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Compare the effectiveness between ultrasound therapy and laser therapy in the management of temporomandibular joint disorders

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Abstract
Background: Temporomandibular disorders (TMD) are characterized by the presence of temporomandibular joint (TMJ) and/or masticatory muscle pain and dysfunction. Ultrasound therapy and low-level laser therapy (LLLT) have been recognized as therapeutic modalities for the treatment of TMD, especially when the presence of inflammatory pain is suspected. This study aims to compare the efficacy of the two treatment modalities in various TMJ disorders.
Objective: The aim of this study was to evaluate the efficacy of low intensity or LLLT and Ultrasound therapy in the treatment of patients with TMD.
Materials and Methods: A sample of 30 individuals, divided into two groups presenting signs and symptoms of TMD (I - LLLT and II - Ultrasound therapy) was taken. Both therapies were done in a total of 14 sessions. Therapy was performed for 5 days within the 1st week and then on the 30th day and the 60th day. The visual analogue scale was used to evaluate pain, digital vernier calliper used to evaluate mouth opening. Deviation from normal motion and clicking were also noted on opening and closing. The analysis of variance for repeated measurements and Tukey's tests were used for the statistical analysis.
Results: The results showed an increase in maximum mouth opening and a decrease in tenderness to palpation for both groups. Results also showed a decrease in clicking sound and deviation in both groups, although more evident for the low-level laser group.
Conclusion: Authors concluded that both therapies were effective as part of the TMD treatment though lasers proved better. However, caution is recommended when judging the results due to the self-limiting aspect of musculoskeletal conditions such as TMD.

Keywords: temporomandibular joint disorders; ultrasound therapy, laser therapy

Introduction
Temporomandibular disorders (TMD) consist of a number of clinical conditions that involve the masticatory musculature and/or temporomandibular joints (TMJ) and associated structures. Failure of any one component of these structures may impair the function of the entire system as a whole. Although the etiology of TMD is not well established, it is known that somatic or psychosocial factors may cause or maintain the disease. It is diagnosed in patients who suffer from muscle and/or joint pain spontaneously, by palpation or function and limited mandibular movements. Joint sounds are another symptom of TMD. Although pain around the myofascial region may be constant or intermittent, it is usually long-lasting and restricting. Non-surgical treatments of TMD generally consist of medications (such as non-steroidal anti-inflammatory drugs and antidepressants), consuming soft foods, treatment of parafunctional activities, occlusal splints, physical therapy such as ultrasound and transcutaneous electrical neural stimulation (TENS) alternative therapies [1].
TMD is considered the most common cause of pain of non-dental origin in the orofacial region and contains a varied group of disorders with common symptoms of psycho-physiological orofacial pain, masticatory dysfunction, or both. Signs and symptoms of this dysfunction are present in approximately 86% of the population, most frequent in women in the 30 years old age group [2].
Dysfunctions in the masticatory muscles are considered the main originating cause of non-dental pain in the orofacial region. The pain described as facial pain, headache, or earache is commonly intensified by mandibular function. TMDs are also accompanied by recurring headaches and pain in the neck, showing a high incidence of signs and symptoms such as muscle spasms, reflex pain, difficulty in joint movement, crepitation, headache, and hearing disorders. The physical therapy approach and appropriate treatment plans for TMD must necessarily be based on the diagnosis. Laser photobiomodulation is a low-cost non-invasive type of treatment that can be used for controlling a variety of such conditions. It is frequently used in clinical practice for pain relief and tissue regeneration and has been certified as beneficial in treating temporomandibular dysfunctions. Among the therapeutic effects are anti-inflammatory, analgesic and cell activity modulating actions, which have been proven in various studies. The mode of action of laser photobiomodulation is by activating the components of the mitochondrial respiratory chain, resulting in the start of a

series of cellular events. Once absorbed by the tissues, the laser radiation causes the release of histamine, serotonin, bradykinin, and prostaglandins that are related to pain. It is also capable of modifying cell and enzymatic activities [3]. The use of low-level laser therapy (LLLT) has gained popularity in recent years as a method of management of many localized, painful, musculoskeletal conditions. Although phototherapy devices have been in use for LLLT treatment since the mid-1960s, their therapeutic value remains controversial as the literature has conflicting results. In the past few years, a number of clinical trials and analyses have shown that LLLT effectively treats different musculoskeletal and neurogenic pain pathologies. However, limited information still exists about the effects of LLLT in such conditions [1].

Ultrasound therapy is used to relax hyperactive muscles. Ultrasound therapy therapy produces low-amplitude, a low-frequency alternating stimulus that causes vibrations. Applied bilaterally between the TMJ and the coronoid process, the stimulus reaches the deep mandibular division of the trigeminal nerve, as well as the superficial facial nerve. Ultrasound therapy is applied to reduce the muscular activity of masticatory muscles [3].

LLLT is in accordance with TMD's treatment philosophy because it represents a non-invasive, reversible therapy without any side effects. LLLT makes use of electromagnetic radiation of a single wavelength, usually in the red or infrared regions. LLLT also helps provide treatment for several pathologies like impaired wound healing, pain conditions, and inflammatory situations [4].

Methods

This study involved 30 patients that came to the Department of Prosthodontics and the Department of Oral Medicine of ITS Paramedical College, Ghaziabad with diagnoses of TMD of multiple causes. Informed consent for participation in this study was obtained in all cases. Following a preliminary evaluation to exclude patients with presence of systemic diseases and those with history of recent trauma, the inclusion criteria comprised of patients with presence of pain, reciprocal joint clicking, restricted mouth opening and jaw deviation and not having medical or pharmacological treatment for TMD. Patients presented multiple causes of TMD. During the study, patients were instructed not to take systemic medication for TMD. Prior to the therapies, the patients were made to sit in a dental chair in an upright position with their heads resting on the head rest. Patients were instructed to open their mouth until it reached maximum capability without excessive discomfort. Clicking sound was noted on opening and closing of the mouth.

Pain was evaluated using the visual analogue scale (VAS). With a digital vernier calliper, the total mouth opening was recorded, with the measure being performed from the incisal of the upper incisors to the incisal of the lower incisors. All patients received both methods randomly alternated, in one treatment session per day for 5 days, followed by recall on the 30th and 60th day. LLLT was performed with a continuous-wave diode laser (Lambda SPA - Italy), emission wavelength of 980 nm, output power of 1 W for 60 s. Four sites were chosen to receive the irradiation: The area over the masseter muscle, the temporal muscle, the condyle, and pre-tragal region. The treatment was performed bilaterally with total time duration of 10 min. Ultrasound therapy was executed with a tranducer head output frequency 3 MHz. The total duration of the treatment was 10 min. The treatment was performed bilaterally. The position of the electrode was between the TMJ and the coronoid process, to allow the arrival of the stimulus to the trigeminal nerve as well as the facial nerve. The results were compared for each individual treatment (before and after treatment values), as well as between treatments (mean of the after treatment improvement).

Statistical Analysis

Data were summarized as mean±standard deviation (SD). Groups were compared by two factors (groups × periods) repeated measures analysis of variance (ANOVA) and the significance of mean difference within and between the groups was done by Tukey's *post-hoc* test. Categorical groups were compared by Chi-square ($\chi 2$) test. A two-sided ($\alpha = 2$) $P < 0.05$ was considered statistically significant. All analyses were performed on SPSS software.

Results

Basic Characteristics

The basic characteristics *viz*., age and sex distribution of two groups (Ultrasound therapy and LASER therapy) are summarized in Table 1. The age of Ultrasound therapy and LASER groups ranged from 22-66 to 26-52 years, respectively with mean (±SD) 45.20 ± 12.70 years and 40.07±7.30 years, respectively. The mean age of Ultrasound therapy was slightly higher than LASER group but not differed statistically (t=1.36, P=0.186). Further, in both groups, the frequency of males was higher than females with slightly higher being in TENS (66.7%) as compared to LASER (60.0%); however, the sex proportion (female/male) also not differed ($P > 0.05$) between the two groups ($\chi 2$=0.14, P=0.705), i.e. found to be statistically the same. In other words, subjects of two groups were age and sex matched and comparable.

Table 1: Basic characteristics of two groups

Basic	US therapy LASER therapy $t/\chi 2$ value P value			
characteristics	n=15 (%)	n=15 (%)		
Age (years)	45.20±12.70	40.07±7.30	1.36	0.186
Sex				
Females	5 (33.3)	6 (40.0)	0.14	0.705
Males	10 (66.7)	9 (60.0)		

Primary Outcome Measures

Maximum mouth opening

Comparing the mean maximum mouth opening of two groups over the periods, ANOVA revealed significant effect of both groups (treatments) (F=18.81, $P < 0.001$) and period (time) (F=65.36, $P < 0.001$) on maximum mouth opening. Further, the interaction (groups × periods) effect of both on maximum mouth opening was also found to be significant (F=19.89, $P < 0.001$).

Further, for each group, comparing the mean maximum mouth opening between the periods (i.e. within groups), Tukey test revealed significant ($P < 0.01$ or $P < 0.001$) improvement in

maximum mouth opening of both the groups over the periods.
Similarly, for each period, comparing the mean maximum mouth opening between the groups, Tukey test revealed significantly (P<0.05 or P<0.01) different and higher improvement in maximum mouth opening of LASER group as compared to Ultrasound Therapy group at all post periods (day 1-60). Moreover, at final evaluation, the net improvement (i.e. mean change from day 0 to 60) in maximum mouth opening of LASER group (28.3%) was 3.2-fold (or 19.4%) higher as compared to Ultrasound Therapy (8.9%).

VAS

The mean VAS scores in both groups decrease (improve) after the treatments, and the decrease (improvement) was evident higher in LASER group as compared to Ultrasound Therapy.
Comparing the mean VAS scores of two groups over the periods, ANOVA revealed significant effect of both groups (treatments) (F=57.46, P<0.001) and period (time) (F=99.24, P < 0.001) on VAS scores. Further, the interaction (groups × periods) effect of both on VAS scores was also found to be significant (F=16.79, P<0.001).
Further, for each group, comparing the mean VAS scores between the periods (i.e. within groups), Tukey test revealed significant (P < 0.05 or P < 0.01 or P < 0.001) improvement in VAS scores of both the groups over the periods.
Similarly, for each period, comparing the mean VAS scores between the groups, Tukey test revealed significantly (P< 0.05 or P < 0.01 or P < 0.001) different and higher improvement in VAS scores of LASER group as compared to Ultrasound Therapy at all post periods (day 1-60). Moreover, at final evaluation, the net improvement (i.e. mean change from day 0 to 60) in VAS score of LASER group (77.1%) was 1.6-fold (or 29.8%) higher as compared to Ultrasound Therapy (47.3%).

Secondary Outcome Measures

TMJ sound

The pre (day 0) and post (day 60) TMJ sound presence of two groups are summarized in Table 4. At day 0, the presence of TMJ sound was higher in LASER group (66.7%) than Ultrasound Therapy group (53.3%); however, at day 60 (final evaluation) it was lower in LASER group (6.75) as compared to Ultrasound Therapy group (26.7%). Comparing the presence of TMJ sound of two groups at two different periods, χ2 test revealed similar TMJ sound between the two groups (χ2=1.98, P=0.159), i.e. not differed statistically.

Muscle tenderness

The pre (day 0) and post (day 60) presence of muscle tenderness of two groups are summarized in Table 3. At day 0, the muscle tenders was present 100.0% in both groups; however, at final evaluation, it decrease (60.0%) significantly in LASER group as compared to Ultrasound Therapy group (χ2=5.66, P=0.017).

Deviation

The pre (day 0) and post (day 60) presence of deviation of two groups are summarized in Table 4. At day 0, both groups showed similar deviation (60.0%); however, not differed also after 60 days post-treatments (χ2 = 1.15, P= 0.284) though it lowered 33.3% more in LASER group as compared to Ultrasound Therapy group.

Discussion

In the present study, many criteria were considered for judgment of treatment effectiveness including range of mouth opening, pain scales and ratings of muscle tenderness and clicking sounds.

Table 2: Pre (day 0) and post (day 60) distribution of TMJ sound presence of two groups

TMJ sound	US therapy	LASER therapy		χ2 value	P value
(present)	n=15 (%)	(n=15) (%)		(df=1)	
Day 0	8 (53.3)	10	(66.7)	1.98	0.159
Day 60	4 (26.7)	1	(6.7)		

TMJ: Temporomandibular joint, US: Ultrasound therapy

Table 3: Pre (day 0) and post (day 60) distribution of muscle tenderness presence of two groups

Muscle	US therapy	LASER therapy	χ2 value	P value
tenderness	n=15 (%)	n=15 (%)	(df=1)	
(present)				
Day 0	15 (100.0)	15 (100.0)	5.66	0.017
Day 60	10 (66.7)	1 (6.7)		

Table 4: Pre (day 0) and post (day 60) distribution of deviation presence of two groups

Deviation	US therapy	LASER therapy	χ2 value	P value
(present)	n=15 (%)	n=15 (%)	(df=1)	
Day 0	9 (60.0)	9 (60.0)	1.15	0.284
Day 60	9 (60.0)	4 (26.7)		

US: Ultrasound therapy

Similar to results shown in our study, many studies have shown the effectiveness of TENS in the management of TMD, individually as well as combined with other therapies and are known to improve the stomatognathic system functionally.5 Grossmann *et al*., 2012 presented a review article on the effectiveness of Ultrasound Therapy for TMD and concluded that Ultrasound Therapy is a treatment alternative for pain as well as TMD.6
Monaco *et al*., 2012 performed studies on 60 patients to evaluate the effect of Ultrasound Therapy on electromyography and kinesiographic activity of patient with TMD. They concluded that Ultrasound Therapy could be effective to reduce the surface electromyography activity in masticatory muscles and improve interocclusal distance of TMD patients.7
Several reports have documented the positive effects of Ultrasound Therapy and LLLT in TMD. In our study, LLLT has shown to have eliminated signs and symptoms of TMD more than TENS therapy has. Similar results were seen by Kato *et al*., in 2006 who performed a comparative study on 18 patients with chronic TMD using Ultrasound Therapy and LLLT and concluded that both therapies were effective for decreasing the symptoms of TMD [8].
Núñez *et al*., in 2006 performed a comparative study on 10 patients, 18-56 years of age with TMD, using Ultrasound Therapy and LLLT and noted the range of mouth opening in the patients. The patients received both methods of treatment

in 2 consecutive weeks. Comparing the two methods, the values obtained after LLLT were significantly higher than those obtained after Ultrasound Therapy ($P < 0.01$). This concluded that even though both methods are effective to improve mouth opening, by comparing the two methods LLLT was more effective than Ultrasound Therapy [4].

A systematic review was done by Maia *et al*., in 2012 on the effect of LLLT on pain levels in patients with TMD. 14 studies were reviewed and a reduction in pain levels was reported in 13 studies. Most papers showed that LLLT seemed to be effective in reducing pain from TMD similar to the results shown in our study. However, the heterogeneity of the standardization regarding the parameters of laser calls for caution in interpretation of these results.[2]

Another meta-analysis study by Enwemeka *et al*., in 2004 on the efficacy of low-power lasers in tissue repair and pain control revealed a positive effect of laser phototherapy on tissue repair and pain control. The positive effect of treatment on specific indices of tissue repair was evident in the treatment effect sizes determined as follows: Collagen formation (d=+2.78), rate of healing (d=+1.57), tensile strength (d=+2.13), time needed for wound closure (d=+0.76), tensile stress (d = +2.65), number and rate of degranulation of mast cells (d=+1.87), and flap survival (d=+1.95). Further, analysis revealed the positive effects of various wavelengths of laser light on tissue repair, with 632.8 nm having the highest treatment effect (d=+2.44) and 780 nm the least (d=0.60). The overall treatment effect for pain control was positive as well (d=+1.11). These findings mandate the conclusion that laser phototherapy is a highly effective therapeutic armamentarium for tissue repair and pain relief.9

In another study in 2009 by Carrasco *et al*., 60 patients with myofascial pain syndrome and having one active trigger point in the anterior masseter and anterior temporal muscles were selected and assigned randomly to six groups (n=10): Groups I-III were treated with gallium aluminum arsenide (780 nm) laser, applied in continuous mode and in a meticulous way, twice a week, for 4 weeks. Groups IV-VI were treated with placebo applications, simulating the same parameters as the treated groups. Pain scores were assessed just before, then immediately after the fourth application, immediately after the eighth application, at 15 days and 1 month following treatment. A significant pain reduction was observed over time ($P < 0.001$). The analgesic effect of the LILT was similar to the placebo groups. Using the parameters described in this experiment, LILT was effective in reducing pain experienced by patients with myofascial pain syndrome.10

Another meta- analysis of the efficacy of phototherapy in tissue repair by Fulop *et al.*, was done by aggregating the literature and using statistical meta-analysis to analyze pertinent studies published between 2000 and 2007. Their findings indicated that phototherapy is a highly effective form of treatment for tissue repair, with stronger supporting evidence resulting from experimental animal studies than human studies.11

Conclusion

1. Both therapies (LLLT and Ultrasound Therapy) were effective in the management of TMDs
2. Range of mouth opening, tenderness (temporomandibular as well as muscular), clicking sound as well as deviation from normal motion have improved for both groups, but LLLT was notably more effective than Ultrasound Therapy.
3. More longitudinal and controlled studies must be performed to evaluate the real effect of physical therapy modalities on TMD signs and symptoms.

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