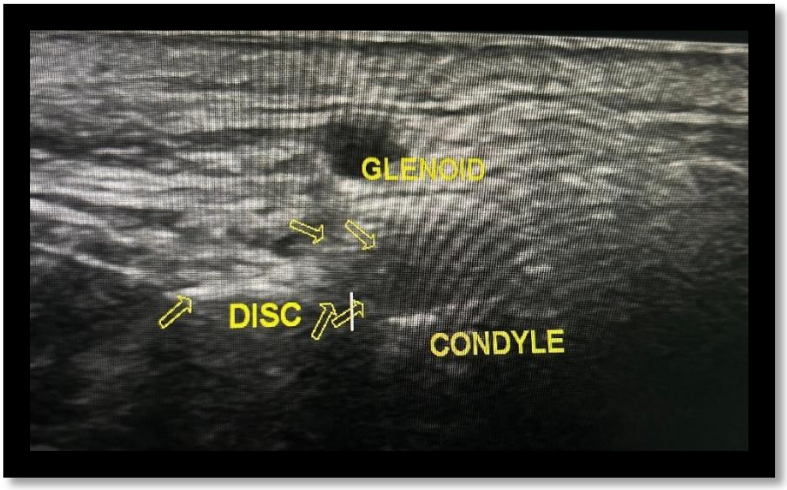


Image 14: Ultrasonography showing disc with pathology showing anterior disc displacement

DATA COLLECTION METHODS AND ANALYSIS

The subjects were initially subjected to clinical examination of temporomandibular joint followed by orthopantomogram.

Further all the subjects were taken up for ultrasonographic examination.

All the findings were noted and sent for analysis.

RESULTS

DEMOGRAPHIC DATA:

GENDER

In this prospective case control study, a total of 70 subjects were included (31 males and 39 females) wherein sixteen males and nineteen females were included in the study group and fifteen males and twenty females in the control group.

Statistically significant difference was not noted along both the groups in terms of gender. The following table shows the distribution of males and females in the study and control groups. Chi- Square test was applied. The P value is 0.810.

Table 1: Table depicting distribution of gender in study and control group

Groups	Gender		Total	P Value
	Male	Female		
Disease	16	19	35	**0.810**
Control	15	20	35	
Total	31	39	70	

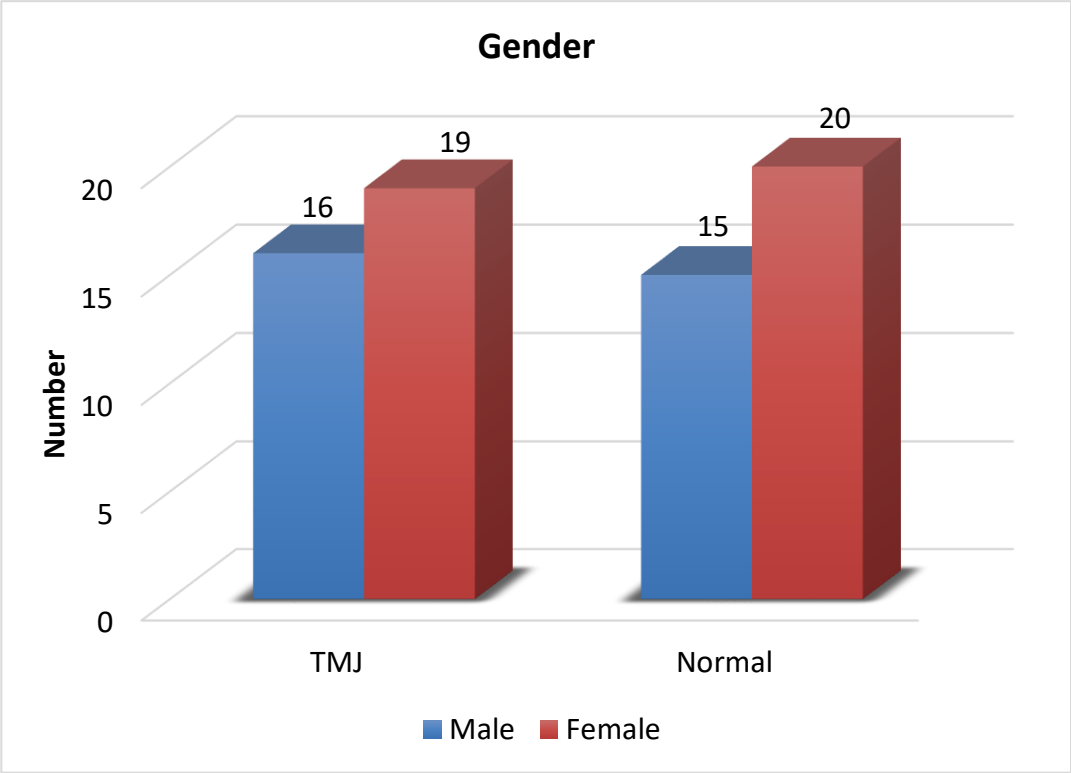


Figure 1: The above graph denotes the gender distribution of the subjects who participated in the study. There were 16 males and 19 females noted in the study group and 15 males and 20 females noted in the control group.

AGE

Majority of the patients in the study group; that is 14 subjects were aged between 20-29 years, 13 subjects were aged between 30-39 years, 6 subjects aged between 40-49 years and 1 subject at an age group of 50-59 years. This infers that majority of the patients who have Temporomandibular disorders were from 20-29 years age group.

Statistically significant difference was noted among the study and control groups. The following table portrays the mean age, standard deviation and P value of age variable which was calculated using unpaired t-test where P value ≈ 0.027.

Table 2: Table showing mean, standard deviation and p value of age in both groups

	Groups	N	Mean	Standard Deviation	P Value
Age	TMJ	35	32.54	7.457	**0.027**
	Normal	35	28.83	6.233	

CLINICAL PARAMETERS

CLICKING AND CREPITUS

In the clinical examination, clicking / crepitus were noticed in 29 subjects from the study group, whereas 6 subjects did not show signs of clicking / crepitus. No clicking / crepitus were noticed in all the 35 subjects in the normal group.

Statistically significant difference was noted between the study and control groups. The following table shows the presence of clicking/crepitus in all the subjects of the study. It was calculated using Chi-Square test. P value ≈ 0.000

Table 3: Table showing the presence of clicking/crepitus in both groups

Groups	Clicking / Crepitus		Total	P Value
	Yes	No		
Disease	29	6	35	**0.000**
Control	0	35	35	
Total	29	41	70	

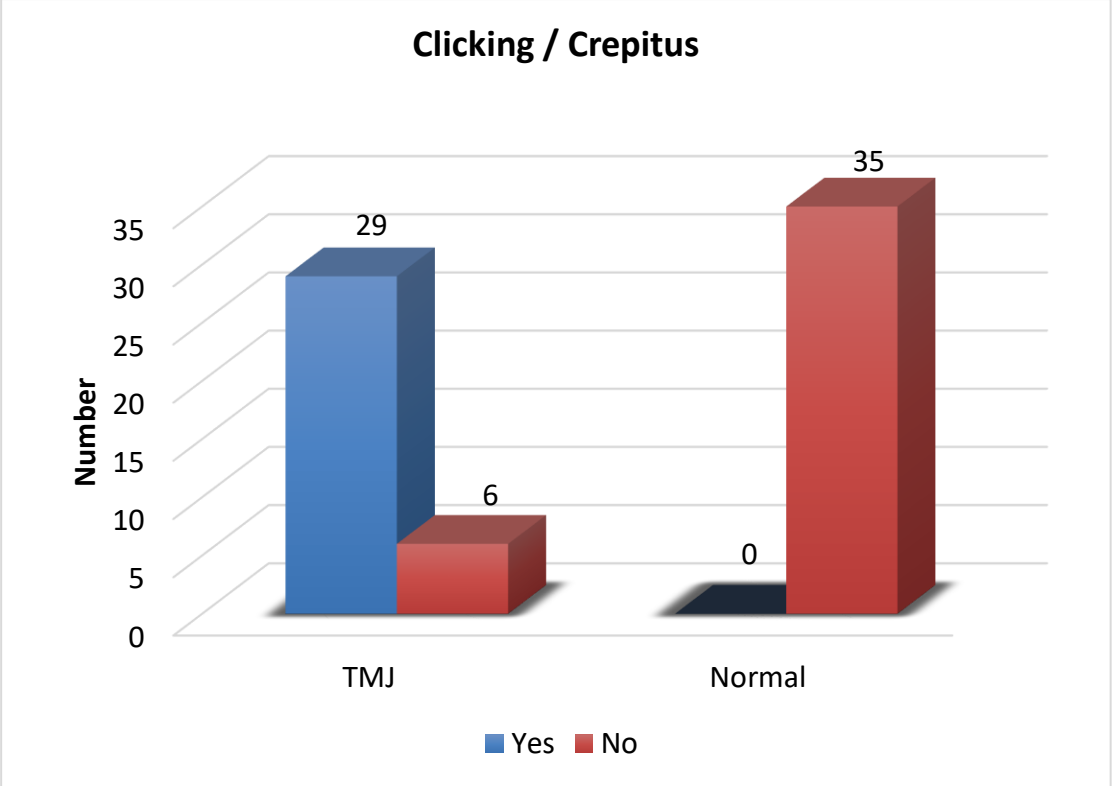


Figure 2: The above graph depicts that 29 subjects had clicking/crepitus as compared to 6 subjects who did not experience any clicking/crepitus. None of the subjects in the control group had clicking/crepitus.

DEVIATION

Deviation was noted among 24 subjects whereas 11 subjects did not show any evident deviation from the study group. Majority of the study subjects had significant deviation noted. None of the subjects in the normal group had any deviation noted.

The following table shows the number of subjects who were noted for deviation of mouth using Chi-Square test. P value ≈ 0.000, hence statically significant between both groups.

Table 4: Table depicting deviation noted amongst the subjects in the control and study group.

Groups	Deviation		Total	P Value
	Present	Absent		
Disease	24	11	35	**0.000**
Control	0	35	35	
Total	24	46	70	

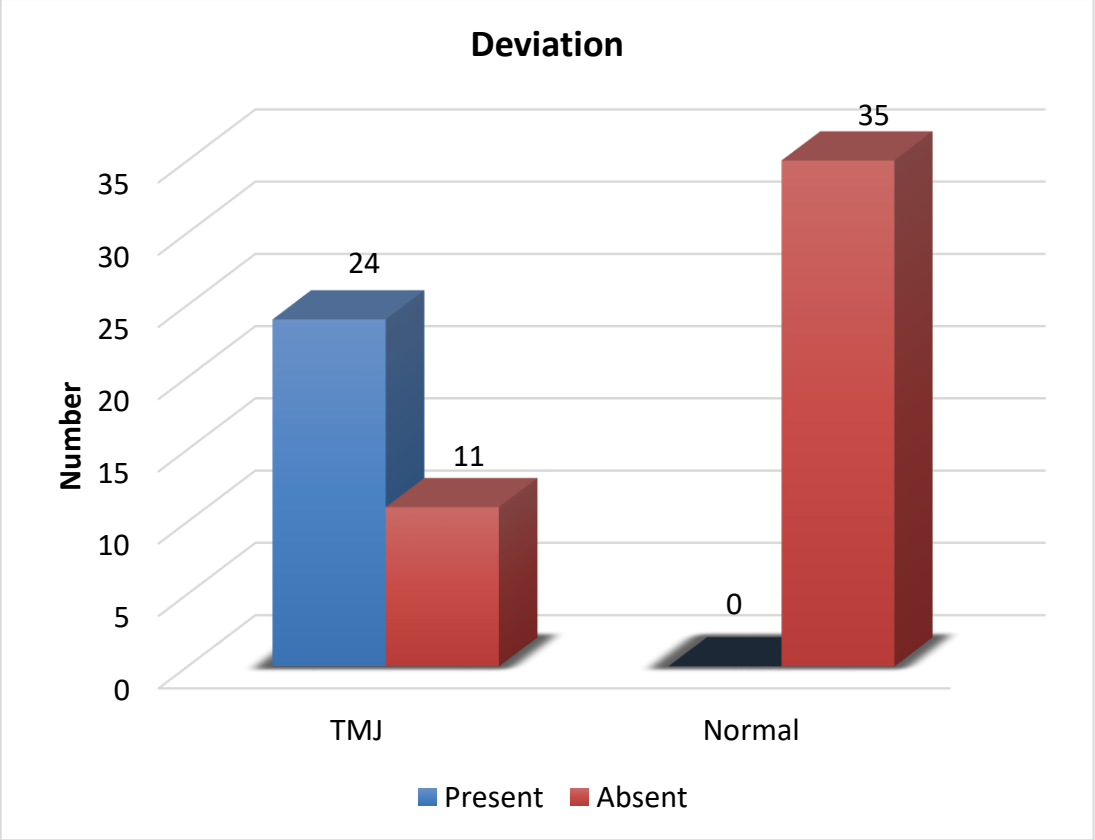


Figure 3: The above graph shows the number of subjects showing deviation among the study and control groups.

MUSCLE TENDERNESS

Subjects were examined for muscle tenderness in both groups. 94% of the study subjects experienced tenderness of muscles on palpation while 6% did not exhibit any tenderness on examination.

The following table shows that 33 of the study subjects exhibited tenderness and the other two subjects did not exhibit any significant muscle tenderness. Chi-Square test was applied to attain the values. P value is < 0.05, hence statistically significant difference was noted.

Table 5: Table shows the number of subjects who experienced muscle tenderness during palpation.

Groups	Muscle Tenderness		Total	P Value
	Yes	No		
Disease	33	2	35	**0.000**
Control	2	33	35	
Total	35	35	70	

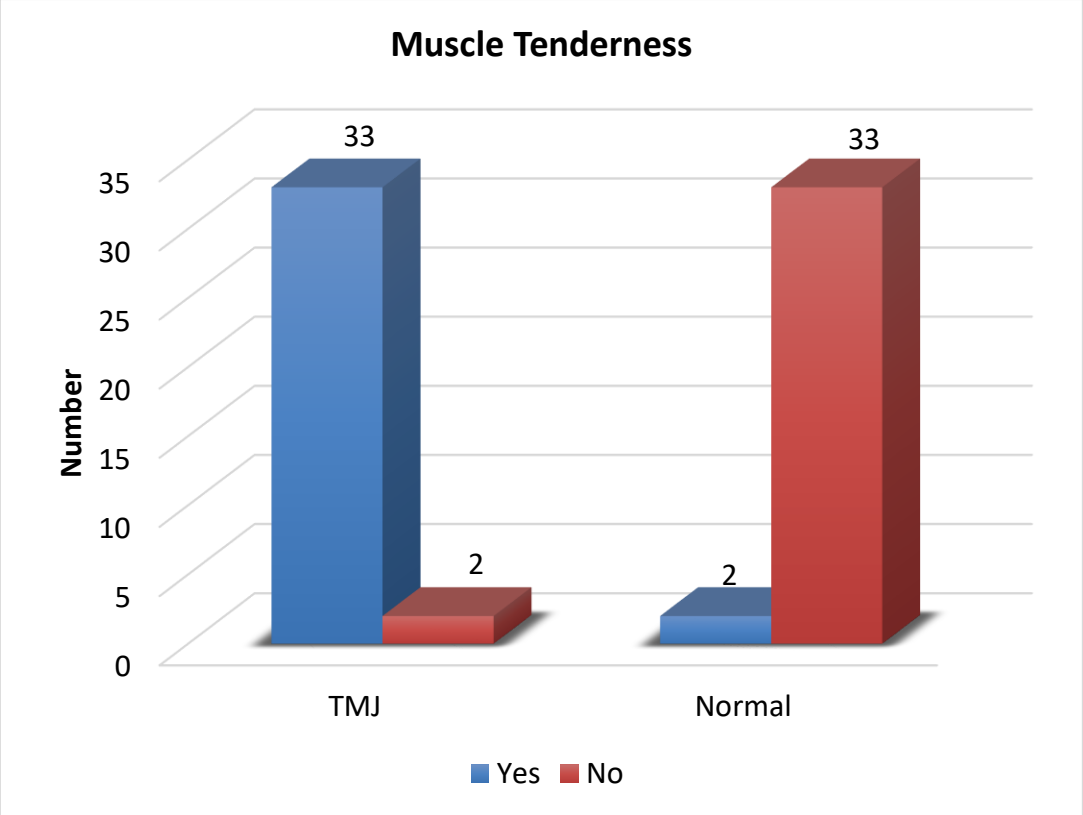


Figure 4: The above graph depicts the muscle tenderness experienced by the subjects of both study and control groups on palpation.

ULTRASONOGRAPHY PARAMETERS

During the ultrasonographic examination, significant disc displacement was observed in 33 subjects whereas 2 subjects did not show much changes in the disc position. None of the subjects in the disease-free group showed disc displacement.

Statistically significant difference was noted among both the groups. The following table shows the disc placement of all the subjects who participated in the study which were calculated using Chi-Square test. P value is 0.000.

Table 6: Table showing the displacement of disc on ultrasonography in both groups

Groups	Disc Displacement		Total	P Value
	Yes	No		
Disease	33	2	35	**0.000**
Control	0	35	35	
Total	33	37	70	

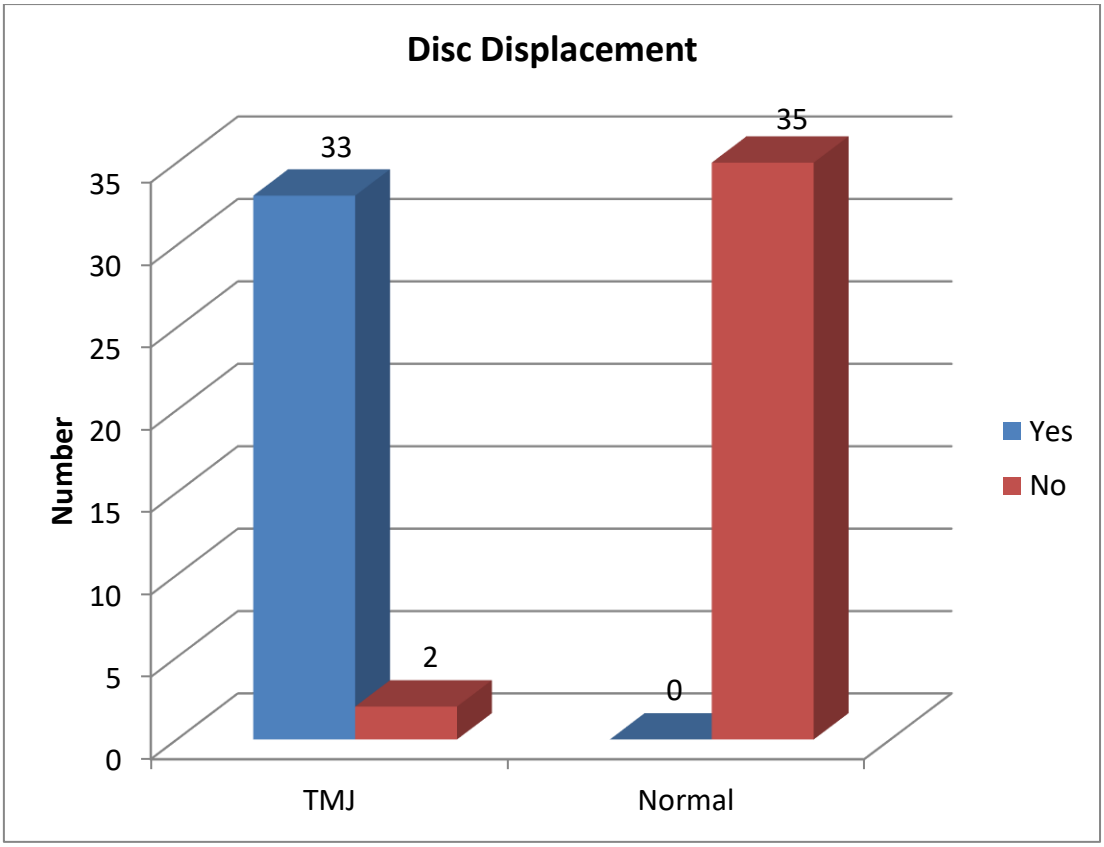


Figure 5: The above graph shows the disc displacement among the normal and study groups.

Table 7: The following table shows comparison of the study and control group for parameters such as pain, mouth opening, range of jaw motion and joint space distance in the ultrasonography. Statistically significant difference was noted between the two groups in view of pain, mouth opening, range of jaw motions and joint space distance. (P Value = 0.00). These were calculated using Mann-Whitney test to get their mean ranks and sum of these ranks to attain a P value < 0.05.

Variables	Groups	N	Mean Rank	Sum of Ranks	P Value
Pain	Disease	35	52.99	1854.50	**0.000**
	Control	35	18.01	630.50	
Mouth Opening	Disease	35	18.61	651.50	**0.000**
	Control	35	52.39	1833.50	
Range of Jaw Motion	Disease	35	18.00	630.00	**0.000**
	Control	35	53.00	1855.00	
Joint Space Distance	Disease	35	52.00	1820.00	**0.000**
	Control	35	19.00	665.00	

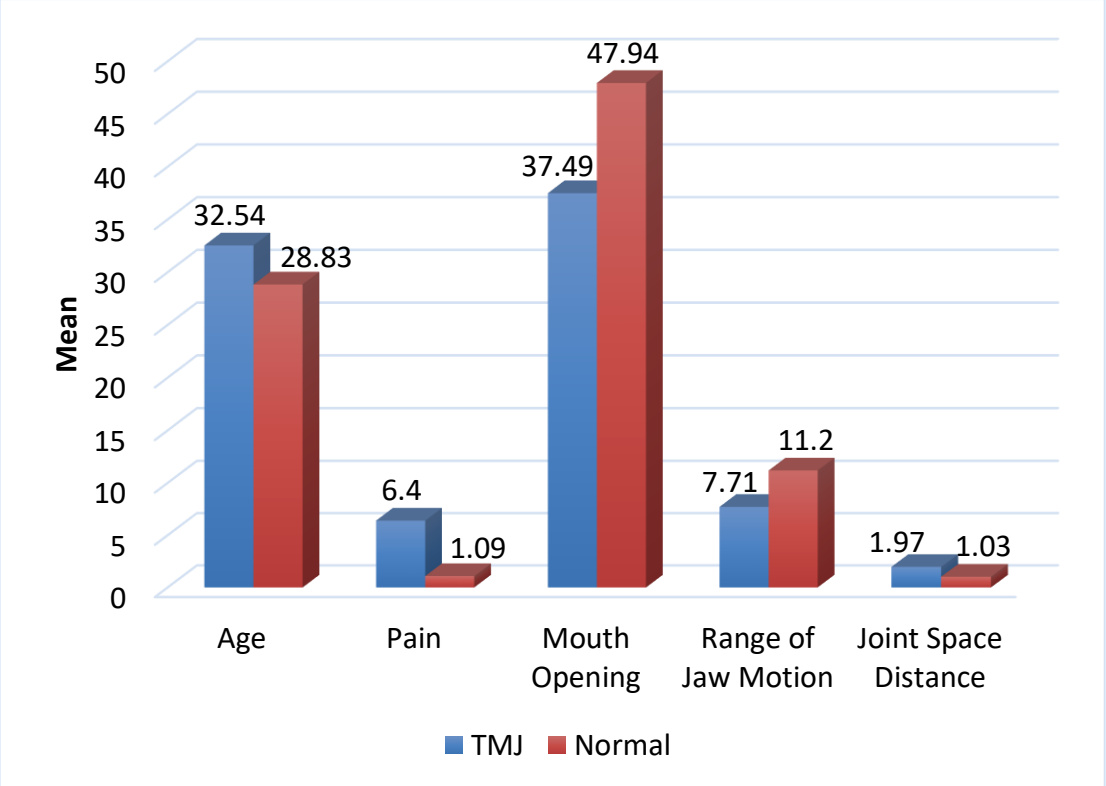


Figure 6: The above graph shows the mean values of quantitative parameters such as age, pain, mouth opening, range of jaw motion and joint space distance.

Table 8 : The following table shows relation between the clinical diagnosis and the ultrasonography diagnosis.

USG Diagnosis	Clinical Diagnosis		Total
	Disease	No disease	
Disease	31	0	**31**
No disease	2	2	**4**
Total	33	2	**35**

True Positive (a) **31**	**False Positive (c)** **0**
False Negative (b) **2**	**True Negative (d)** **2**

Table 9: The following table shows the disease prevalence based on clinical gold standard findings. It shows 93.94% sensitivity and 100% specificity and a disease prevalence of 94.29% using clinical examination between study and control groups.

Statistic	Value	95% Cl
Sensitivity	93.94%	79.77% to 99.26%
Specificity	100.00%	15.81% to 100.00%
Positive likelihood ratio	-	-
Negative likelihood ratio	0.06	0.02 to 0.23
Disease prevalence	**94.29%**	80.84% to 99.30%
Positive predictive value	100.00%	88.78% to 100.00%
Negative predictive value	50.00%	20.70% to 79.30%
Accuracy	94.29%	80.84% to 99.30%

Table 10: The following table shows the disease prevalence among the normal and study groups based on ultrasonographic findings. It shows 93.94% sensitivity, 100% specificity and a disease prevalence of 88.57% which is within the 95% Confidence Intervals.

Statistic	Value	95% Cl
Sensitivity	93.94 %	79.77% to 99.26%
Specificity	100.00%	15.81% to 100.00%
Positive likelihood ratio	**Infinity**	-
Negative likelihood ratio	0.06	0.02 to 0.23
Disease prevalence	**88.57 %**	69.47 % to 94.14 %
Positive predictive value	100.00%	88.78% to 100.00%
Negative predictive value	68.04%	35.72% to 89.08%
Accuracy	94.63%	81.34% to 99.41%

Table 11: The following table depicts categorization of variables such as pain, mouth opening, range of jaw motion and joint space distance into mild, moderate and severe based on a range of values.

Variables	Categories	Range
Pain	Mild	3- 5
	Moderate	5-7
	Severe	7- 10
Mouth Opening	Mild	40 - 36
	Moderate	35 – 31
	Severe	30 - 25
Range of Jaw Motion	Mild	8 - 9
	Moderate	7-8
	Severe	6-7
Joint Space Distance	Mild	1.5- 1.80
	Moderate	1.81 - 1.89
	Severe	1.90 - 1.95

DISCUSSION

After odontogenic pain, temporomandibular disorders (TMDs) rank among the most prevalent causes of discomfort in the oral and facial regions, with the potential to result in persistent or chronic pain. Additionally, they also frequently occur in association with clenching and depression. Hence, early identification, counselling and management are pivotal in enhancing prognosis and mitigating the adverse effects of these conditions on quality of life. Population-based studies reveal that TMD affect approximately 10% to 15% of adults. However, it's noteworthy that only a minority, around 5%, actively seek treatment for these issues. [50] [51]

The diagnosis of temporomandibular disorders (TMD) initially depends on the history and clinical examination of patient. TMD symptoms typically manifest during jaw movements such as opening and closing of the mouth, as well as during chewing, often leading to pain in areas like the preauricular, masseter, or temporal regions. Although jaw sounds like clicking, popping, locking of the joint or crepitus occur along with TMD, they also appear in up to 50% of asymptomatic individuals. [52][53] [54]

Imaging serves as a valuable aid in diagnosing temporomandibular disorders (TMD), especially when the patient history and clinical examination results are inconclusive. Various imaging modalities offer additional insights into suspected TMD aetiologies ranging from non-invasive techniques like orthopantomogram, conventional radiographs which can reveal fractures, dislocations, and severe degenerative diseases. CT is better compared to plain radiography in assessing bony deformities and for comprehensive joint evaluation. Currently, MRI is reserved as the gold standard for patients, it's high cost and time-consuming nature are the main drawbacks.

Nabeih and Speculand in 1991 first visualized the temporomandibular joint and disc using ultrasonography (41) In 1992, Stefanoff et al. checked the TMJ disc in subjects using a 5-MHz transducer and documented favourable outcomes. Since then, ultrasonography has come up as an important diagnostic method in the detection of TMJ disorders, as it is less expensive and less time consuming and offers dynamic imaging. High-resolution ultrasonography (HR-US) has shown superior outcomes in recent times. This dynamic view aids investigators in detecting the disc's position more precisely compared to static examinations. [(55) (56)]

US exhibited a sensitivity 75-90 % and specificity ranging from 80-100%, average accuracy is 75%, positive predictive value and negative predictive value being 92% and 42%, respectively in diagnosing TMJ disorders [57] Meanwhile MRI showed sensitivity between 70-95% and specificity 75-100% , accuracy of 80%, average positive predictive value and negative predictive value and likelihood ratio are 95% and 66%. [44] This shows that though MRI being the gold standard does not reveal 100% sensitivity and specificity results and shows similar range of values with ultrasonography. Hence ultrasonography can be considered as a viable diagnostic tool for temporomandibular disorders. [58]

Mean age of study subjects was 32.54 and control subjects were 28 and a total of 31 male subjects and 39 female subjects participated for the study. difference noted among both the groups in terms of age, pain, clicking/crepitus, deviation, muscle tenderness, range of jaw motion and disc displacement and joint space distance assessed on ultrasonography ($P < 0.05$).

However, the difference was not there noted among the gender of subjects in both groups ($P = 0.810$), which suggests that TMD is not gender specific.

The surface of the condyle exhibits hyperechoic characteristics in ultrasound imaging, and appears white . Conversely, connective tissues, including the joint capsule, retrodiscal tissue, and muscles display isoechoic features, appearing as a heterogeneous grey in ultrasound images.

Notably, the joint capsule's margin reflects ultrasound waves intensely, creating a distinct hyperechoic white line. These anatomical spaces, though typically not observable, become apparent in cases of effusion, as the opposing surfaces come into contact.

The space measurement of joint involves assessing the distance from the condyle's contour to the articular which offer optimal assessment. [59]

Based on the clinical and ultrasonographic findings a co-relation table was made between the clinical and ultrasonographic diagnosis. Clinically, 33 subjects were detected positive for the disease and 2 were detected disease free. And after these subjects underwent ultrasonography of temporomandibular joint, 31 subjects were detected positive for the disease and 4 were detected disease free.

Sensitivity and specificity and disease prevalence, positive likelihood ratio, negative likelihood ratio, positive predictive value, negative predictive values were calculated. In the clinical examination, 93.94% sensitivity, 100.00% specificity and 94.29% disease prevalence were noted. There was 93.4% sensitivity, 100% specificity and 88.57% disease prevalence in ultrasonography which were within the 95% Confidence Interval limits. In most of the studies specificity was more compared to sensitivity. [36]

To make diagnosis easier, an ultrasonographic classification was formulated using the joint space distance into mild, moderate and severe. All the subjects in the study group were then subjected for further management according to Weinberg & Shankland classification (1982) as Palliative, Causative, Adjunctive, Definitive.

Initial treatment advised was conservative management which included soft diet, restriction in mouth opening, muscle relaxants. If the symptoms were not resolved, the patients were further advised for occlusal splint therapy in adjunct with the conservative measures. For worser conditions, arthrocentesis was advised followed by splint therapy. [60]

Hence, our study concluded that ultrasonography can be done for internal derangement and patients can be advised for treatment plan based on the clinical and ultrasonographic findings. The study group subjects underwent both non-invasive and interventional modalities for the resolution of their symptoms. The continuation of the treatment modalities and their outcome will be documented in further studies.

CONCLUSION

The selection of the appropriate radiological imaging for temporomandibular joint (TMJ) evaluation, along with the selection of the patient, requires careful consideration by the clinician, taking into account the patient's clinical manifestations. The primary objective of the chosen radiographic investigation should be to enhance both diagnosis and treatment outcomes, pertaining to specific indications and varying levels of sensitivity and specificity of each imaging modality.

Currently, although Magnetic resonance imaging (MRI) is the most commonly recognized gold standard imaging modality but because of its high cost and time-consuming nature, many patients discontinue further investigations. This study attained results showing the range of sensitivity and specificity in ultrasonography which when compared to that of MRI, arrives at near limits and thus can be used an alternative approach for the diagnosis of a temporomandibular disorder. Additionally, the non-invasive nature, less cost and less time consumption of high resolution ultrasonography promises it as a potential diagnostic tool for assessing TMJ disc positioning.

The study group subjects underwent both non-invasive and interventional modalities for the resolution of their symptoms.

LIMITATIONS

This study focussed on the use of ultrasonography as a promising diagnostic tool in the assessment of disc position in internal derangement of temporomandibular joint particularly in the North Karnataka region using 70 subjects. Although, few limitations warrant for consideration of further studies to improve these results.

Studies confined to a particular region may limit the generalized results hence, this necessitates the need for further studies at **larger geographical populations**.

Also, **larger sample size** enhances the study results and can also allow sub group analyses which can yield better results.

Use of **higher resolution** frequency of the probe can help in better visualizing the disc displacement; promising better results.

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ANNEXURE I

ETHICAL CLEARANCE CERTIFICATE

Research and Ethics Committee
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A Constituent Unit of KLE Academy of Higher Education & Research
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CERTIFICATE

Sl. No. : 1594

EC/NEW/INST/2021/2435
Research & Ethics Committee

This is to Certify that the synopsis titled

ASSESSMENT OF DISK POSITION IN INTERNAL DERANGEMENT OF TEMPOROMANDIBULAR JOINT USING ULTRASONOGRAPHY AS A DIAGNOSTIC TOOL - A PROSPECTIVE STUDY IN NORTH KARNATAKA REGION *Submitted by*

Dr. REG.NO. – IF0221005 *P. G. Student /*

Staff, Guided by [redacted] *from Department of*

Co Guide Dr. [redacted]

Oral and Maxillofacial Surgery *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

Date : 08-04-2024

Member Secretary
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

Chairman
Research and Ethical Committee
KLEVK Institute of Dental Sciences
Belagavi

ANNEXURE II

BIOSTATISTICS CLEARANCE CERTIFICATE

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Biostatistics Clearance Certificate

This is to certify that Biostatics aspect of the Dissertation/Research work of REG.NO. – IF0221005 **Post Graduate Student,** under the guidance of **Professor, Department of Oral and Maxillofacial** Surgery, entitled **"Assessment Of Disk Position In Internal Derangement Of Temporomandibular Joint Using Ultrasonography As A Diagnostic Tool - A Prospective Study In North Karnataka Region** has been done under my guidance and considered satisfactory.

Place: Belagavi
Date : 2/9/2024

Name & Signature of Biostatistician
Dr Anuradha Bandivadekar

ANNEXURE III

PLAGERISM CHECK CERTIFICATE

Scientific Correspondence and Review Committee

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PLAGIARISM CHECK REPORT

Name of the Applicant : REG.NO. – IF0221005
UG / PG / Ph.D / Staff : POST GRADUATE
Batch & Year : 2021 - 2024
Department : ORAL AND MAXILLOFACIAL SURGERY

The soft copy of Research Work / Manuscript by REG.NO. – IF0221005 . entitled

"ASSESSMENT OF DISC POSITION IN INTERNAL DERANGEMENT OF TEMPOROMANDIBULAR JOINT USING ULTRASONOGRAPHY AS A DIAGNOSTIC TOOL - A PROSPECTIVE STUDY IN NORTH KARNATAKA REGION"

under the guidance of .....has been submitted for Anti-Plagiarism check to the Scientific Correspondence & Review Committee of KLE VK Institute of Dental Sciences using "Turn-it-in" software.

The scan has been carried out and the scanned output reveals a Similarity Index of ..... 4 %, which is **within** / **not within** the acceptable limits of 10% as per the UGC guidelines.

10/04/2024

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