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EVALUATION OF THE EFFICACY OF THERAPEUTIC ULTRASOUND, TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION AND LOW-LEVEL LASER THERAPY IN THE MANAGEMENT OF TEMPOROMANDIBULAR DISORDERS: A COMPARATIVE STUDY

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Abstract. Aim. *Temporomandibular disorders (TMDs), one of the most common causes of chronic orofacial pain is caused by the dysfunction of the various components of the temporomandibular joint and often require the use of non-invasive physical therapeutic modalities for its management. The present study was undertaken to compare the efficacy of plain therapeutic ultrasound (Th US), transcutaneous electric nerve stimulation (TENS therapy) and low-level laser therapy (LLLT) in the management of TMD.* ***Materials and methods.*** *In this randomized clinical trial, 45 subjects aged between 18 to 40 years and diagnosed with TMD were randomly divided into three groups. The subjects of group A, group B and group C were treated with Th US, TENS therapy and LLLT, respectively, twice a week for a period of two weeks. The efficacy of each modality was evaluated in terms of pain intensity and functional improvement of the subjects both prior to and after each session using Visual Analogue Scale (VAS), Helkimo dysfunctional clinical index (HI) and Maximum Mouth Opening (MMO). Inter-group and multi-group comparisons of all the parameters, along with age-based differences, were analyzed using SPSS software (version 26) and a p-value of 0.05 was considered to be statistically significant.* ***Results.*** *The mean age of the included study subjects were 30.3 ± 9.1, 27.5 ± 6.7 and 27.4 ± 6 years in the Th US, TENS therapy and LLLT respectively, with a female predominance (53.3%). A significant reduction of pain intensity (VAS) and dysfunction (HI), along with improvement of mouth opening (MMO), was seen among the subjects of all three groups by the end of the last interventional session ($p < 0.05$). However, a maximum difference was noted among the subjects of group C (LLLT) in terms of inter-group and multi-group comparisons of VAS, HI and MMO, followed by group A (Th US) and group B (TENS), respectively. Though the recurrence rate was high among the subjects of group B (26.6%), there was no statistical significance.* ***Conclusion.*** *Although significant improvements were observed among all three study groups, LLLT established a superiority over Th US and TENS therapy in terms of pain relief, mouth opening as well as functional outcome of the joint. Based on our results, we suggest the application of LLLT as an effective interventional option for TMD patients to achieve better and long-lasting functional results.*

Key words: *temporomandibular joint disorders, orofacial pain, photobiomodulation therapy, Visual analogue pain scale, therapeutic ultrasound*

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INTRODUCTION

The temporomandibular joint (TMJ) is one of the distinctively intricate synovial joints of the human body, which is structurally formed by a combination of the mandibular condyle and its associated components of the temporal cavity, the articular eminence and glenoid fossa. Interconnection of the various articular aspects of the TMJ is achieved by the articular eminence, a non-vascularized structure [1, 2]. Temporomandibular disorders (TMD) cause chronic pain in the orofacial region [2, 3]. The American Academy of Orofacial Pain (AAOP) defined TMD as a collective term that represents a compilation of clinical symptoms involving the TMJ and its associated structures along with the masticatory muscles [1]. Currently, the Research Diagnostic Criteria for TMD (RDC/TMD) is a widely used diagnostic strategy that standardizes the clinical evaluation of TMD patients, enhances its reproducibility among the orofacial clinicians, and eases the comparison of findings among the researchers [2-5].

With a multifactorial aetiology, TMD has an incidence of 11% in children and 31% in adults, and it has a female predominance. A variety of non-invasive and invasive techniques are utilized to manage TMDs. Some of the options for conservative management of these TMDs involve physical therapies such as therapeutic ultrasound (Th US), transcutaneous electrical nerve stimulation (TENS) therapy, acupuncture, low-level laser therapy (LLLT), oral pharmacotherapy including muscle relaxants and NSAIDS, occlusal therapy, orthodontic treatment [6, 7]. However, the fundamental care of TMDs seeks to give symptomatic relief without side effects and achieve pain reduction as well as restoration of the masticatory function [6].

The concept of transcutaneous electrical nerve stimulation (TENS), which operates on the idea of “gate control theory”, is an efficient and affordable electrophysical modality. It stimulates the intricate neural network of the central nervous system, which produces the analgesic effect [8]. When applied to painful areas, TENS stimulates various vibratory receptors by generating significantly low doses of electric current. This results in the contraction and relaxation of the muscles due to reduced transmission of unpleasant stimuli to the brain [9, 10].

Another non-invasive technique that uses sonic waves exceeding 16 Hertz or 16,000 vibrations per second is therapeutic ultrasound (Th US). Th US is routinely used to lessen muscular spasms by alleviating the sense of pain and improving the extensibility of collagen fibers which ultimately reduces the stiffness of joints [11]. The working mechanism of Th US relies on the suppression of various pain mediators through increased neo-vascularization, changes in nerve transmission and cellular membrane permeability which eventually reduces the inflammatory conditions [12]. In addition, it limits the release of inflammatory cytokines and further encourages the growth of articular cartilage to repair the damaged cartilage [13].

LLLT is a flexible treatment option for several musculoskeletal conditions and management of TMD patients [9]. LLLT utilizes single wavelength electromagnetic radiation to treat a variety of pathological conditions, such as painful inflammatory disorders, by intensifying the process of wound healing [10]. LLLT causes a reduction in acetylcholine and histamine release in conjunction with the increased production of bradykinin which brings out its anti-inflammatory effects. These processes enhance lymphatic drainage as well as micro-circulation by reducing the levels of cyclooxygenase-2 (COX2) and prostaglandin E2 (PGE2), thereby decreasing oedema. The analgesic effects of LLLT can be explained on the basis of the electrolytic nerve fibers which rises the pain threshold by the simultaneous actions of increased ß-endorphins production as well as excretion of glucocorticoids [14]. A photo-chemical reaction is triggered when low-energy laser light is emitted for extended time periods, which further depends on the dose, mode of operation as well as wavelength [6].

Though there are several non-invasive techniques of physical therapy available for the management of patients with TMD, there is a scarcity of studies in the literature that compares the effectiveness of various electro-physical therapeutic modalities with

the proposed goals being pain reduction as well as functional improvement. Therefore, the present study was undertaken with the aim of comparing the efficacy of plain Th US, TENS therapy and LLLT in the management of TMD.

OBJECTIVES

The present interventional study was carried out with the following objectives: (i) To evaluate and compare the efficacy of the electro-physical treatment modalities (plain Th US, TENS therapy and LLLT) for the management of TMD patients. (ii) To monitor the efficacy of the listed treatment modalities by using visual analogue scale (VAS), Helkimo dysfunctional clinical index and maximum mouth opening (MMO).

MATERIALS AND METHODS

Selection of sample

The present interventional study was carried out in accordance with the principles of the Declaration of Helsinki following the approval of the Institutional Ethical Committee (ETHICS/ABSMIDS/199/2022). A double-blinded randomized clinical trial was conducted on a total of 45 subjects (21 males and 24 females) in the age group of 18 to 40 years, who reported to the Orofacial Pain Clinic of Private Dental Hospital with complaint of pain in the TMJ region. The subjects with temporomandibular joint disorders who satisfied the TMD/RDC were selected based on the selection criteria and divided into three groups. The subjects of Group A (n = 15) received plain Th US, Group B (n = 15) received TENS therapy, and Group C (n = 15) received LLLT, respectively.

Inclusion and exclusion criteria

Subjects with a history of chronic TMJ pain for more than three months, subjects falling under Group I (Myofascial pain) and Group II (Disc displacement) of the RDC/TMD and those with the willingness to participate in the study were included. Subjects with a history of recent trauma, pace-makers, open facial wounds, metal implants of the craniofacial region; history of regular intake of medications such as anxiolytics, anti-depressants, anti-convulsants and muscle relaxants; history of neurologic, metabolic, psychiatric and skin disorders, neoplastic and vascular conditions; history of any congenital abnormalities; history of known allergy to electrodes or adhesive tapes used for TENS therapy; subjects with the pain of odontogenic origin or pure arthrogenic pain (RDC/TMD Group III) and subjects who were previously treated with Th US, TENS therapy and LLLT without any general improvement of their condition were excluded from the study.

Procedure

The subjects were explained in detail regarding the study procedure followed by the procurement of their informed consent before the procedure. A detailed history of the study subjects and specific examinations for the signs and symptoms of the TMDs was carried out by a trained Oral Medicine and Radiology specialist with a minimum of 10 years of clinical experience. In addition, an orthopantomogram (OPG) was taken to rule out any bony changes in the TMJ. All the included study subjects were refrained from the consumption of any form of analgesic drugs or other forms of management therapy, such as behavioural counselling, muscle exercises, dry needling, acupressure and palliative home care, during the course of the study.

Devices and treatment modalities

The subjects were seated on the dental chair for the performance of various electro-physical therapies. Before the application of both Th US as well as TENS therapy, the pre-auricular region of affected TMJ was cleansed with a sterile cotton roll dabbed in spirit (70% isopropyl alcohol). The working surfaces such as the transducer head in Th US and electrodes in TENS therapy were evenly submerged with ultrasound gel and electroconductive gel (5mm in thickness), respectively. The plain therapeutic ultrasound was performed with Electroson – 709 (Technomed Electronics) in continuous circular motions with a frequency of 1 MHz, at an intensity of 1.3 W/cm² for 10 mins (Figure 1). For the performance of TENS therapy, electrodes of size 4 x 2.5 cm were placed on the TMJ region and back of the neck to complete the circuit. With the intensity adjusted from 10 to 15 (subject's comfort level), Acutens – 4 model (Technomed Electronics) was used for performing TENS therapy at a frequency of 75 Hz and a pulse width of 120 µs for 15 minutes per session (Figure 2). Epic X – Diode Laser system (Biolase) with a wavelength of 940 nm, mean output power of 2.5 W and an energy density of 900 J per TMJ was administered on each affected TMJ site for six minutes. The LLLT was directed in continuous and contact mode using the pain therapy handpiece (Figure 3). All three electro-physical treatment techniques were administered twice a week for two weeks.

Fig. 1. Clinical image of application of therapeutic ultrasound (Th US) along with the image of instuments used for the procedure

Fig. 2. Clinical image showing the application of transcutaneous electrical nerve stimulation (TENS) therapy along with the image of instuments used for the procedure

Fig. 3. Clinical image showing the application of low-level laser therapy (LLLT) along with the image of instruments used for the procedure

Evaluation of the study subjects

Pre and post electro-physical therapy session, the study subjects were assessed. The following parameters were used for the assessment of pain intensity and functional improvement of the subjects: (i) The evaluation of pain intensity of the study subjects by the Visual Analogue Scale (VAS) scores which utilizes a score from 0 (no pain at all) up to 10 (worst pain imaginable). (ii) The evaluation of functional improvement of the study subjects was determined by the Helkimo dysfunctional clinical index (HI), which measures the degree of the severity of TMD with the aid of mandibular movements, joint function and pain intensity [15]. (iii) The evaluation of Maximum Mouth Opening (MMO) was done using a calibrated vernier calliper with a precision of 1mm in order to determine the interincisal distance.

Statistical Analysis

The collected data were entered in Microsoft Excel-2010 and statistically analyzed using Statistical Package for Social Sciences software (IBM, Armonk, NY, USA) Version 26. Categorical data were shown as 'n' (percentage of cases), whereas the data on continuous variables were represented as Mean and Standard Deviation (SD) across the three groups. The pre and post-treatment parameters like VAS, Helkimo dysfunctional clinical index and MMO in all three study groups were compared using Paired T-test. One-way ANOVA was used to compare the means of continuous variables between the three groups as well as the age-based differences among the study subjects. The Post-Hoc Bonferroni test was used for the comparison of multiple groups. The inter-group comparison of recurrence rates among the three groups was statistically tested using the Chi-square test. A p-value of 0.05 was considered to be statistically significant.

RESULTS

The present study included 45 subjects in three groups, of which 21 (46.7%) were males and 24 (53.3%) were females. The included subjects were of age groups ranging between 18 to 40 years with a mean age of 30.3 ± 9.1, 27.5 ± 6.7 and 27.4 ± 6 years in the Th US, TENS therapy and LLLT groups, respectively. However, there was no significant difference in the mean age of subjects among the three groups ($p > 0.05$). The characteristic features (age-based differences and gender) of the included study subjects were shown in Table 1.

Table 1. Characteristic features (age-based differences and gender) of the study subjects.

CHARACTERISTICS OF THE STUDY SUBJECTS		GROUP			TOTAL
		Th US	TENS	LLLT	
Gender distribution	Male	7 (46.7%)	7 (46.7%)	7 (46.7%)	21 (46.7%)
	Female	8 (53.3%)	8 (53.3%)	8 (53.3%)	24 (53.3%)
Age distribution		GROUP			P-value
		Th US	TENS	LLLT	0.490
		30.3 ± 9.1	27.5 ± 6.7	27.4 ± 6.0	

**** One-Way ANOVA***

Pain score, Helkimo dysfunctional index and Maximum mouth opening:

Comparison of pre and post-treatment parameters (VAS, HI and MMO) among all three study groups is shown in Table 2. On comparison of the pre and post-treatment scores, there was a significant decrease in the VAS and HI scores along with an increase in the MMO among the study groups with a statistically significant difference ($p < 0.001$). The differences in pre- and post-treatment parameters among the three groups were compared (Table 3). On comparison of the VAS, HI and MMO, maximum difference was noted in the LLLT group, followed by Th US and TENS with a statistically significant difference of $p = 0.002$, $p = 0.006$ and $p = 0.001$, respectively. Post-hoc comparisons of differences in VAS scores between the study groups showed a statistically significant difference between Th US and TENS ($p = 0.028$) as well as LLLT and TENS ($p = 0.003$). Post-hoc comparisons of differences in HI scores showed a significant difference between LLLT and TENS ($P = 0.005$). Post-hoc comparisons of differences in MMO between the groups showed significant differences between Th US and LLLT ($P = 0.017$) and LLLT and TENS ($P = 0.001$) (Table 4). Thus, it was found that the subjects of LLLT showed a significant improvement in all the parameters like pain score (VAS), Helkimo dysfunctional index (HI) score and Maximum mouth opening (MMO) followed by the subjects of Th US group. The least improvement was noted among the subjects of TENS group.

Table 2. Comparison of the three groups before and after treatment according to three parameters (VAS, HI, MMO)

Parameters Mean ± SD		Th US (N = 15)		TENS (N = 15)		LLLT (N = 15)	
		P-value	Mean ± SD	P-value	Mean ± SD	P-value	
Pain scores- VAS	Pre-VAS	7.2 ± 2.1	< 0.001	6.6 ± 0.8	< 0.001	7.7 ± 1.1	< 0.001
	Post-VAS	2.3 ± 1.4		3.0 ± 1.1		2.4 ± 0.7	
Helkimo Index scores- HI	Pre-HI	4.8 ± 1.5	< 0.001	3.4 ± 0.5	< 0.001	4.3 ± 1.6	< 0.001
	Post-HI	2.2 ± 1.3		1.6 ± 0.5		1.2 ± 0.4	
Maximum Mouth opening- MMO	Pre-MMO	40.6 ± 3.0	< 0.001	41.0 ± 6.6	< 0.001	39.3 ± 4.6	< 0.001
	Post-MMO	43.4 ± 3.2		43.4 ± 6.5		43.2 ± 3.9	

* Paired T-test

Table 3. Comparison of difference in the pre and post-treatment parameters among the study groups

Parameters	Modalities used	N	Mean ± SD	P-value
Difference in VAS	Th US	15	4.86 ± 1.7	0.002
	TENS	15	3.6 ± 0.5	
	LLLT	15	5.26 ± 1.2	
Difference in HI	Th US	15	2.6 ± 1.0	0.006
	TENS	15	1.8 ± 0.4	
	LLLT	15	3.06 ± 1.3	
Difference in MMO	Th US	15	2.8 ± 1.0	0.001
	TENS	15	2.46 ± 0.6	
	LLLT	15	3.86 ± 1.2	

* One-way ANOVA

Table 4. Inter-interval comparison of the mean difference in VAS, HI and MMO among the study groups during pre and post-treatment

Dependent Variable (Study parameters)	Comparison among the study groups		Mean Difference (I-J)	Std. Error	**Significance**
	GROUP (I)	GROUP (J)			
Difference VAS	1	2	1.26667*	.46553	.028
		3	-.40000	.46553	1.000
	2	1	-1.26667*	.46553	.028
		3	-1.66667*	.46553	.003
	3	1	.40000	.46553	1.000
		2	1.66667*	.46553	.003
Difference HI	1	2	.80000	.37768	.120
		3	-.46667	.37768	.670
	2	1	-.80000	.37768	.120
		3	-1.26667*	.37768	.005
	3	1	.46667	.37768	.670
		2	1.26667*	.37768	.005
Difference in MMO	1	2	.33333	.36457	1.000
		3	-1.06667*	.36457	.017
	2	1	-.33333	.36457	1.000
		3	-1.40000*	.36457	.001
	3	1	1.06667*	.36457	.017
		2	1.40000*	.36457	.001
Group 1 – Th US, Group 2 – TENS, Group 3 – LLLT					

* Post-hoc Bonferroni test

Recurrence

Two (13.3%) subjects in Group A, four (26.6%) subjects in Group B and three (20%) subjects in Group C reported recurrence in pain as well as functional disabilities within a period of 3 months of the intervention. However, there was no statistically significant difference in the recurrence rates among the three study groups ($p > 0.05$) (Table 5).

Table 5. Comparison of Recurrence among the three study groups

Recurrence	Group			P-value
	Th US	TENS	LLLT	
Absent	13 (86.7%)	11 (73.3%)	12 (80%)	0.659
Present	2 (13.3%)	4 (26.6%)	3 (20%)	
Total (N)	15	15	15	45

* Chi Square test

DISCUSSION

The universal term “temporomandibular joint disorder” refers to a combination of clinical signs and symptoms that primarily affects the TMJ and its associated structures along with the involvement of masticatory muscles [16]. Being the second most prevalent musculoskeletal condition, TMD frequently affects the orofacial region leading to joint noises and tenderness with a limited mouth opening [17]. The multifactorial etiology of TMD includes several initiating and predisposing factors which enhance the outbreak of TMD and increase its risk by sustained interference in the process of healing [18]. Some of the factors are constant stress and trauma, the existence of parafunctional habits as well as systemic, occlusal and hereditary influences [19]. Often, patients with TMD present with a wide variety of signs and symptoms during the early and later phases. Functional abnormalities like subluxation and dislocation with clicking are observed during the early symptomatic phase, while limited mandibular movements by 30 to 50 years are noticed during the late symptomatic phases in addition to tenderness of associated muscles and periauricular region [6, 20].

In the present study, the mean age of subjects in the Th US, TENS and LLLT groups were 30.3, 27.5 and

27.4 years, respectively, with a female predilection. According to studies by Rahimi et al. and Budakoti et al., TMD is a widespread disorder that commonly affects individuals between 20 to 40 years of age with a female predominance [20, 6]. A systematic review of the epidemiology of the presence of TMDs among a general population revealed a two-to-four-fold increased prevalence of TMD among women, which can be attributed to the variations in the behavioural, hormonal (estrogen) and constitutional patterns in females [21].

Among the various therapeutic approaches available to effectively reduce discomfort and increase the functional capacity of TMJ, therapeutic ultrasound has been studied to be an adaptable tool that aids in the effective alleviation of pain due to its numerous benefits, including higher patient toleration, elimination of systemic administration and reduced invasiveness [22, 23]. One of the intrusive modalities of management of TMDs is the application of bi-phasic pulsed electrical waves via multiple electrodes placed on the cutaneous surface for pain relief via TENS therapy [24]. Literature evidence suggests the role of TENS therapy in the management of acute as well as chronic pain of musculoskeletal origin in addition to the electro-myographic action of the masticatory muscles [6, 25]. Alternatively, LLLT has been more frequently utilized in recent years due to its fundamental effects such as wound repair and healing, preventing cell death, reducing inflammation, relieving pain, inducing angiogenetic and anti-oxidative phases as a result of irradiation of the affected area [26]. These effects produce biochemical changes at cellular levels, thereby achieving the therapeutic impact of photo-biomodulation [27]. Based on the findings of numerous experimental and therapeutic research, LLLT also enhances muscular performance by decreasing fatigue [20]. The paucity of literature evidence comparing all the three physical therapeutic modalities justified the way for the present study.

Pain is the major driving factor for TMD patients to seek medical attention, including conservative techniques [28]. The present study evaluated the efficacy of treatment by assessing parameters such as pain, clinical dysfunction (HI) and MMO. In order to evaluate pain, which is a subjective experience of the patient, a variety of quantitative and qualitative techniques can be used [29]. For the measurement of the severity of pain, Hjermstad et al. suggested the use of uni-dimensional pain scales such as the Numerical Rating Scale, Verbal Rating Scale and Visual Analogue Scale (VAS) [30]. For the purpose of evaluating pain intensity, the present study employed VAS, which is considered a highly reliable method because the patient is not biased by the numbers as often occurs with the standard numerical scales [31]. VAS has also been used for quantifying TMJ-related pain in various other studies [6, 9, 12, 32]. Assessment of TMD-related dysfunction is another crucial element required for determining the effectiveness of the treatment modalities. According to Alonso-Royo et al., the Helkimo Clinical Dysfunctional Index (HI) is a swift and accurate method to evaluate limited mandibular movement, resultant joint function as well as pain [33].

In the present study, we found a significant decrease in the VAS and HI, along with an improvement in MMO among the subjects of the LLLT group, followed by Th US and TENS, respectively ($p < 0.001$). The mean difference in VAS was highest in the LLLT group (5.26 ± 1.2), followed by Th US (4.86 ± 1.7) and TENS (3.6 ± 0.5). Similarly, LLLT showed higher mean differences in the HI index (3.06 ± 1.3) followed by Th US (2.6 ± 1.0) and TENS (1.8 ± 0.4) therapy, respectively. A significant improvement was observed in the MMO of the subjects of Th US (2.8 ± 1.0), which was lower than the LLLT group (3.86 ± 1.2) but higher than the TENS group (2.46 ± 0.6). In the present study, subjects of all three groups showed considerable reduction in pain as well as dysfunction along with overall improvement of MMO. Our study results are in accordance with Budakoti et al., who reported LLLT to be superior to the Th US and TENS therapy in the functional and pain management of TMDs. In spite of the fact that all three physical therapies minimized the symptoms and signs of TMD, it was reported that LLLT offered the most significant relief of symptoms with greater improvements in parameters like maximal mouth opening, TMD-related pain, tender points related to masticatory muscle as well the joints. Furthermore, they recommended using LLLT to reduce pain more rapidly and for a longer period of time which can be evident spontaneously during the first week of treatment [6].

The improved efficacy of LLLT can be attributed to the combined analgesic and photo-chemical effects, increased anti-oxidant response, intensification of lymphatic flow with a rise of the vascular supply, stimulation of repair mechanisms for wound healing, which ultimately contributes to the decline in joint inflammation. It has also been shown effective in treating the early stages of TMD since it relaxes the chronic musculoskeletal pain experienced by the patients [9, 16, 34]. Khairnar et al., in their clinical trial, compared the effects of ultrasound heat therapy and LLLT in reducing pain related to TMD. They found a significant decrease in post-treatment VAS scores and an increase in the overall mouth open-

ing, thereby favouring the LLLT group [32]. A study conducted by Chellappa et al. compared the efficacy of TENS therapy and LLLT for the management of TMD and reported a significant difference in the VAS scores and mouth opening among the LLLT group. They also suggested the use of LLLT before any conventional dental therapy in TMD patients, which could also be beneficial in increasing the amplitude of movements of the mandible [9].

In contrast with most other studies, the present study also determined the HI scores among all three study groups. HI provides a comprehensive overview of the TMD findings based on a wide range of criteria. Considering the HI scores, our findings were in contrast to the study conducted by Rezazadeh et al., who reported no significant difference in HI between LLLT and TENS. The results of their study concluded that TENS-induced pain and functional improvement among drug-resistant TMD patients were more rapid and persistently longer in comparison to the effects of LLLT [35]. However, a randomized control trial by Veras NK et al. to investigate the efficacy of LLLT on functional improvements in TMJ concluded that LLLT-induced therapeutic effects generated a long-lasting reduction of pain along with functional improvement. They also observed the LLLT-enhanced change in the functionality of muscles pertaining to TMJ and cervical region with the aid of pachymetry and goniometry after each interventional session [36].

The present study also depicted an increase in the efficacy of Th US in TMD management when compared to TENS therapy. Various other studies have also found Th US to be beneficial in pain relief with improved functions of the mandible and masticatory muscles, similar to our finding [12, 37, 38]. The increased efficacy of Th US can be explained on the basis of improved cellular metabolic and vasodilatory rates leading to an alteration in the cellular permeability. Ultimately, the rise in the utilization of inflammatory mediators yields a significant sensation of pain relief with decreased stiffness of the TMJ, thereby improving the MMO [39, 40].

The main goal of the management of TMJ disorders is to achieve alleviation of pain sensation, which is found to be proportional to the deteriorated functions of the joint. Thus, the application of an effective therapeutic management strategy of TMDs with the aid of various physical therapy modalities can reduce the symptomatic dysfunction of the joint [39]. Though the findings of our study indicated an overall pain and functional improvement among all the study groups, we noted recurrence in 13.3%, 26.6% and 20% among the subjects of Th US, TENS and LLLT groups, respectively. Though the symptomatic recurrence was less in Th US group, it was not statistically significant. The varied recurrence rates may be attributed to the multifactorial nature of the TMDs. Planning a treatment strategy for TMDs with the aid of physical therapeutic modalities must incorporate an individual's needs in addition to the eradication of etiologic factors and reduction of musculoskeletal pain as well as discomfort, thereby preventing any long-term recurrences of the disorder [12].

CONCLUSION

The present study evaluated the efficacy of three different physical therapy modalities such as Th US, TENS therapy and LLLT for the management of TMDs. Although significant improvements were observed among the patients in all three treatment modalities, LLLT established a superiority over the therapeutic ultrasound and TENS therapy in terms of pain relief, mouth opening as well as functional outcome of the joint. Based on our results, we also suggest LLLT as an effective interventional option for TMDs and also for patients with intolerance to medications. Further, longitudinal studies involving large samples should be warranted for the evaluation of the long-term effects of these treatment modalities.

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