Original Article

Effect of Low-Level Laser Therapy on Sternocleidomastoid and Trapezius Muscles' Spasm for Treatment and Alleviation of Temporomandibular Disorders

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Abstract

Objectives: The aim was to evaluate the therapeutic effect of low-level laser therapy LLLT on pain intensity of different cervicofacial muscles symptoms to alleviation of temporomandibular disorders TMDs.

Methods: A randomized clinical trial was conducted on 60 patients. Patients were divided into three equal groups. The LLLT were received in Group 1: on masticatory muscles and temporomandibular joints TMJs. Group 2: on neck muscles. Group 3: on both masticatory and neck muscles with TMJ. Pain intensity was assessed before and after treatment by Visual Analogue Scale, and TMJ clicks recorded by normal listening, feeling, and palpation. Inter-incisor distance measured by digital Vernia calliper and LLLT therapy provided by BIOLASE-EPIC device. (Germany).

Results: Demographic features were not different among the groups. The highest pain score per case for TMJ and muscle, TMJ alone(arthrogenic), Muscle alone (myogenic) before and after LLLT was improved significantly p-value of <0.001.The majority of click types 38.4% improved, the frequency and types of clicks that were decreased significantly in all groups. The majority of clicks were either disappeared 40% or changed from painful to painless 31.7% clicks significantly p-value = 0.003. The maximum opening capacity MOC was significantly increased p<0.001 after LLLT.

Conclusions: The result recorded significant association between TMJ pain and neck muscles symptom. Further, there was significant improvement in TMD pain relief, TMJ click, and MOC after the application of LLLT to the neck muscles, Therefore LLLT could be suggested as a TMDs treatment option and added to the treatment protocol of TMDs.

Keywords: *Low-level laser therapy LLLT, Sternocleidomastoid, trapezius, Temporomandibular disorders TMDs, MOC.*

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Introduction

Temporomandibular disorders TMDs are painful conditions that involve the temporomandibular joint TMJ, masticatory muscles, and the surrounding tissues[1]. Further, the TMJ and the masseter muscles mostly produce pain in patients with TMDs[1]. Masseter and sternocleidomastoid muscles are often the most painful sites in patients suffering from joint noise[2].

The classification of TMD is based on research diagnostic criteria for temporomandibular disorders RDC/TMD, which describes the signs and symptoms[2]. The main features of TMDs are pain, joint noise, reduced range of mandibular movement, and mandibular deviation during TMJ function[2].

The etiology of TMDs is not well established, and it is a multifactorial disorder. Occlusal disharmony, muscle hyperactivity, central pain mechanisms, psychological distress, trauma, sleep disturbance, and unhealthy lifestyle are considered etiological factors[3]. Epidemiological studies revealed that 75% of adults have at least one sign of TMDs, and 30% have more than one symptom[4]. About 12% of TMDs patients experience prolonged pain that results in disability, and about 25% of acute cases develop chronic pain in the absence of appropriate intervention[3].

The pain of TMDs is frequently associated with headache and neck muscular dysfunction[5] and cervical spine disorders[6]. A previous study showed a strong association between neck disabilities and jaw disabilities[5]. Patients with TMDs suffer from neck symptoms more frequently than others, and patients with neck pain suffer from signs and symptoms of TMDs more frequently than do healthy control[7]. Sternocleidomastoid and trapezius muscles are one of the leading causes of neck pain, and it is characterized by deep, intense pain and by the presence of one or more myo-facial trigger points MTPs[8]. The literature showed that 23–67% of patients with TMD had sternocleidomastoid and upper trapezius muscle tenderness and other cervical and shoulder muscle tenderness on palpation[9].

The management of this complex disorder required a multidisciplinary team, including dentists, physicians, physical therapists, psychologists, and speech therapists[10]. Different therapies were applied to manage the TMDs, including medications, occlusal splint therapy, physical therapy, psychotherapy, acupuncture, behavioral therapy, and laser[10].

Low-level laser therapy LLLT is one of the various treatment strategies used to treat TMDs and neck pain[11]. In recent years, the application of photobiomodulation lasers with different wavelengths (e.g. 660, 810, 840, 980, and 940 nm) has become popular for pain reduction and healing acceleration after surgeries[14].

This therapy has a stimulative effect on target tissues[11]. Photobiomodulation lasers emit radiation with wavelengths between 600–1000 nm spectrum range in the red or infrared spectrum, which are absorbed weakly by water and can penetrate soft and hard tissue to depths of 3 to 15 mm, and low light energy of few to 200 milliwatts (mW) for seconds to minutes; thus, it non-significantly raises tissue temperature about one °C thus temporary relief of minor pain, and inflammation, stimulates collagen metabolism and wound healing, and promotes fracture healing[11,12-13-14]. Describing the working mechanism of photobiomodulation lasers is difficult, but importantly, the absorption of red and infrared beams occurs in photoreceptors[11,12-14]. Also, it stimulates membrane permeability, intracellular calcium influx, and adenosine triphosphate ATP production[11]. Besides, the laser stimulates the endogenous opioid release, elevates pain thresholds, and modifies bradykinin and histamine release[11-13]. It also downsizes the transmission of pain signals and regulates serotonin and norepinephrine so increases the pain threshold[13,15]. Therefore, it had been used to treat musculoskeletal conditions[11,13-16]

At present, all common commercially available LLLT systems use semi-conductor diode lasers. Gallium-Arsenide GaAs emit laser energy at the infrared range and the GaAlAs pulsed laser[4,13-17].

The exact association of signs and symptoms in patients with TMD to their cause(s) is not clear, and there is little evidence regarding the association of symptoms of TMDs with cervical pain and spasm. Therefore, this study aimed to evaluate the therapeutic benefit of LLLT on different muscles in the cervicofacial region in patients suffering from TMDs; the study attempts to evaluate the effect of using LLLT on neck muscles TMJ management.

Materials and methods

A randomized clinical trial was conducted on 60 patients[15] with TMDs using a computerized program. They had neck pain and spasm and visited the

maxillofacial unit in Shar and Sulaimanyah Teaching Hospitals, Sulaimanyah City, Kurdistan Region, Iraq. A study proposal was applied to and accepted by the Kurdistan Board of Medical Specialties KBMS Ethical Committee in 18/03/2019.

Patients above 18 years of age complaining of TMDs with or without neck symptoms were included.

Patients with TMJ congenital abnormality, concomitant inflammatory, neoplastic conditions, and history of trauma and systemic diseases, such as systemic lupus erythematosus, rheumatoid arthritis, infectious diseases, were excluded.

After thorough history taking, detailed examination, and investigation, the diagnosed patients were interviewed for demographic information. The treatment protocol was clearly explained, and a written information sheet was given to the patients; then, the patients signed a consent form confirming their participation in the study.

All patients were examined and evaluated by two oral medicine specialists. The condition of TMDs was diagnosed according to RDC/TMDs[2] with/without neck pain. The pain intensity at ten tender points in masticatory muscles; four masseters, two temporalis, two medial and two lateral pterygoids at each side, 18 tender points in neck muscles; four for sternocleidomastoids, 11 for trapezius, one for the posterior belly of digastric, and two for scalenus capitus at each side were assessed and recorded. Furthermore, three tender points in the preauricular region during closed-mouth, opened-mouth, and through external auditory meatus on each side were all assessed by the 10 mm Visual Analogue Scale (VAS) on both sides.

Clinical pain intensity was evaluated on the first day before the first session of the LLLT application and before receiving each LLLT session. Patients received five laser therapy sessions, with three days intervals. The study ended on day 15 after the fifth session.

During closing and opening mouth positions, the types and frequency of TMJ clicks were evaluated by normal listening, feeling, and palpation. The total count of clicking for both sides was recorded before and after 15 days of the follow-up period. The patients were asked to open her/his mouth as much as possible to measure maximum mouth opening capacity MOC. The MOC was measured as maximum inter incisor distance plus overbite.

A comfortable maximum mouth-opening was achieved by asking the patient to open his/her mouth to a comfortable opening without pain and application of pressure. The inter incisor distance between upper and lower central incisor teeth was measured by digital Vernia caliper in mm. Measurements were done before and 15 days after the last session.

The patients were divided equally into three groups according to the LLLT treatment manner.

Group 1: LLLT was applied to masticatory muscles and temporomandibular joints TMJs bilaterally, i.e., only the face.

Group 2: LLLT has only applied to neck muscles sternocleidomastoids, scalenus capitus, trapezius, and posterior belly of digastric muscles, bilaterally, i.e., only the neck muscles.

Group 3: LLLT was applied on both masticatory and neck muscles with the TMJs, bilaterally described, i.e., face and neck together.

The patients' allocation was done by using a simple random method. The LLLT therapy was provided by the BIOLASE-EPIC (Germany) device GaAsP Semi-conductor diode laser classification IV, in GaAs, 940 nm wavelength used with a specific probe for delivering the laser to treat pain, the surface area of the tip of the probe is 2.35 cm^2 square, according to this the energy density is going to be 4.25 j/cm2 that delivered the laser light with an output power of 0.5 watts at the fiber-optic tip, duration of 20 seconds, and dosage energy of 10 J (following 13). according to this, the energy density will be 4.25 j/cm2, and the total energy delivered to one point in all sessions will be 30 J. The laser probe was applied 1 cm distance away from the skin in a perpendicular position at the area of the insertion and origin of muscles in addition to points of tenderness during the examination, the TMJ area, and the external acoustic meatus during mouth closing and maximum opening. Intra-orally, the LLLT probe applied to the anterior border of the ramus of the mandible for the attachment of temporalis muscle, posterior, and superior to the molars in the buccal vestibule for lateral pterygoid muscle, and on the lingual aspect of the mandible posteriorly for medial pterygoid muscle by the same probe and 1 cm away from the mucosal surface that protected by film barrier for infection control purpose. The patient and the physician used protective eyewear.

Statistical analysis

After data collection and before data entry and analysis, the questions of the study were coded. Data entry was performed using an excel spreadsheet; then the statistical analysis was performed by the SPSS program, version 25 IBM SPSS Statistical Package for the Social Sciences.

Compliance of quantitative random variables with Gaussian curve normal distribution was analyzed using the Kolmogorov-Simonov test.

The data presented in tabular forms. Chi-square tests were used to compare the categorical data between these groups of patients with respect to different variables. Different types of charts were used to describe some variables of the study diagrammatically.

Some quantitative variables as highest pain scores and maximum mouth opening scores were not normally distributed quantitative variables by non-parametric tests as the Mann- Whitney test and Wilcoxon sign ranked test was used to describe the statistical significance of the test.

p-values of 0.05 were used as a cut-off point for the significance of statistical tests.

Results

The demographic features of the patients in the total sample and the three studied groups were presented in Table 1. Male patients were about n = 36.7%, and about 63.3% were female. The male: female ratio was 0.58:1. About 25% were student, 46.7% were employed, 25% unemployed, 3.3% worker. Regarding the complaint of the patients, 3.3% presented with pain, 10% with clicking, 1.7% with limitation in mouth opening, 65% with pain and clicking, 3.3% with pain and limitation, 1.7% with click and limitation, and 15% presented with all features.

There were statistically non-significant differences between gender, patients' occupation, and the patients' presenting complaints among the three studied groups (Table 1).

Pain and Maximum Opening Capacity

The difference in the highest pain score before and after LLLT among the three studied groups was highly significant p = <0.001, i.e., there was a statistically significant improvement in the highest pain score LLLT. These associations were statistically significant for all the three groups, p <0.001 (Table 2).

The MOC was also statistically significantly increased in all three studied groups (Table 2). The differences of TMJ pain with neck pain were statistically non-significant in all the three studied groups (Table 3). The severity of TMD pain during LLLT therapy has decreased. Further, this decrease was more frequent among patients in group 3, followed by group 2 for the mean highest pain score in TMJ alone, neck muscles alone, and TMJ and muscles (Figure 1).

Clicking

Very interesting results regarding the clicking were gained in the current study. The painful late opening and early closing clicks were presented in 25 % of all cases. Early opening and late closing painless clicks were predominant 15 %. Late opening and early closing painful clicks were more in group 2 (15%) and in group 3 about 8.3%, one painful click before treatment. Also, most click types n = 38.3% improved after application on LLLT that changed to one painless click. The difference in click types before and after treatment was statistically significant among the studied groups (Table 4). The frequency of clicks in group 1 was mostly during the wide opening of mouth 20% and in group 2 (18.3%) followed by group 3 (31.7%). Although the difference in frequency of click before treatment with the studied groups was statistically non-significant, this difference after treatment became significant. The frequency of clicks decreased in all the three studied groups (Table 4).

The majority of the clicks were either disappeared or changed from painful to painless clicks. Furthermore, the intensity of pain that accompanied clicks was changed from painful to painless was statistically significant, and group 2 had the highest percentage 21.7% p-value of <0.001. However, the click disappeared significantly in group 3, 20%. Then click change was highly significant in group 3 p<0.001, followed by group 2 p=0.01, while significant in group 1 p=0.049 and the click change was statistically significant in all groups p = 0.003 (Table 4).

Discussion

The LLLT has been used as a convenience therapy with a high beneficiary effect for TMD; it can relieve pain and other symptoms[3,5-19]. After application of the LLLT on TMD, the effect and patients' outcome are correlated with the dose and type of laser. Still, it also correlates with different locations and types of tissue targeted where the therapy was applying[16,20]. The pattern of group selection in this study was aimed to evaluate the therapeutic benefit of LLLT on TMDs by lasing different muscles in the cervicofacial region or applying LLLT on the cervical muscles.

The sample was divided into three studied groups with nearly matched demographic features; no significant differences were present in gender, occupations, and presenting complaints to eliminate the effect of confounding factors on the results.

Table 1: Demographic features and presenting complaints of the patients among the studied groups.

Demography		Group 1 (%)	Group 2 (%)	Group 3 (%)	Total (%)	*p*-value*
Gender	Male	7 (11.7)	10 (16.7)	5 (8.3)	22 (36.7)	0.26
	Female	13 (21.7)	10 (16.7)	15 (25)	38 (63.3)	
	M:F ratio	0.54:1	1:1	0.33:1	0.58:1	
Occupation	Student	5 (8.3)	7 (11.7)	3 (5)	15 (25)	0.39
	Employee	7 (11.7)	10 (16.7)	11 (18.3)	28 (46.7)	
	Unemployed	7 (11.7)	2 (3.3)	6 (10)	15 (25)	
	Worker	1 (1.7)	1 (1.7)	0 (0)	2 (3.3)	
Complaint	Pain	1 (1.7)	1 (1.7)	0 (0)	2 (3.3)	0.11
	Click	5 (8.3)	1 (1.7)	0 (0)	6 (10)	
	Limitation	0 (0)	0 (0)	1 (1.7)	1 (1.7)	
	Pain and click	8 (13.3)	17 (28.3)	14 (23.3)	39 (65)	
	Pain and limitation	1 (1.7)	0 (0)	1 (1.7)	2 (3.3)	
	Click and limitation	1 (1.7)	0 (0)	0 (0)	1 (1.7)	
	All features	4 (6.7)	1 (1.7)	4 (6.7)	9 (15)	

* Chi-Squared test. M: F ratio = male: female ratio.

Table 2: Mean differences between the variables before and after LLLT of highest pain scores of TMJ alone, muscles alone, TMJ with muscles together, and maximum opening capacity (MOC) among the studied groups.

		Group 1	Group 2	Group 3	*p*- values +
TMJ and muscles highest pain score (Mean ± SD)	Before	4.5 ± 2.6	7.42 ± 1.8	8.0 ± 1.29	<0.001
	After	1.44 ± 1.65	0.95 ± 1.8	1.63 ± 1.74	
p values*		<0.001	0.001	0.001	
TMJ highest pain score (Mean ± SD)	Before	4.3 ± 2.98	5.28 ± 2.49	6.42 ± 2.117	<0.001
	After	1.2± 1.48	0.31 ± 0.87	0.84 ± 1.21	
p values*		0.01	<0.001	<0.001	
Muscles highest pain score (Mean ± SD)	Before	4.5 ± 2.6	7.32 ± 1.7	8 ± 1.29	<0.001
	After	1.33 ± 1.68	0.95 ± 1.84	1.32 ± 1.7	
p values*		<0.001	<0.001	<0.001	
MOC	Before	39.68 ± 10.02	47.05 ± 7.39	41.15 ± 6.07	0.001
	After	47.05 ± 5.35	50.15 ± 4.89	47.90 ± 4.38	
p values*		<0.001	0.01	<0.001	

- TMJ = temporomandibular joint; SD = standard deviation; * MannWhitny
- +Wilcoxon signed rank test

Table 3: association of highest pain score in TMJ with neck pain among the study groups.

Highest pain score in TMJ	Neck pain		No neck pain		p-values[+]
	Median ± mean rank	Frequency (%)	Median ± mean rank	Frequency (%)	
Group 1	4.5 ± 8.32	14 (23.3)	5.7 ± 9.75	2 (3.3)	0.7
Group 2	3.5 ± 6.59	8 (13.3)	3.5 ± 4.75	2 (3.3)	0.71
Group 3	6.0 ± 10.35	17 (28.3)	5.50 ± 7.0	2 (3.3)	0.49

- TMJ = temporomandibular joint; +Mann- Whitney-test.

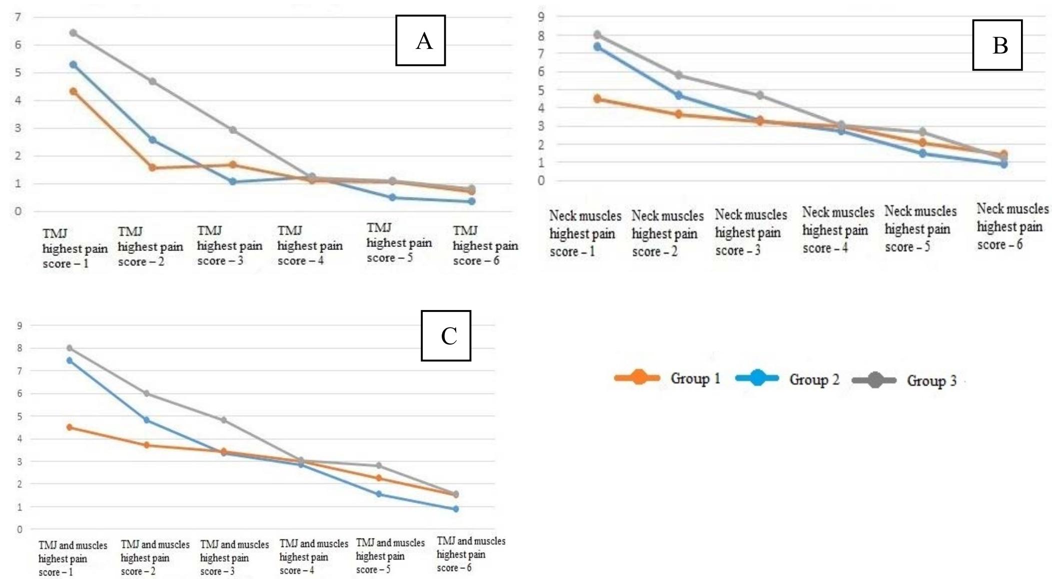

Figure 1: A-Shows mean highest pain score in TMJ alone during LLLT. X-axis TMJ highest pain score. Y-axis VAS. B-Shows mean highest pain score in neck muscle during LLLT. X-axis TMJ highest pain score. Y-axis VAS. C-Shows mean highest pain score in TMJ and muscles during LLLT. X-axis TMJ highest pain score. Y-axis VAS.

Table 4: Types and frequencies of clicks before and after applying LLLT, with the association of change in a click within the studied groups.

Clicking	period of treatment			Groups no. (%)			Total No. (%)	*p*-values*	
				Group 1	Group 2	Group 3			
Types	Before	Early opening-late closing	painful	1 (1.7)	7 (11.7)	3 (5)	11 (18.3)	0.003	
			painless	9 (15)	0 (0)	2 (3.3)	11 (18.3)		
		Late opening early closing	painful	1 (1.7)	9 (15)	5 (8.3)	15 (25)		
			painless	3 (5)	0 (0)	3 (5)	6 (10)		
		One-click	painful	3 (5)	2 (3.3)	5 (8.3)	10 (16.7)		
			painless	1 (1.7)	1 (1.7)	0 (0)	2 (3.3)		
		None		2 (3.3)	1 (1.7)	2 (3.3)	5 (8.3)		
	after	Early opening-late closing	painful	1 (1.7)	0 (0)	0 (0)	1 (1.7)	0.002	
			painless	4 (6.7)	4 (6.7)	0 (0)	8 (13.3)		
		Late opening early closing painful	painful	0(0)	0(0)	0(0)	0(0)		
			painless	0(0)	0(0)	0(0)	0(0)		
		One-click	painful	0(0)	0(0)	0(0)	0(0)		
			painless	6 (10)	10 (16.7)	7 (11.7)	23 (38.3)		
		None		9 (15)	6 (10)	13 (21.7)	28 (46.7)		
Frequency	Before	Wide opening		12 (20)	11(18.3)	8 (13.3)	31 (51.7)	0.15	
		Functioning,Every opening		5 (8.3)	8 (13.3)	4 (6.7)	17 (28.3)		
		Very Wide opening,		1 (1.7)	0 (0)	4 (6.7)	5 (8.3)		
		None		2 (3.3)	1 (1.7)	4 (6.7)	7 (11.7)		
	After	Wide opening		5 (8.3)	12 (20)	5 (8.3)	22 (36.7)	0.046	
		Functioning,Every opening		1 (1.7)	0 (0)	2 (3.3)	3(5)		
		Very wide opening		5 (8.3)	2 (3.3)	0(0)	7 (11.7)		
		None		9 (15)	6 (10)	13 (21.7)	28 (46.7)		
Change in click							Total (%)	*p*-values*+	*p*-value+
	Painful to painless			3(5)	13(21.7)	3(5)	19(31.7)	<0.001	0.003
	Disappeared			7(11.7)	5(8.3)	12(20)	24(40)	0.07	
	No change			9(15)	2(3.3)	4(6.7)	15(25)	0.03	
	Worse			1(1.7)	0(0)	1(1.7)	2(3.3	0.4	
	Total			20(33.3)	20(33.3)	20(33.3)	60(100)	—	
	p values*+in each groups			0.049	0.001	<0.001	—	—	

*Chi-Squared test. *+ *p* values for each click change were calculated after processing the data into dichotomous categorical data of yes and no.

Nevertheless, the male: female ratio was 0.58:1; this gender difference was in line with Ferreira et al.[3,20], where the males: female ratio in their study was about 0.22:1. TMD in the community occurs at about twice the rate in women as in men, yet women are eight times more common in the clinic population than men. The reason why women make up the majority of patients presenting for treatment is still unclear; for example, oral contraceptives and estrogen replacement in women older than 40 years substantially increases the risk of developing TMD [3].

The TMDs patients mostly presented with pain in the neck and TMJ, clicks in TMJ, and reduced range of jaw motion[19,22]. In the current study, the clinical features among the patients were a pain in the masticatory muscle or joint, pain and spasm of neck muscle, TMJ click, and limitation of range of motion.

There was a noticeable improvement and significant reduction in the pain within the three groups after LLLT therapy. The best results reported in group 3, which laser applied to the muscle of mastication, neck, and TMJs and least improvement were recorded in group 2 that laser applied only to the neck muscles. In a recent systematic review and meta-analysis of randomized clinical trials performed by Xu et al.[23], the LLLT showed positive effects on pain relief; however, dosage and location analyses in the reviewed literature showed a discrepancy. We, therefore, tried to investigate the application of LLLT in different locations for the management of TMD. However, the association of TMD pain with neck pain in the current study was statistically non-significant. Our findings were contrary to the study of Nunes et al. [24], in which they found a significant association between neck pain and mandibular function. However, the association of cervical disability and mandibular dysfunction in their study was statistically non-significant.

Although other studies had confirmed the efficacy of LLLT in the improvement of clinical symptoms of TMDs when LLLT was applied on different points of the pterygoid, temporalis, trapezius, and masseter muscles, its effect was not consistent when the dose and sessions were different[26-27].

Pain is mostly produced by TMJ and masseter muscles in patients with TMD[1]; however, TMJ clicks are frequent when the masseter and sternocleidomastoid muscles are the most painful sites[2]. However, this association of sternocleidomastoid pain with TMJ clicks[2] did not explain why neck pain with the change of clicks was statistically insignificant in our study. This may be because most of our patients, 81.7% in all the three studied groups, had already presented with neck pain.

One of the common findings in TMD is a limitation of mandible movements due to pain[28]. Therefore, clinicians assess maximum mouth opening and jaw deviations to assess the limitation of movement in TMJ [28]. In the current study, the MOC has significantly increased after LLLT therapy in all three studied groups regardless of the site of application. Our result was with a randomized clinical trial performed by Khairnar et al.[28]. They found a significant increase in the mouth opening after applying LLLT in India compared to another group with whom they used ultrasound therapy. Further, it is expected to improve the limitation of movement and increase mouth opening after improvement of pain.

Therefore, we suggest further follow upping the patients for a longer period to suggest LLLT of neck muscles into the algorithm of TMD management.

Conclusion

Although there was an insignificant association of TMD pain with neck pain, the study has recorded significant relief in TMD pain, improvement of TMJ click, and MOC of mouth after applying LLLT to the neck muscles. Therefore, we suggest further studies on applying LLLT of other craniofacial muscles to suggest using LLLT of the craniofacial muscles into the algorithm of TMD management.

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