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Original Article

Dentistry Section

Effects of Transcutaneous Electrical Nerve Stimulation, Laser Therapy, and Ultrasound in Managing Temporomandibular Disorders: A Randomised Clinical Study

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ABSTRACT

Introduction: Temporomandibular Joint Disorders (TMDs) are considered multifactorial, and several treatment approaches have been proposed for their effective management. The use of non invasive treatment modalities is recommended, which includes Transcutaneous Electric Nerve Stimulation (TENS), Low-Level Laser Therapy (LLLT), acupuncture, ultrasound, and manual therapies.

Aim: To evaluate the effectiveness of TENS, LLLT, and ultrasound therapy in patients suffering from TMDs.

Materials and Methods: This prospective, randomised clinical trial was conducted on thirty patients (11 males, 19 females) clinically diagnosed with TMD associated with Temporomandibular Joint (TMJ) pain, clicking joint sound, pain in the muscles of mastication, and limited mouth opening. Patients were sequentially randomised into three groups to be treated with TENS, laser beam, and ultrasound therapies, respectively. The Visual Analog Scale (VAS) Score and pain-free mouth opening were recorded before, during, and after treatment. Data were analysed using Statistical Package for Social Sciences (SPSS) version 16.0 statistical software. Statistical tests such as the paired sample t-test, Analysis of Variance (ANOVA), and post-hoc Tukey test were performed.

Results: There was a significant reduction in the VAS score in the TENS group (3.15), LLLT group (5.75), and ultrasound group (5.50) post-treatment ($p<0.001$). In addition, improvements in Mean Mouth Opening (MMO) levels were observed with TENS (7.80 mm), LLLT (9.09 mm), and ultrasound therapy (7.15 mm). These differences were found to be statistically significant ($p<0.05$). The laser and ultrasound groups fared better than the TENS group in the reduction of VAS scores ($p<0.05$), and there was no significant difference in MMO among the three therapies.

Conclusion: Reductions in VAS scores and improvements in mouth opening were noticed in all three groups post-treatment. The laser and ultrasound therapies were more effective in reducing pain compared to TENS therapy. Comparing pre-treatment and mid-treatment values, laser beam therapy proved to be more effective in reducing pain scores compared to TENS and ultrasound therapy.

Keywords: Pain measurements, Temporomandibular joint disorders, Therapeutics, Visual analog scale

INTRODUCTION

Temporomandibular Joint Disorders (TMDs) are musculoskeletal disorders of the masticatory system involving the TMJ, the muscles of mastication, and associated head and neck musculature [1]. This prevalent condition affects approximately 5-12% of the adult population [2]. The literature states that 40-75% of healthy individuals have atleast one sign of TMD, while about 33% may have atleast one symptom of TMD [1,2]. Although TMDs can occur at any age, an increased prevalence is observed in early adulthood, between 20 and 40 years [3]. Regarding gender, a two- to four fold higher prevalence is observed in women [4].

TMDs exhibit a multifactorial aetiology with varied clinical signs and symptoms such as pain while chewing, headaches, neck pain, tinnitus, clicking, TMJ sounds, restricted jaw movement, deviation, locked jaw, etc., [2,5]. In most cases, symptoms cause increased tension in the masticatory musculature, and parafunction may worsen the symptoms [6,7]. Patients with TMD have an altered clinical presentation, experiencing mild to moderate or severely painful episodes that may be associated with restricted jaw motion or hypermobility of the TMJ [8].

Management is extensive and diverse due to the varied clinical presentations and the multifactorial aetiology, thus involving professionals from different disciplines. Treatment includes non invasive and invasive modalities. According to the literature, several physical therapy interventions are found to be potentially effective, including TENS, LLLT, acupuncture, ultrasound, TMJ mobilisation, and manual therapies. In addition, various non-surgical treatment options also exist, such as physiotherapy, removable appliances, and relaxation exercises [8-11].

Very few studies in the literature compare the three treatment modalities of TENS, LLLT, and ultrasound therapy [12,13]. The physician's goal is to provide relief, reduce the frequency and intensity of pain, and improve jaw movements. Therefore, the present study aimed to perform a comparative analysis to evaluate the effectiveness of TENS, LLLT, and ultrasound therapy in reducing pain and improving pain-free mouth opening in patients suffering from TMDs. The novelty of this study lies in evaluating the mid-treatment values of the VAS score and MMO.

MATERIALS AND METHODS

The randomised clinical trial was conducted in 30 patients clinically diagnosed with TMDs. The study took place in the Department of Oral Medicine and Radiology at Panineeya Institute of Dental Sciences and Research Centre, Hyderabad, Telangana, from December 2014 to February 2017. The study protocol was approved by the institutional ethical review board (Institutional Ethical Committee, PMVIDS/OMR/0019/2014). Signed informed consents were obtained from all patients involved in the study.

Inclusion criteria: A total of 30 patients aged 18-65 years, exhibiting clinical signs and symptoms of TMD i.e., TMJ pain, clicking joint sound, limited mouth opening, jaw lock and also those exhibiting disc displacement with and without reduction, TMJ arthralgia, and degenerative joint disease, based on the Research Diagnostic Criteria (RDC/TMD), were included in the study after obtaining consent.

Exclusion criteria: Patients with cardiac pacemakers, malignancy, or any other severe systemic illness and those patients who were not willing to undergo treatment were excluded from the study

Sample size estimation: The sample size was estimated using a study conducted by Cetiner S et al., [14]:

The formula used was: $n_i=2\ (Z_{1-\alpha/2}+Z_{1-\beta}/ES)^2$

Where,

n_i=sample size required in each subgroup

$Z_{1-\alpha/2}$=value from the standard normal distribution holding 1-α/2 below it=1.96 for 95% CI

$Z_{1-\beta}$=value from the standard normal distribution holding 1-β below it for a power of 80%=0.84.

ES=Effect size, calculated from the mean, is 1.2

Substituting the above values in the formula:

$n_i=2\ (1.96+0.84\ /\ 1.2)^2=2(2.2)^2$

=9.68, which is rounded off to 10

Thus, a sample size of 10 per subgroup would be required for the study to have 80% power and 95% confidence intervals.

Hence, the total sample size for the study was calculated as 30.

Procedure

Investigations such as a complete blood picture, clotting time, Orthopantomography (OPG), and Cone Beam Computed Tomography (CBCT) were performed as and when required.

Thirty patients were sequentially randomised into three groups (Group-A, Group-B, Group-C) of ten each by an individual not participating in the study. This trial was not blinded. The CONSORT flow chart is shown in [Table/Fig-1].

Group-A was treated with TENS therapy (TENS Machine 4CH TENS, Pune) for eight sessions, divided into two sessions per week.

The electrodes were placed over tender points during the therapy, and an output frequency of 2-130 Hz was applied for 20 minutes, with the intensity adjusted according to the patient's sensitivity [5,15].

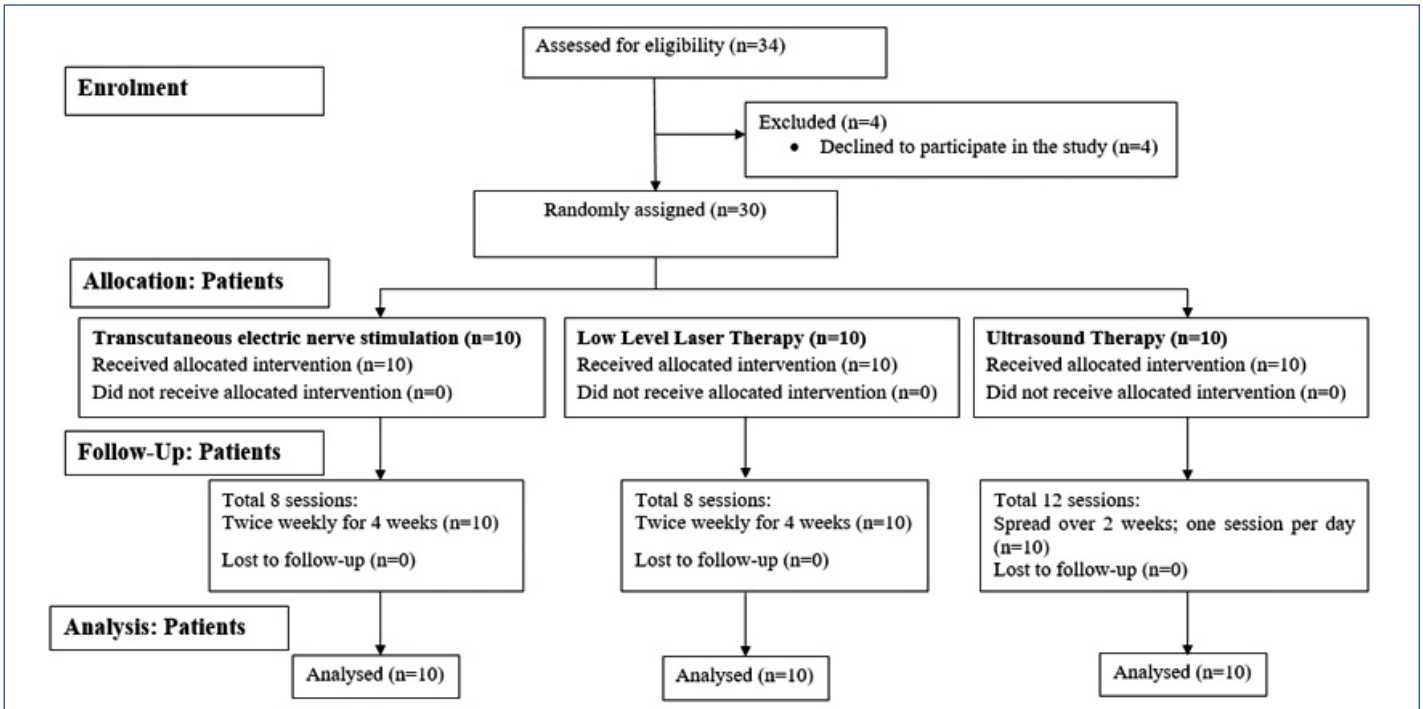
Group-B underwent treatment with LLLT-Diode laser (Lite Medics, Italy) with a wavelength of 980 nm, one Joule, and 500 mW for six minutes. The treatment continued for eight sessions, i.e., two sessions per week [16,17].

Group-C received treatment with ultrasound (Manual US Mini, SAS 180, Delhi) at an output of 1.0 W/cm^2 for 10 minutes, adjusted to pulsed mode at a frequency of 1 MHz. There were 12 sessions over two weeks, i.e., one session per day [18,19]. The application of TENS, LLLT, and ultrasound therapy is shown in [Table/Fig-2].

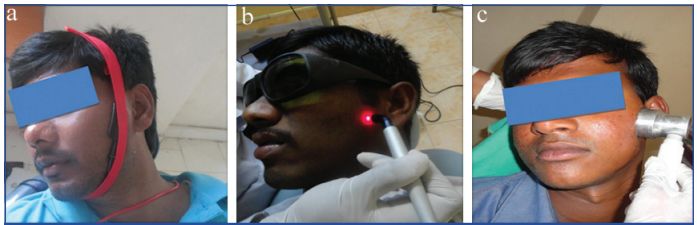
A history was recorded, and clinical examination was carried out for each patient prior to treatment. The pain score (0-10, where 0 represents no pain and 10 represents the worst pain as perceived by the patient subjectively) was evaluated before, during (mid-treatment), and after treatment using the Visual Analogue Scale (VAS) [20]. Pain-free interincisal mouth opening was recorded before, during (mid-treatment), and after treatment using a vernier caliper [Table/Fig-3].

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS version 16.0. A paired sample t-test was conducted to analyse the results of each



[Table/Fig-1]: CONSORT Flow Chart.



[Table/Fig-2]: TENS therapy; b) Low level Laser Therapy (LLLT); c) Ultrasound therapy.

[Table/Fig-3]: Pre, mid and post-treatment change in Mean Mouth Opening (MMO). a) Pre-treatment pain free mouth opening. b) Mid treatment pain free mouth opening. c) Post-treatment pain free mouth opening.

therapy pre- and post-treatment. An ANOVA test was conducted to compare the mean VAS scores of the three groups. A post-hoc Tukey test was conducted to perform inter-group comparisons and reveal which group had shown more improvement.

RESULTS

Thirty patients, including 19 females and 11 males, were randomly assigned into three groups. The greatest number of patients, i.e., 33.3% (n=10), were between the ages of 18-25 years, while the mean age recorded was 33.6 years (n=30).

Intra-group comparison:

1. **VAS score:** A statistically significant (p<0.001) mean difference was recorded in the VAS scores of patients before and after treatment with TENS, LLLT, and ultrasound therapy [Table/Fig-4].
2. **Mean Mouth Opening (MMO):** A significant mean difference (p<0.001) in mouth opening levels before and after treatment was observed in all three groups [Table/Fig-5].

Inter group comparison:

1. VAS score: Mid-treatment reduction in the VAS score of patients treated with TENS was found to be less in comparison to patients treated with LLLT, and the difference was statistically significant (p=0.01). The comparison of TENS with ultrasound at mid-treatment showed no difference and was statistically insignificant (p=0.71). LLLT, compared to the ultrasound method, showed a better reduction in the mid-treatment VAS score (p=0.062) [Table/Fig-6,7].

Post-treatment reduction in VAS score of patients treated with TENS (3.15±1.10) was found to be significantly less (p=0.002) when compared to LLLT (5.75±1.58) and ultrasound (5.50±1.71) (p=0.004). LLLT compared to the ultrasound method showed a similar reduction in VAS score post-treatment. However, it was found to be statistically insignificant (p=0.92) [Table/Fig-8].

2. Mean Mouth Opening (MMO): Mid-treatment MMO with TENS was found to be less in comparison to LLLT, and it was statistically insignificant (p=0.9). However, a greater difference was observed compared to ultrasound, which was statistically significant (p=0.049). LLLT compared to the ultrasound method showed a similar change in MMO mid-treatment, and the result was statistically significant (p=0.02) [Table/Fig-9,10].

Post-treatment, all three treatment modalities were found to be equally effective in improving mouth opening levels. However, the result was found to be statistically insignificant, with all p-values being greater than 0.05 [Table/Fig-11].

Treatment modalities/ Groups	VAS score		Mean difference	Std. Deviation	Std. Error mean	95% Confidence interval of the difference		t	df	p-value
	Before	After				Lower	Upper			
TENS	5.60±1.26	2.45±0.89	3.15	1.10	0.35	2.35	3.94	9.0	9	**<0.001**
LLLT	7.35±1.37	1.60±1.24	5.75	1.58	0.50	4.61	6.88	11.46	9	**<0.001**
Ultrasound	6.80±1.75	1.30±1.05	5.50	1.71	0.54	4.27	6.72	10.13	9	**<0.001**

[Table/Fig-4]: Comparison of change in mean VAS Score pre and post-treatment with TENS, LLLT and ultrasound therapy.
VAS: Visual analog scale; TENS: Transcutaneous electric nerve stimulation; LLLT: Low level laser therapy

Treatment modalities/ Groups	Mouth opening (mm)		Mean difference (mm)	Std. Deviation	Std. Error mean (mm)	95% Confidence interval of the difference		t	df	p-value
	Before	After				Lower	Upper			
TENS	27.15±4.9	34.95±5.7	7.80	2.81	0.88	5.78	9.81	8.77	9	**<0.001**
LLLT	23.70±4.1	32.79±5.4	9.09	3.80	1.20	6.36	11.81	7.54	9	**<0.001**
Ultrasound	25.10±3.8	32.25±3.6	7.15	2.23	0.70	5.54	8.75	10.10	9	**<0.001**

[Table/Fig-5]: Comparison of change in Mean Mouth Opening (MMO) pre and post-treatment with TENS, LLLT and ultrasound therapy.
TENS: Transcutaneous electric nerve stimulation; LLLT: Low level laser therapy

Treatment modalities/ Groups	VAS score		Mean difference	Std. Deviation	Std. Error	95% Confidence interval of the difference		Anova
	Before	Mid				Lower	Upper	
TENS	5.60±1.26	3.35±0.91	2.2	1.31	0.41	1.25	3.14	F=5.432 **p-value=0.01**
LLLT	7.35±1.37	3.4±1.09	4.0	0.94	0.29	3.32	4.67	
Ultrasound	6.80±1.75	4.15±1.78	2.65	1.49	0.47	1.58	3.71	

[Table/Fig-6]: Comparison of change in VAS score pre and mid treatment with TENS, LLLT and ultrasound therapy.
VAS: Visual analog scale; TENS: Transcutaneous electric nerve stimulation; LLLT: Low level laser therapy

Group	Group comparison	Mean difference	Std. Error	Significance	95% Confidence interval	
					Lower bound	Upper bound
TENS	LLLT	-1.80	0.56	0.010	-3.2	-0.39
	Ultrasound	-4.50	0.56	0.711	-1.8	0.95
LLLT	TENS	1.80	0.56	0.010	0.39	3.2
	Ultrasound	1.35	0.56	0.062	-0.05	2.7
Ultrasound	TENS	0.450	0.56	0.711	-0.95	1.8
	LLLT	-1.35	0.56	0.062	-2.7	0.05

[Table/Fig-7]: Intergroup comparison of change in mean VAS score pre and mid- treatment with TENS, LLLT and ultrasound therapy.
VAS: Visual analog scale; TENS: Transcutaneous electric nerve stimulation; LLLT: Low level laser therapy

Group	Group comparison	Mean difference	Significance	95% Confidence interval	
				Lower bound	Upper bound
TENS	LLLT	-2.60	0.002	-4.25	-0.94
	Ultrasound	-2.35	0.004	-4.0	-0.69

LLLT	TENS	2.60	0.002	0.94	4.25
	Ultrasound	0.25	0.926	-1.40	1.90
Ultrasound	TENS	2.35	0.004	0.69	4.00
	LLLT	-0.25	0.926	-1.90	1.40

[Table/Fig-8]: Intergroup comparison of change in mean VAS score pre and post-treatment with TENS, LLLT and ultrasound therapy.
VAS: Visual analog scale; TENS: Transcutaneous electric nerve stimulation; LLLT: Low level laser therapy

	Mouth opening		Mean difference (mm)	Std. Deviation (mm)	Std. Error (mm)	95% Confidence interval of the difference		Anova
	Before	Mid				Lower	Upper	
TENS	27.15 mm±4.9 mm	32.6 mm±4.8 mm	5.45	2.56	0.81	3.61	7.28	F=4.560 **p-value=0.02**
LLLT	23.70 mm±4.1 mm	29.4 mm±4.5 mm	5.70	2.86	0.90	3.64	7.75	
Ultrasound	25.10 mm±3.8 mm	27.9 mm±3.2 mm	2.80	1.47	0.46	1.74	3.85	

[Table/Fig-9]: Comparison of change in Mean Mouth Opening (MMO) pre and mid treatment with TENS, LLLT and ultrasound therapy.
TENS: Transcutaneous electric nerve stimulation; LLLT: Low level laser therapy

Group	Group comparison	Mean difference	Std. Error	Significance	95% Confidence interval	
					Lower bound	Upper bound
TENS	LLLT	-2.50	1.06	0.970	-2.88	2.38
	Ultrasound	2.65	1.06	0.049	0.01	5.28
LLLT	TENS	0.250	1.06	0.970	-2.3	2.88
	Ultrasound	2.90	1.06	0.029	0.26	5.53
Ultrasound	TENS	-2.65	1.06	0.049	-5.2	-0.01
	LLLT	-2.90	1.06	0.029	-5.5	-0.26

[Table/Fig-10]: Intergroup comparison of change in Mean Mouth Opening (MMO) levels pre and mid-treatment with TENS, LLLT and ultrasound therapy.
TENS: Transcutaneous electric nerve stimulation; LLLT: Low level laser therapy

Group	Group comparison	Mean difference	Std. Error	Sig.	95% Confidence interval	
					Lower bound	Upper bound
TENS	LLLT	-1.29	1.35	0.611	-4.64	2.06
	Ultrasound	0.65	1.35	0.881	-2.70	4.00
LLLT	TENS	1.29	1.35	0.611	-2.06	4.64
	Ultrasound	1.94	1.35	0.338	-1.41	5.29
Ultrasound	TENS	-0.65	1.35	0.881	-4.00	2.70
	LLLT	-1.94	1.35	0.338	-5.29	1.41

[Table/Fig-11]: Intergroup comparison of change in Mean Mouth Opening (MMO) pre and post-treatment with TENS, LLLT and ultrasound therapy.
TENS: Transcutaneous electric nerve stimulation; LLLT: Low level laser therapy

DISCUSSION

In the current study, all three therapies-TENS, LLLT, and ultrasound-were found to be effective in relieving pain and improving mouth opening in TMD patients. However, when comparing the pre- and post-treatment effects, ultrasound and LLLT were more effective in reducing pain compared to TENS therapy. LLLT performed better in increasing post-treatment mouth opening levels compared to the other modalities, but the difference was statistically insignificant among the three groups, indicating the equal effectiveness of all three therapies.

The literature suggests that TMD is a disorder of early adulthood, evidenced by the increased prevalence among the 20-49 year age group compared to other age brackets [21-23]. The mean age of the patients in the present study was 33.6 years.

Pain is the primary ailment of TMD for which patients seek medical consultation. The therapeutic goal should be aimed at reducing the signs and symptoms [24]. Therefore, it is vital to assess the efficacy of different treatment approaches in order to offer the best possible resolution for the pain and the discomfort it causes. The concept of conservative management of TMD is advocated in the literature, as it is less aggressive and tends to yield satisfactory clinical outcomes in mild to moderate cases [25-27].

TENS is a safe, effective, non-invasive treatment modality for managing TMD pain. The gate control theory is believed to be its primary operating principle [28]. It induces involuntary muscle contractions, which increase blood flow and lessen the pain [28,29].

LLLT is another form of physical therapy used in TMD management. Its mechanism of action is not completely understood. However, the basic effects involve the release of endogenous opioids, enhanced vasodilation and pain threshold levels, and anti-inflammatory and analgesic effects [30,31]. It is a light-based therapy producing monochromatic and coherent light of a single wavelength [31].

Ultrasound has been a primary treatment choice for TMD patients. Therapeutic ultrasound involves high-frequency sound waves that penetrate deep into tissues, producing heat that leads to increased blood flow along with nutrients and oxygen to the TMJ region, thereby reducing pain and inflammation [32].

In this study, significant improvement was observed in the patients' VAS scores and mouth opening levels before and after TENS, LLLT, and ultrasound therapy. These results are consistent with findings from other studies [Table/Fig-12] [13,33-37].

S. No.	Author's name and year	Place of study	No. of subjects	Intervention	Parameters assessed	Conclusion
1.	Kato MT et al., 2006 [33]	Brazil	n=18	Groups: TENS (n=9) LLLT (n=9)	Pain assessment- VAS score Active Range of Motion (AROM) Muscle Palpation	Authors concluded that both the therapies were effective in the management of TMD and also stated that cumulative effect may be responsible for the improvement.
2.	Shanavas M et al., 2014 [34]	Mangalore	n=40	Group-I: Analgesics and muscle relaxants (n=20) Group-II: TENS + Medication (n=20)	Pain assessment- VAS score	Adjuvant TENS therapy was more effective than medication alone.
3.	Rai S et al., 2016 [13]	Uttar Pradesh	n=90	Group-I: Healthy Controls (n=30) Group-II: Therapeutic Ultrasound (n=30) Group-III: TENS therapy (n=30)	Pain assessment-VAS score Pain free maximum mouth opening	Post-treatment - therapeutic ultrasound appeared to be subjectively better related to VAS score of massage impression, muscle pain and impediment to daily life.
4.	Rezazadeh F et al., 2017 [35]	Iran	n=45	Groups: TENS (n=19) LLLT (n=15)	Helkimo Index Pain assessment-VAS score	Both TENS and LLLT were effective in relieving pain and muscle tenderness. Although TENS was found to be more effective than LLLT.

5.	Varma SR et al., 2018 [37]	United Arab Emirates	n=24	Group-I: Experimental group LLLT (n=16) Group-II: Placebo group: LLLT without emission (n=8)	Pain assessment - Wong and Baker pain scale Clinical signs of TMD	Significant amount of pain reduction was observed with LLLT on short term basis. Majority of the patients reported with a decrease in clicking frequency and softer mandibular movement as compared to placebo group.
6.	Jain R et al., 2020 [36]	Pune	n=20	Group-I: Conventional therapy Group-II: Conventional therapy + Therapeutic Ultrasound	Pain assessment - VAS score Maximum Inter-incisal distance	Authors concluded that ultrasound therapy was useful in relieving pain and improved mouth opening. Ultrasound massage therapy serves as a potent and independent therapeutic modality in myofascial pain dysfunction syndrome.
7.	Present study	Hyderabad	n=30	Group-I: TENS (n=10) Group-II: LLLT (n=10) Group-III: Ultrasound therapy (n=10)	Pain assessment - VAS Score-Pre, Mid and Post-treatment Pain free mouth opening - Pre, Mid and Post-treatment	Reduction in VAS scores and improvement in mouth opening were noticed in all the three groups. Post-treatment laser and ultrasound were more effective in reducing the pain compared to TENS therapy. Comparing pre and mid treatment values, LLLT proved to be more effective in reducing the pain score compared to TENS and ultrasound therapy.

[Table/Fig-12]: Comparison of studies using TENS, LLLT and ultrasound therapy in the TMD management.
TENS: Transcutaneous electric nerve stimulation; LLLT: Low level laser therapy

According to the findings of the study by Kato MT et al., which included 18 TMD patients, TENS therapy significantly reduced pain and discomfort and increased the active range of motion in TMD patients [33]. Another study of 40 patients with TMD-associated pain found that TENS therapy combined with analgesics and muscle relaxants was significantly more effective in reducing pain compared to the control group, in which only medication was administered to the patients [34]. However, in this study, TENS was not compared with medications prescribed to patients. Instead, it was compared with other conservative treatment options, including LLLT and ultrasound. Chellappa D and Thirupathy M, observed significant improvement in the range of motion and pain control in 60 TMD patients treated with LLLT [12]. Similar results were mentioned in a clinical trial including 45 patients, where reductions in VAS score and Helkimo index were observed [35].

The therapeutic effects of TENS, LLLT, and ultrasound varied in the current study. An increased reduction in VAS score was observed with LLLT and ultrasound therapy. Furthermore, greater improvement in mouth opening levels post-treatment was observed with LLLT. Rai S et al., reported that the ultrasound group (20.87±6.35) showed better improvement in the VAS score with a statistically significant difference compared to the TENS group (32.37±13.02). Furthermore, a highly significant difference in mouth opening levels was observed in both groups post-treatment. However, upon inter group comparison, no statistical significance was found (p-value 0.105) [13].

It is theorised that TENS causes stimulation of thick, myelinated sensory A-fibers, causing a blockade of impulses from thin C-fibers that modulate pain, leading to inhibition of pain signals at their point of entry into the spinal cord [12]. Therapeutic ultrasound exerts thermal and mechanical effects on tissues, leading to increased blood flow and local metabolism, and the removal of inflammatory mediators, as well as preventing the accumulation of inflammatory mediators at the region of pain [36].

Chellappa D and Thirupathy M, compared the efficacy of LLLT and TENS in symptomatic TMD patients and reported a significant reduction in VAS scores and improvement in mouth opening in both groups. However, upon comparison of the two groups, LLLT (86%) appeared to perform better in reducing the VAS score than TENS (83%). Furthermore, the study demonstrated that laser therapy was significantly more efficient in improving mouth opening compared to TENS [12]. Laser therapy appears to have analgesic, anti-inflammatory, and biostimulant effects. It is considered to raise the pain threshold by inhibiting electrolytic nerve fibers and causes a reduction in the production of bradykinins and the release of histamine and acetylcholine. In addition, it produces an increase in ATP synthesis, improved blood circulation, and reduction in oedema via enhancing lymphatic flow [38].

Upon comparison of the pre- and mid-treatment values, i.e., after four therapy sessions, it was revealed that LLLT showed better efficacy in reducing the VAS scores compared to TENS and ultrasound therapy. Sayed N et al., used laser therapy on twenty TMD patients and observed a rapid decrease in pain intensity, with a reduction of 23.19% after the first session, 49.29% at mid-treatment (after 3 sessions), and 79.16% at the end of the treatment (after 6 sessions). The active range of motion also increased in all patients [39]. The accelerated healing process and angiogenesis stimulated by laser therapy in the damaged tissues could be the reason for the rapid effects of the laser [40].

Although all three modalities were effective in providing symptomatic relief, laser therapy stands out among these approaches and has proven to be cost-effective. Moreover, these therapies can be of great help to patients. None of the subjects included in the study reported any adverse effects during or post-treatment.

Limitation(s)

The follow-up period of only one month that too conducted on a small sample, is limitation of the present study. Though none of the patients reported any adverse events during or post-therapy, a few patients were non-compliant with TENS therapy due to the electric sensation on the skin. TENS and ultrasound therapies are not recommended for patients with pacemakers; therefore, the choice of treatment approach differs in such cases.

CONCLUSION(S)

The present study revealed that all three treatment modalities-TENS, LLLT, and ultrasound-showed a significant reduction in pain scores and improvement in pain-free mouth opening. When comparing the pre- and post-treatment effects, LLLT and ultrasound were found to be more effective in reducing pain compared to TENS therapy. Although the LLLT group showed an increased change in mouth opening levels post-treatment, there was no significant difference between the three groups, indicating that TENS, LLLT, and ultrasound therapies were equally effective in improving mouth opening.

Future studies with larger samples and long-term follow-up are recommended to compare the effectiveness of the three therapies. Further studies could be conducted combining LLLT and ultrasound to determine their effectiveness in pain reduction, as well as combining LLLT and TENS therapy to assess their role and effectiveness in achieving pain-free mouth opening.

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