RESEARCH PAPER

Assessment and Intervention of Transcutaneous Electrical Nerve Stimulation in Temporomandibular Disorder using Jaw Vibratory Analysis (JVA) in Patients Undergoing Implant Placement - A Clinical Study

Janani G[1], Sahana Selvaganesh[2*], Thiyaneswaran N[3]

[1]Postgraduate, Saveetha Dental College & Hospitals, Saveetha Institute of Medical & Technical Sciences, Saveetha University, Chennai, Tamilnadu, India. Email: 152303002.sdc@saveetha.com

[2*]Assistant Professor, Department of Implantology, Saveetha Dental College, Saveetha Institute of Medical & Technical Sciences, Saveetha University, Chennai, Tamilnadu, India.
Email: sahanas.sdc@saveetha.com (Corresponding Author)

[3]Professor and Head, Department of Implantology, Saveetha Dental College, Saveetha Institute of Medical & Technical Sciences, Chennai, Tamilnadu, India. Email: dr.thiyan@gmail.com

ABSTRACT

Background: Temporomandibular disorders (TMD) are common conditions affecting the temporomandibular joint (TMJ) and associated musculature, often presenting with pain, joint sounds, and functional limitations. Dental implant procedures, which require prolonged mouth opening, may exacerbate or precipitate TMD symptoms. Objective diagnostic tools such as Joint Vibration Analysis (JVA) and conservative treatment modalities like Transcutaneous Electrical Nerve Stimulation (TENS) play a crucial role in the assessment and management of these conditions.

Aim: To evaluate TMJ status using JVA in patients undergoing implant placement and to assess the effectiveness of TENS therapy compared to warm compression in reducing TMD-related pain.

Materials and Methods: A cross-sectional clinical study was conducted on 60 patients aged 20–60 years undergoing dental implant placement with TMD symptoms. Participants were randomly divided into two groups: Group A (TENS therapy) and Group B (warm compression). Pain levels were assessed using the Visual Analog Scale (VAS) before and after treatment. JVA was performed to objectively evaluate TMJ function. Statistical analysis included paired and unpaired t-tests with significance set at $p < 0.05$.

Results: Both TENS and warm compression significantly reduced pain ($p < 0.001$). Group A (TENS) showed a mean pain reduction of 2.66, while Group B (warm compression) showed a reduction of 0.76. Intergroup comparison demonstrated a statistically significant difference ($p \approx 0.017$), with warm compression showing comparatively greater pain reduction. JVA findings indicated higher vibrational activity in the left TMJ compared to the right, suggesting asymmetrical joint involvement.

Conclusion: Both TENS and warm compression are effective in managing TMD-related pain in patients undergoing implant placement, with warm compression demonstrating superior efficacy. TENS remains a valuable adjunctive modality for symptomatic relief. JVA serves as a reliable, non-invasive diagnostic tool for assessing TMJ function and should be incorporated in preoperative evaluation to improve clinical outcomes.

Keywords: Dental implants, Joint Vibration Analysis (JVA), Orofacial pain, Temporomandibular disorders (TMD), Temporomandibular joint (TMJ), Transcutaneous Electrical Nerve Stimulation (TENS), Visual Analog Scale (VAS)

How to cite this article: Janani G, Selvaganesh S, Thiyaneswaran N. Assessment and Intervention of Transcutaneous Electrical Nerve Stimulation in Temporomandibular Disorder using Jaw Vibratory Analysis (JVA) in Patients Undergoing Implant Placement - A Clinical Study. Int J Drug Deliv Technol. 2026;16(21s): 775-783. DOI: 10.25258/ijddt.16.21s.82

Source of support: Nil.

Conflict of interest: None

Introduction

Edentulism remains a significant global oral health concern, particularly among adult and aging populations, and is frequently associated with progressive alveolar bone resorption. Patients with advanced bone loss often experience considerable functional and esthetic limitations, including compromised mastication, impaired speech, and

difficulty in retaining conventional prostheses. Beyond these functional challenges, edentulism also has profound psychosocial implications, such as reduced self-confidence, social withdrawal, and an increased perception of aging. In contemporary dental practice, implant-supported prosthetic rehabilitation has emerged as a predictable and effective treatment modality that not only restores oral function and esthetics but also helps preserve alveolar bone and enhance overall quality of life [1].

Dental implant therapy is a multi-stage procedure encompassing both surgical and prosthetic phases, often requiring prolonged mouth opening and sustained mandibular positioning. Such clinical conditions may predispose patients to the onset or exacerbation of Temporomandibular Disorders (TMD), particularly in individuals with underlying risk factors such as parafunctional habits including bruxism, clenching, and grinding. Temporomandibular disorders represent a heterogeneous group of conditions affecting the temporomandibular joint, masticatory muscles, and associated structures, and are recognized as one of the most common causes of non-dental orofacial pain. The etiology of TMD is complex and multifactorial, involving an interplay of biomechanical, neuromuscular, psychological, and behavioral components [2]. The clinical presentation of TMD varies widely, ranging from mild discomfort and joint sounds to severe pain, restricted mandibular movement, and functional impairment. While some cases may resolve spontaneously, others persist chronically, posing diagnostic and therapeutic challenges for clinicians [3].

The temporomandibular joint is a unique and highly specialized synovial articulation formed between the mandibular condyle and the temporal bone, functioning in coordination with associated ligaments, articular disc, and masticatory musculature [4]. Its complex biomechanics allow for both rotational and translational movements, making it highly susceptible to functional disturbances. Factors such as prolonged mouth opening during implant placement, iatrogenic trauma, occlusal discrepancies, and pre-existing joint abnormalities may contribute to the initiation or aggravation of TMD symptoms. Therefore, a thorough and systematic evaluation of the temporomandibular joint prior to implant therapy is essential to minimize complications and optimize treatment outcomes [5].

Among the various diagnostic modalities available, Joint Vibration Analysis (JVA) has gained increasing importance as an objective and non-invasive method for assessing temporomandibular joint function [6].

JVA involves the bilateral recording of vibratory signals generated by the TMJs during mandibular movement using sensitive accelerometers or piezoelectric sensors. These signals are subsequently analyzed using specialized software to evaluate parameters such as amplitude, frequency distribution, total vibrational energy, and symmetry between the joints [7],[8].The fundamental principle underlying JVA is that joints with normal biomechanical relationships exhibit minimal friction and therefore produce minimal vibration, whereas structural or functional abnormalities—such as disc displacement, internal derangement, or degenerative changes—lead to increased friction and characteristic vibratory patterns. These vibration signatures provide quantitative and reproducible data that aid in differentiating normal from pathological joint function and enhance the diagnostic accuracy when used in conjunction with clinical examination [9],[10].

To facilitate clinical interpretation of these complex vibratory signals, the Milwaukee Chart (also referred to as the JVA flowchart or classification system) is used. The Milwaukee Chart provides a standardized method to classify TMJ conditions based on JVA parameters, particularly total vibration energy and frequency distribution [11]. It categorizes joint function into different levels ranging from normal joint activity to severe pathological conditions.

Typically, lower vibration amplitudes and low-frequency signals correspond to normal or minimally affected joints, whereas higher amplitude vibrations and increased high-frequency components (>300 Hz) are associated with disc displacement, joint instability, or degenerative changes [12]. The chart thus translates quantitative JVA data into clinically meaningful diagnostic categories, such as normal joint function, disc displacement with reduction (clicking), disc displacement without reduction, and degenerative joint disease (crepitus).

The integration of JVA with the Milwaukee Chart enhances diagnostic accuracy by reducing subjectivity associated with conventional clinical examination methods such as palpation and auscultation. It allows clinicians to objectively assess joint function, identify early or subclinical abnormalities, and monitor disease progression or response to treatment as shown in figure[7].

Management of temporomandibular disorders encompasses a broad spectrum of therapeutic approaches, ranging from pharmacological interventions such as analgesics, muscle relaxants, and antidepressants, to non-invasive modalities including

occlusal splints, physiotherapy, behavioural therapy, and ultrasound therapy. In advanced or refractory cases, surgical interventions such as arthrocentesis or arthroscopy may be indicated. Among conservative treatment options, Transcutaneous Electrical Nerve Stimulation (TENS) has gained considerable attention as a safe, non-invasive, and effective method for pain control. TENS operates by delivering low-frequency electrical impulses through the skin, which modulate pain perception through mechanisms such as the gate control theory and endogenous opioid release [13],[14]. In addition to pain reduction, TENS may also improve muscle relaxation and enhance mandibular function. Previous studies have reported significant reductions in masticatory muscle pain and improvement in functional outcomes following TENS therapy in patients with TMD [15],[16].

Given the potential for dental implant procedures to influence temporomandibular joint dynamics and the availability of objective diagnostic tools such as JVA along with conservative therapeutic modalities like TENS, there is a clear need to evaluate TMJ status prior to implant placement and to manage associated symptoms effectively. Early identification of TMD and appropriate intervention can play a crucial role in preventing exacerbation of symptoms and improving patient comfort during and after implant therapy[17], [18].

The present study aims to emphasize the importance of comprehensive temporomandibular joint evaluation prior to implant placement and to assess the effectiveness of TENS therapy as an adjunct modality in managing TMD-related pain. The study also compares the efficacy of TENS therapy with warm compression in reducing pain among TMD patients undergoing implant placement.

Materials and methods

This cross-sectional study was conducted at Saveetha Dental College and Hospital between November 2023 and March 2024 after obtaining ethical clearance from the Institutional Ethical Committee of Saveetha University (IHEC/SDC/IMPLANT-2302/24/260).

A total of 60 patients undergoing dental implant placement and presenting with symptoms of temporomandibular disorders were included in the study. Written informed consent was obtained from all participants.

Inclusion Criteria

- Patients aged 20–60 years
- Presence of pain, tenderness, stiffness, clicking, or crepitus in the TMJ or masticatory muscles
- Patients undergoing implant placement
- Posterior Partial edentulousness in the lower jaw

Exclusion Criteria

- Patients with pacemakers or metallic/electrical implants
- History of cardiovascular disease or major surgery
- Pregnant patients
- History of epilepsy or seizures
- Overactive urinary bladder

Assessment

TMD symptoms were evaluated through:

- Assessment questionnaire (pain, discomfort, clicking)
- Clinical examination (palpation and auscultation)

Additionally, Joint Vibration Analysis was performed for all patients using a standardized protocol figure [2],[5]

Sample Size

Sample size was calculated using G*Power software with 95% confidence interval and 80% power, resulting in 60 participants.

Group Allocation

Patients were randomly divided into:

Group A (n = 30): TENS therapy

Group B (n = 30): Warm compression

Intervention

Group A – TENS (TENS machine manufactured by Bharat Medical Systems, Chennai, India) figure [1]

Two electrodes placed:

- One at implant site
- One at cervical region (ground)

Parameters:

- Frequency: 25 Hz
- Pulse: 100 µs
- Mode: Burst
- Duration: 10 minutes

Sessions: Day 0, Day 5, Day 7 as shown in Figure [3].[4]

Group B – Warm Compression

- Warm compression applied for 10 minutes
- Same intervals: Day 0, Day 5, Day 7

Outcome Measure

Pain was assessed using:

- Visual Analog Scale (VAS) (0–10) figure[8]

Recorded:

- Before treatment
- After treatment

Statistical Analysis

- Paired t-test (within group)
- Unpaired t-test (between groups)
- Significance level: $p < 0.05$

RESULTS

In the present study, the age of the participants ranged from 20 to 55 years, with the highest number of patients observed in the third decade of life. A total of 6 patients (15%) were aged 20 years. The majority of participants, 14 patients (35%), belonged to the 21–30 years age group, followed by 12 patients (30%) in the 31–40 years age group.

A smaller proportion of participants, 8 patients (20%), were above 40 years of age, among whom only 1 patient (2.5%) was above 50 years Table[1].

Table 1

Age Group (years)	**Group A (TENS) n (%)**	**Group B (Warm Compression) n (%)**	**Total n (%)**
20	3 (10)	3 (10)	6 (10)
21–30	11 (36.7)	3 (10)	14 (23.3)
31–40	8 (26.7)	4 (13.3)	12 (20)
41–50	6 (20)	2 (6.7)	8 (13.3)
51–60	2 (6.7)	0 (0)	2 (3.3)
Total	**30 (100)**	**30 (100)**	**60 (100)**

Out of the total 60 participants, 24 (40%) were males and 36 (60%) were females, indicating a higher proportion of female participants in the study population Table [2]

Table 2

Gender	Group A (TENS) n (%)	Group B (Warm Compression) n (%)	Total n (%)
Male	12 (40)	12 (40)	24 (40)
Female	18 (60)	18 (60)	36 (60)
Total	30 (100)	30 (100)	60 (100)

JVA PARAMETER

Joint Vibration Analysis (JVA) parameters were recorded and analyzed separately for the left and right temporomandibular joints. For the left TMJ, the mean total integral value was 0.784, indicating the overall vibrational energy of the joint. The mean maximum mouth opening value was 0.024, while the mean high-frequency component (>300 Hz) was 0.669, suggesting the presence of higher frequency vibrations associated with joint alterations.The ratio of high-frequency to low-frequency vibrations (>300 Hz / <300 Hz) was 0.022, reflecting the relative distribution of vibrational energy. The mean diagnostic score obtained was 930, which provides an overall assessment of joint condition based on vibrational characteristics Table [3],figure [6]

Table 3

TOTAL INTEGRAL	.784
MAX MOUTH OPENENING	.024
>300 Hz VALUE	.669
>300 Hz/<300 Hz RATIO	.022
DIAGNOSIS	930

For the right temporomandibular joint, the mean total integral value was **0.137**, representing lower overall vibrational energy compared to the left side. The mean maximum mouth opening value was **0.024**, which was consistent with the left TMJ.The mean high-frequency component (>300 Hz) was **0.094**, indicating comparatively reduced high-frequency vibrations. However, the ratio of high-frequency to low-frequency vibrations (>300 Hz / <300 Hz) was **0.587**, suggesting a relatively higher proportion of high-frequency components within the total vibrational spectrum.The mean diagnostic score for the right TMJ was **335**, which was lower than that observed on the left side, indicating comparatively lesser joint involvement Table [4]

Table 4

TOTAL INTEGRAL	.137
MAX MOUTH OPENENING	.024
>300 Hz VALUE	.094
>300 Hz/<300 Hz RATIO	.587
DIAGNOSIS	335

The mean pre-treatment VAS value in group A was 5.26 and the mean value for post-treatment VAS was 2.9. The mean paired difference was 2.66667. The paired difference was statistically significant on the student's paired *t*-test. The *P*-value was <0.001. The mean pre-treatment VAS value in group B was 3.56 and the mean post-treatment VAS value was 4.2. The mean paired difference was 0.76667. The paired difference was statistically significant on the student's paired *t*-test. The *P*-value was <0.001 Table[5]

Table 5

Group	Mean	Std. Deviation	Sig.(2-tailed)
Group A pre-post	2.66667	1.12444	.000
Group B prepost	.76667	1.25075	.002

The mean pain reduction (pre-VAS value- post-VAS value) in group A was; while in the group B it was 4.1 ± 0.78807. These data were subjected to the student's independent *t*-test and the difference was statistically significant. (*P*-value = 0.019) Table[6]

Table 6

Study group	N	Mean VAS score	SD	Independent t value
A	30	2.66667	0.23472	11.3
B	30	0.76667	0.31079	2.4

*P value was 0.017

DISCUSSION

Analyzing the results of the present study, the age of the patients ranged from 20 to 55 years, with the majority of participants observed in the third (35%) and fourth (30%) decades of life. This finding is consistent with previous studies by Riden,[30] Juniper[31] and Moger et al.,[27] which reported that temporomandibular disorders most commonly occur between the second and fourth decades of life. The higher prevalence in these age groups may be attributed to increased functional demands, occupational stress, and parafunctional habits, all of which contribute to the development of TMD.

In the present study, a higher proportion of participants were females, with 24 (60%) females and 16 (40%) males, indicating a clear female predilection. This observation is in agreement with studies conducted by Isacsson et al.,[19] Dworkin et al.,(20] and Jensen et al.,[21] Manfredini et al.[22] also reported a higher prevalence of disc displacement in females. Furthermore, studies by Berger et al.,[23], [24] and Nekora-Azak [25] have demonstrated a greater prevalence of TMD among women of reproductive age, suggesting a possible hormonal influence. Leucuța et al.,[26] proposed that estrogen receptors present in the temporomandibular joint may influence ligament laxity, pain modulation, and inflammatory responses, thereby contributing to the increased susceptibility of females to TMD. Additionally, psychosocial factors such as higher pain sensitivity and stress-related behaviors may further explain this gender disparity.

With respect to treatment outcomes, the present study demonstrated that both TENS therapy and warm compression were effective in reducing pain associated with temporomandibular disorders. In Group A (TENS), the mean pre-treatment VAS score of 5.35 reduced to 1.90, with a mean pain reduction of 3.45 ± 0.88704, which was statistically highly significant ($p < 0.001$). Similarly, in Group B (warm compression), the mean pre-treatment VAS score of 5.90 reduced to 1.80, with a mean pain reduction of 4.10 ± 0.78807, which was also statistically significant ($p = 0.002$). These findings confirm that both modalities are effective conservative approaches for the management of TMD-related pain.

On intergroup comparison, warm compression demonstrated a greater reduction in VAS scores compared to TENS therapy, and the difference between the two groups was statistically significant. This suggests that thermal therapy, through mechanisms such as increased local blood circulation, muscle relaxation, and reduction of muscle spasm, may provide superior pain relief in the studied population. Warm compression is also simple, cost-effective, and easily accessible, which enhances patient compliance and makes it a practical option in routine clinical practice.

An important aspect of this study was the incorporation of Joint Vibration Analysis (JVA) as an objective diagnostic tool for assessing temporomandibular joint function. JVA provides quantitative analysis of joint vibrations based on parameters such as total integral, frequency distribution, and energy levels. In the present study, the left TMJ exhibited higher total integral (0.784) and high-frequency (>300 Hz) values (0.669) compared to the right TMJ (0.137 and 0.094 respectively), suggesting greater vibrational activity and possible joint dysfunction on the left side.

These findings can be interpreted using the Milwaukee classification system, which correlates JVA vibration patterns with specific joint conditions. Lower amplitude vibrations with minimal high-frequency components are typically associated with normal joint function, whereas increased total energy and high-frequency vibrations indicate pathological conditions such as disc displacement or degenerative changes. The higher diagnostic score observed on the left TMJ (930) compared to the right TMJ (335) further supports the presence of greater joint involvement on the left side in the study population.

The integration of JVA findings with Milwaukee chart interpretation allows for a more objective and standardized assessment of TMJ dysfunction, reducing reliance on subjective clinical examination alone. This is particularly important in patients undergoing implant placement, where prolonged mouth opening and biomechanical stress may exacerbate pre-existing joint abnormalities. Early detection of such changes can aid in timely intervention and improved treatment planning

The findings of the present study are partially consistent with previous literature. Rodrigues et al.[16] demonstrated that TENS application significantly reduces pain in jaw elevator muscles among TMD patients. Similarly, [17] and Rajpurohit et al [18] reported significant improvement in pain and discomfort following TENS therapy. Moger et al [27] also observed that TENS therapy was effective in reducing muscular and chronic pain associated with TMD. These studies support the role of TENS as a beneficial modality in managing TMD symptoms, particularly in cases involving muscular pain.

However, the results of the present study differ from certain other investigations. Kruger et al [28] reported that TENS combined with conservative therapy did not significantly enhance symptom relief in patients with myofascial pain dysfunction. Similarly, Alvarez-Arenal et al. [29] found that the use of TENS in combination with occlusal splints did not produce significant improvement in TMD symptoms. These conflicting findings highlight the variability in response to TENS therapy and suggest that its effectiveness may depend on factors such as patient selection, severity of symptoms, underlying pathology, and treatment protocols.

The variation in outcomes across studies, including the present study, may be attributed to differences in biological, psychological, and social factors influencing temporomandibular disorders. Additionally, variations in TENS parameters such as frequency, intensity, electrode placement, and duration of application may significantly impact treatment outcomes. Differences in study design, sample size, and baseline pain severity may also contribute to discrepancies in reported results.

Another important aspect of the present study is the use of Joint Vibration Analysis (JVA) as an objective diagnostic tool. The observed differences in JVA parameters between the left and right temporomandibular joints indicate asymmetry in joint function, suggesting underlying joint alterations or internal derangements. The higher total integral and frequency values on the left side may reflect increased vibrational activity, which is often associated with pathological joint conditions. The incorporation of JVA in the diagnostic protocol enhances the objectivity of assessment and provides valuable insights into joint biomechanics, thereby aiding in early detection and appropriate management of TMD.

Clinically, the findings of this study underscore the importance of preoperative TMJ evaluation in patients undergoing implant placement. Procedures involving prolonged mouth opening may exacerbate existing joint dysfunction or precipitate new symptoms. Early identification and management of TMD can help prevent complications, improve patient comfort, and contribute to the overall success of implant therapy.

Despite the significant findings, the present study has certain limitations. The relatively small sample size and short follow-up period may limit the generalizability of the results. Long-term studies with larger sample populations and multicentric designs are required to further validate the findings and assess the sustained effects of these treatment modalities.

Overall, the present study highlights the effectiveness of conservative treatment approaches in managing TMD-related pain and emphasizes the need for a comprehensive, multidisciplinary approach that integrates accurate diagnosis, appropriate therapy selection, and patient-specific considerations

CONCLUSION

The findings of the present study demonstrate that both Transcutaneous Electrical Nerve Stimulation (TENS) and warm compression therapy are effective in reducing pain associated with temporomandibular disorders. However, warm compression showed a comparatively greater reduction in VAS scores than TENS therapy, indicating superior efficacy in pain relief within the study population.

Despite this, TENS therapy remains a valuable adjunctive modality due to its non-invasive nature and its ability to provide significant symptomatic relief. It may be particularly beneficial in patients who require additional pain management support during or after implant procedures.

The relatively small sample size of the present study necessitates further research with larger populations and longer follow-up periods to validate these findings and to assess long-term outcomes. Additionally, it should be emphasized that TENS therapy primarily offers symptomatic relief and does not address the underlying etiology of temporomandibular disorders. Therefore, it should be considered as part of a comprehensive, multimodal treatment approach rather than a definitive or curative intervention.

FOOT NOTES

Source of Support: Nil.

Conflict of Interest: None declared

REFERENCES

1. Emami E, de Souza RF, Kabawat M, Feine JS. The impact of edentulism on oral and general health. Int J Dent. 2013;2013:498305. doi: 10.1155/2013/498305. Epub 2013 May 8. PMID: 23737789; PMCID: PMC3664508.

2. Mosaddad SA, Talebi S, Keyhan SO, Fallahi HR, Darvishi M, Aghili SS, Tavahodi N, Namanloo RA, Heboyan A, Fathi A. Dental implant considerations in patients with systemic diseases: An updated comprehensive review. J Oral Rehabil. 2024 Jul;51(7):1250-1302. doi: 10.1111/joor.13683. Epub 2024 Apr 3. PMID: 38570927..

3. Chisnoiu AM, Picos AM, Popa S, Chisnoiu PD, Lascu L, Picos A, Chisnoiu R. Factors involved in the etiology of temporomandibular disorders - a literature review. Clujul Med. 2015;88(4):473-8. doi: 10.15386/cjmed-485. Epub 2015 Nov 15. PMID: 26732121; PMCID: PMC4689239.

4. Alomar X, Medrano J, Cabratosa J, Clavero JA, Lorente M, Serra I, Monill JM, Salvador A. Anatomy of the temporomandibular joint. Semin Ultrasound CT MR. 2007 Jun;28(3):170-83. doi: 10.1053/j.sult.2007.02.002. PMID: 17571700).

5. Abbass MMS, Rady D, El Moshy S, Ahmed Radwan I, Wadan A-HS, Dörfer CE, El-Sayed KMF. The Temporomandibular Joint and the Human Body: A New Perspective on Cross Talk. *Dentistry Journal*. 2024; 12(11):357. https://doi.org/10.3390/dj12110357).

6. Widmalm SE, Williams WJ, Zheng C. Time frequency distributions of TMJ sounds. J Oral Rehabil. 1991 Sep;18(5):403-12. doi: 10.1111/j.1365-2842.1991.tb01685.x. PMID: 1800692.

7. Ishigaki S, Bessette RW, Maruyama T. Vibration of the temporomandibular joints with normal radiographic imagings: comparison between asymptomatic volunteers and symptomatic patients. Cranio. 1993 Apr;11(2):88-94. doi: 10.1080/08869634.1993.11677948. PMID: 8495512.

8. Radke JC, Kull RS. Comparison of TMJ vibration frequencies under different joint conditions. Cranio. 2015 Jul;33(3):174-82. doi: 10.1179/2151090314Y.0000000019. Epub 2014 Jul 31. PMID: 25079855.

9. Kondrat W, Sierpińska T, Radke J. Assessment of the Temporomandibular Joint Function in Young Adults without Complaints from the Masticatory System. Int J Med Sci. 2018 Jan 1;15(2):161-169. doi: 10.7150/ijms.21665. PMID: 29333100; PMCID: PMC5765729.

10. Sharma S, Crow HC, Kartha K, McCall WD Jr, Gonzalez YM. Reliability and diagnostic validity of a joint vibration analysis device. BMC Oral Health. 2017 Feb 16;17(1):56. doi: 10.1186/s12903-017-0346-9. PMID: 28209141; PMCID: PMC5314607.)(Karthik R, et al. Assessing prevalence of TMD using JVA. *J Pharm Bioallied Sci*. 2015;7:S45–S48.

11. Widmalm SE, Williams WJ, Zheng C. Time frequency distributions of TMJ sounds. J Oral Rehabil. 1991 Sep;18(5):403-12. doi: 10.1111/j.1365-2842.1991.tb01685.x. PMID: 1800692

12. Iyer PK, Venugopalan S, N T, Jebaraj S. T-scans in implant procedures. Bioinformation. 2023 Jan 31;19(1):35-38. doi: 10.6026/97320630019035. PMID: 37720290; PMCID: PMC10504522.

13. Rebekah R, Navaneethan R, Nagachandran KS. Effect of transcutaneous electrical nerve stimulation therapy on condylar position and myofascial pain in patients with temporomandibular joint disorders-A pilot clinical trial. J Orthod Sci. 2024 Sep 17;13:36. doi: 10.4103/jos.jos_21_24. PMID: 39450226; PMCID: PMC11500744.

14. Johnson M. Transcutaneous Electrical Nerve Stimulation: Mechanisms, Clinical Application and Evidence. Rev Pain. 2007 Aug;1(1):7-11. doi: 10.1177/204946370700100103. PMID: 26526976; PMCID: PMC4589923.

15. Armijo-Olivo S, Pitance L, Singh V, Neto F, Thie N, Michelotti A. Effectiveness of Manual Therapy and Therapeutic Exercise for Temporomandibular Disorders: Systematic Review and Meta-Analysis. Phys Ther. 2016 Jan;96(1):9-25. doi: 10.2522/ptj.20140548. Epub 2015 Aug 20. PMID: 26294683; PMCID: PMC4706597.

16. Rodrigues D, Siriani AO, Bérzin F. Effect of conventional TENS on pain and electromyographic activity of masticatory muscles in TMD patients. Braz Oral Res. 2004 Oct-Dec;18(4):290-5. doi: 10.1590/s1806-83242004000400003. PMID: 16089258

17. Kato MT, Kogawa EM, Santos CN, Conti PC. TENS and low-level laser therapy in the management of temporomandibular disorders. J Appl Oral Sci. 2006 Apr;14(2):130-5. doi: 10.1590/s1678-77572006000200012. PMID: 19089044; PMCID: PMC4327455.

18. Rajpurohit B, Khatri SM, Metgud D, Bagewadi A. Effectiveness of transcutaneous electrical nerve stimulation and microcurrent electrical nerve stimulation in bruxism associated with masticatory muscle pain--a comparative study. Indian J Dent Res. 2010 Jan-Mar;21(1):104-6. doi: 10.4103/0970-9290.62816. PMID: 20427917.

19. Isacsson G, Linde C, Isberg A. Subjective symptoms in patients with temporomandibular joint disk displacement versus patients with myogenic craniomandibular disorders. The Journal of prosthetic dentistry. 1989 Jan 1;61(1):70-7.

20. Dworkin SF, Huggins KH, LeResche L, Von Korff M, Howard J, Truelove E, Sommers E. Epidemiology of signs and symptoms in temporomandibular disorders: clinical signs in cases and controls. The Journal of the American Dental Association. 1990 Mar 1;120(3):273-81

21. Jensen R, Rasmussen BK, Pedersen B, Lous I, Olesen J. Prevalence of oromandibular dysfunction in a general population. J Orofac Pain. 1993 Spring;7(2):175-82. PMID: 8358364

22. Manfredini D, Piccotti F, Ferronato G, Guarda-Nardini L. Age peaks of different RDC/TMD diagnoses in a patient population. Journal of dentistry. 2010 May 1;38(5):392-9.

23. Berger M, Szalewski L, Bakalczuk M, Bakalczuk G, Bakalczuk S, Szkutnik J. Association between estrogen levels and temporomandibular disorders: a systematic literature review. Prz Menopauzalny. 2015 Dec;14(4):260-70. doi: 10.5114/pm.2015.56538. Epub 2015 Dec 22. PMID: 26848299; PMCID: PMC4733902

24. Warren MP, Fried JL. Temporomandibular disorders and hormones in women. Cells Tissues Organs. 2001 Jun 29;169(3):187-92.

25. Nekora-Azak A. Temporomandibular disorders in relation to female reproductive hormones: a literature review. J Prosthet Dent. 2004 May;91(5):491-3. doi: 10.1016/j.prosdent.2004.03.002. Retraction in: J Prosthet Dent. 2005 Sep;94(3):305. doi: 10.1016/j.prosdent.2005.08.005. PMID: 15153858.

26. Leucuța DC, Anton D, Almășan O. Estrogen Hormones' Implications on the Physiopathology of Temporomandibular Dysfunction. J Clin Med. 2024 Jul 27;13(15):4406. doi: 10.3390/jcm13154406. PMID: 39124673; PMCID: PMC11313074.

27.Moger, G., Shashikanth, M. C., Sunil, M. K., & Shambulingappa, P. (2011). Transcutaneous electrical nerve stimulation therapy in temporomandibular disorder: A clinical study. *Journal of Indian Academy of Oral Medicine and Radiology*, *23*(1), 46-50.

28. Kruger LR, Van der Linden WJ, Cleaton-Jones PE. Transcutaneous electrical nerve stimulation in the treatment of myofascial pain dysfunction. South African Journal of surgery. Suid-afrikaanse Tydskrif vir Chirurgie. 1998 Feb 1;36(1):35-8.

29.Alvarez-Arenal, A., Junquera, L.M., Fernandez, J.P., Gonzalez, I. and Olay, S., 2002. Effect of occlusal splint and transcutaneous electric nerve stimulation on the signs and symptoms of temporomandibular disorders in patients with bruxism. *Journal of oral rehabilitation*, *29*(9), pp.858-863.

30. Riden, D. K. (1986). A clinical approach to pain: 2. Extraoral structures. *Dental Update*, *13*(9), 439-46.

31. Juniper, R. P. (1986). Temporomandibular joint dysfunction: Facts and fallacies. *Dental update*, *13*(10), 479.

Figure 1

Figure 2

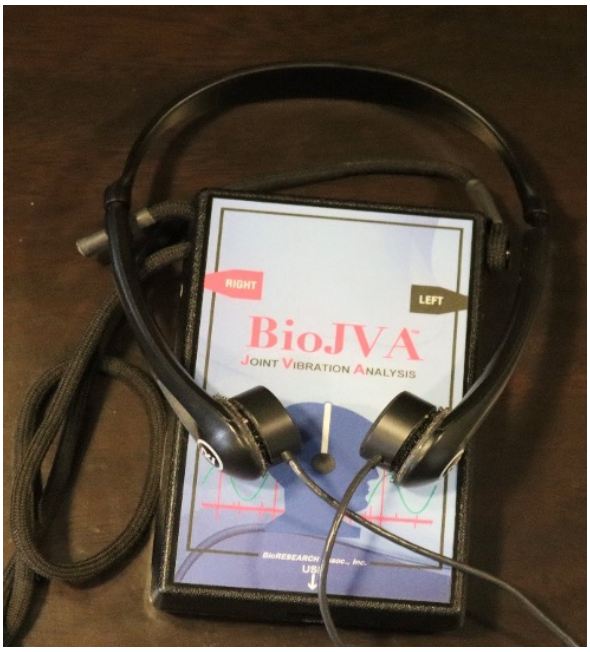

Figure 3

Figure 4

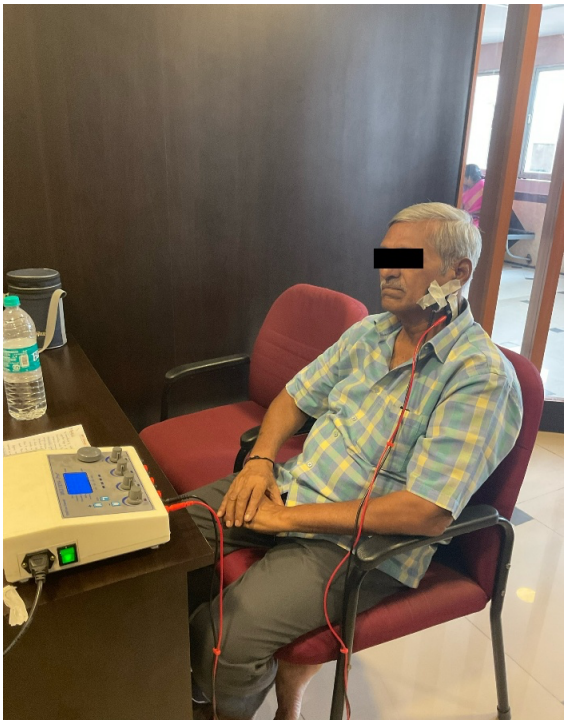

Figure 5

Figure 6

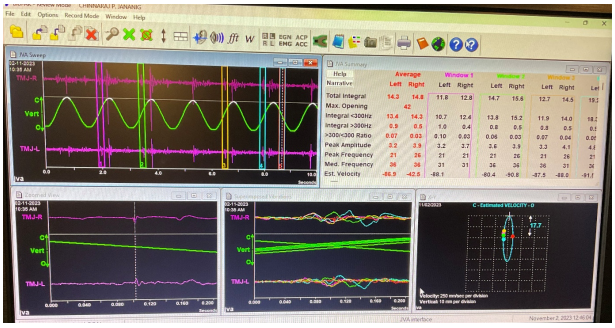

Figure 7

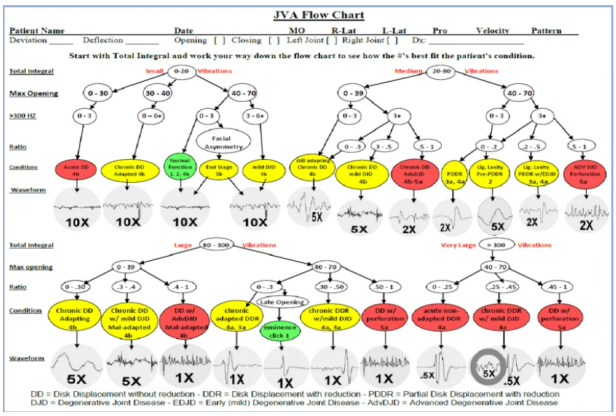

Figure 8