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Review

A Meta-analysis of Clinical Effects of Low-level Laser Therapy on Temporomandibular Joint Pain

Wen-Dien Chang, PhD[1)], Chia-Lun Lee, PhD[2)], Hung-Yu Lin, PhD[3)], Yung-Chun Hsu, MS[4)], Chung-Jieh Wang, PhD[5)], Ping-Tung Lai, BS[6)*]

[1)] *Department of Sports Medicine, China Medical University, Taiwan*
[2)] *Physical Education Section of General Education, National Sun Yat-sen University, Taiwan*
[3)] *Department of Occupational Therapy, I-Shou University, Taiwan*
[4)] *Rehabilitation Therapy Center, Tungs' Taichung MetroHarbor Hospital, Taiwan*
[5)] *Department of Rehabilitation Science, Jen-Teh Junior College of Medicine, Nursing and Management, Taiwan*
[6)] *Department of Physical Therapy and Rehabilitation, Da-Chien General Hospital: No. 6, Shin Guang Street, Miaoli, Taiwan*

Abstract. [Purpose] Temporomandibular joint (TMJ) pain is a symptom of TMJ disease. Low-level laser therapy (LLLT) is often used in the clinical treatment of TMJ pain. The aim of this study was to review the effective parameters of LLLT for TMJ pain. [Methods] This study was a systematic review in which electronic databases were searched for the period of January 2005 to January 2010. We selected reports of randomized controlled trials and calculated the effect size (ES) of the pain relief to evaluate the effect of LLLT. [Results] Seven reports are found to meet the inclusion criteria and discussed. Based on the calculation results, the pooled ES was –0.6, indicating a moderate effect of pain relief. In addition, the dosages and treatments with wavelengths of 780 and 830 nm can cause moderate and large pain relief effects. [Conclusion] Use of LLLT on the masticatory muscle or joint capsule for TMJ pain had a moderate analgesic effect. The optimal parameters for LLLT to treat TMJ pain have not been confirmed. However, our results can be a vital clinical reference for clinical physicians in treatment of patients with TMJ pain.

Key words: Temporomandibular joint pain, Low-level laser therapy, Analgesic effect

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INTRODUCTION

Temporomandibular disorder is a common disease of the facial joint. The ordinary symptoms include pain in the temporomandibular joint (TMJ), disability of mouth opening, and sounds of the joint. The pain occurs in palpation or during mastication. These discomforts affect the daily lives of patients[1)]. The necessity of surgery can be reduced by some of the effective conservative treatments, such as diet changes, medications, and physical therapies[2)]. Modality therapies, including electrotherapy, low-level laser therapy (LLLT), and laser acupuncture, are also adopted at the beginning of treatment of temporomandibular disorder[3, 4)].

LLLT is often used to clinically treat TMJ pain; the output power of LLLT is less than 500 mW, and the therapeutic doses are less than 35 J/cm^2[2, 5)]. The intensity of the laser does not harm the tissue, but can cause biochemical effects on cells, so the laser is also known as the cold laser or soft laser[6)]. Previous literature indicates that LLLT can affect the synthesis of prostaglandin, causing arachidonic acid to enter endothelial tissues and smooth muscles and allowing them to generate vasodilatation and anti-inflammation[7, 8)]. Therefore, LLLT is a popular treatment for musculoskeletal diseases[9)]. Furthermore, laser irradiation could lead to a change in biochemical reactions in cells and tissues[6)]. This is called laser photobiomodulation of which is produced using different laser dosages and wavelengths[10, 11)]. A pervious study found that the applicable laser dosage would follow the Arndt-Schultz rule, which means that photobiomodulation only occurs when the dosage reaches the threshold level[11)]. Such an effect would be suppressed if the dosage exceeds the threshold. With different media and wavelengths, the laser would also have different penetration depths. Appropriate parameters that influence the therapeutic effects for TMJ pain remain controversial at present[12)]. Various clinical doses, methods, and modes of LLLT could also result in different treatment effects. Therefore, the aim of this systematic review study was to investigate the analgesic effect of applying LLLT for TMJ pain. The research results may serve as references for clinical physicians when treating patients with TMJ pain.

* Correspondence author. Ping-Tung Lai (E-mail: steven-mandy@yahoo.com.tw)

Table 1. The parameters of LLLT and the PEDro scores in each article

Author (year)	n	Region	Wavelength (nm)	Power (mW)	Dosage (J/cm^2)	Session (times)	Result	PEDro
Da Cunha (2008)[15]	40	Tender point	830	500	100	4	VAS decreased	9/11
Emshoff (2008)[16]	52	Joints	632.8	30	1.5	20	VAS decreased	11/11
Carrasco (2008)[17]	14	Joints	780	70	105	8	VAS decreased	11/11
Fikácková (2007)[18]	80	Tender point	830	400	10/15**	10	VAS decreased *	8/11
Mazzetto (2007)[19]	48	Joints	780	70	89.7	8	VAS decreased *	10/11
Cetiner (2006)[20]	39	Tender point	830	400	7	10	VAS decreased *	9/11
Venancio (2005)[21]	30	Joints	780	30	6.3	6	VAS decreased	9/11

n, number; W, wavelength ; VAS, visual analogue scale
* There is a significant difference between the experimental group and the control group ($p < 0.05$).
**There were two experimental groups using dosages 10 and 15 J/cm^2, respectively.

SUBJECTS AND METHODS

This study searched and reviewed research articles available in the electronic databases of Medline, PubMed, and CINAHL that had been published between 2005 and January 2010 with the key words “low-level laser”, “low-level laser therapy”, “temporomandibular joint disease” and “temporomandibular joint pain”. In addition, further investigation was performed by examining some review articles that met the requirements. The literature review and meta-analysis in this study was performed to investigate the analgesic effect of LLLT that was used to treat TMJ pain, and articles describing randomized controlled trials (RCTs) were selected. The articles had to meet the following criteria: the patients had to have been diagnosed with TMJ pain or pain on masticatory muscles by the physical examination; LLLT was used as the treatment to TMJ pain, and the exposure site including the inflammatory TMJ or point of muscle tenderness; the experimental design had to have been randomized, single-blind, or double-blind tests; and the control group had to have been treated without laser therapy or with a placebo as a control. According to these inclusion criteria, all articles are assessed using the Physiotherapy Evidence Database (PEDro) scale[13].

The data from the selected articles were coded and collected. The analysis included two parts. In the first part of the analysis, article-related information, such as authors, year of publication, and subject number, and treatment-related information, such as the treatment site and wavelength, output power, therapeutic doses, and course of laser treatment used in the experiments, were summarized. The results after using LLLT and the quality of the reviewed articles were also summarized. In the second part of the analysis, the effect size (ES) of pain relief was calculated to evaluate the effect of the treatments. The visual analogue scale (VAS) is often used to estimate the degree of analgesia. The VAS is graded before and after treatment, when observing the actions of the TMJ and the pain conditions under normal conditions and palpation.

Statistical analysis was performed using the MedCalc software (MedCalc, Mariakerke, Belgium). The meta-analysis was performed with the means and standard deviations of the VAS scores to estimate the ES of each variable and the aggregated ES[14]. The pooled ES of every variable is the sum of all the individual ES weighted by the total number of subjects. A negative ES for pain relief suggests a decrease in the pain threshold and analgesia. On the other hand, a positive ES implies an increase in the pain threshold and no analgesic effect. The analgesic ES is given with a 95% confidence interval (CI). Inclusion of 0inside the 95% CI was considered to indicate acceptance of the null hypotheses. The absolute value of ES was determined by the Cohen’s d method; 0.2 indicates an inferior ES, 0.5 suggests a moderate ES, and 0.8 means a superior ES[14].

RESULTS

As a result of our search for research articles, 7 articles discussing clinical findings with a PEDro score of between 9 and 11 were selected to examine the pain relief effect of LLLT when treating TMJ pain[15–21]. All of the treatment parameters and PEDro scores are shown in Table 1. In these studies, the patients in the experimental groups generally felt less pain in the TMJ after being treated with LLLT.

A meta-analysis analysis on the VAS scores was conducted. A lower VAS scores indicates a better treatment effect, so a negative ES is considered the analgesic effect. Table 2 show the ES of pain relief after subjects were treated with LLLT. The results of Fikácková et al. showed the category variable of successful and unsuccessful rate after LLLT[18]. Their data could not be subjected to meta-analysis. Therefore, the results are based on the treatment outcomes of 223 subjects in six articles[15–17, 19–21]. Four of the articles showed a positive effect on pain relief after LLLT was employed[15, 17, 19, 20]. But no statistically significant differences ($p > 0.05$) existed in the results of the studies of Emshoff et al.[16] and Venancio et al.[21]. The pooled ES was –0.6, with a 95% confidence interval (95% CI: –0.73 to –0.47, $p < 0.05$) that did not contain 0. This ES suggests a moderate effect ($0.8 > |\text{pooled ES}| > 0.5$), and that LLLT results in statistically significant analgesia ($p < 0.05$).

DISCUSSION

At present, the mechanism of LLLT in pain relief is still unclear. In a previous cell study in vitro, the researchers

Table 2. Effect sizes of LLLT on analgesia in each article

Author (year)	Experimental			Control			Wt	ES (95%CI)
	Mean	SD	n	Mean	SD	n		
Da Cunha (2008)[15]	3.62	2.45	20	4.67	1.9	20	0.18	−0.48 (−0.17 to −0.79)
Emshoff (2008)[16]	1.23	1.61	23	1.18	1.68	22	0.23	0.03 (0.30 to −0.24)
Carrasco (2008)[17]	1.00	1.64	7	4.02	2.28	7	0.06	−1.52 (−1.00 to −2.04)
Mazzetto (2007)[19]	1.67	2.10	24	2.81	2.62	24	0.22	−0.48 (−0.20 to −0.76)
Cetiner (2006)[20]	2.25	2.05	24	5.60	1.76	15	0.17	−1.72 (−1.41 to −2.04)
Venancio (2005)[21]	4.07	3.35	15	4.67	3.29	15	0.13	−0.18 (0.18 to −0.54)
Pool (95% CI)			113			103		−0.60 (−0.47 to −0.73)

n, number; SD, standard deviation; Wt, weight; CI, confidence interval

Table 3. Analysis of laser wavelength and treatment parameters and effect sizes of analgesia

Wavelength	632.8 nm	780 nm	830 nm
Output power (mW)	30	30–70	400–500
Therapeutic dose (J/cm^2)	1.5	6.3–105	7–100
Course of treatment (sessions)	20	6–8	4–10
Effect size with absolute value, | ES |	0.03	0.18–1.52	0.48–1.72

found that a low-level laser could inhibit the synthesis of cyclooxygenase (COX–2), thus hindering the transformation of arachidonic acid to prostaglandins (PGE2, PGF2α) and thromboxane. They inferred that the analgesia was caused by the decrease in synthesis of those precursors[15]. They also indicated that a low-level laser could penetrate tendons or the joint capsule to decrease the prostaglandin (PGE2) level in vivo and inflammation[15]. In some clinical studies, researchers believed that the analgesic mechanism of LLLT was an increase in the beta-endorphin content in the central nervous system, thus increasing raise the pain threshold[15, 19, 21]. Venancio et al., for example, considered that LLLT could increase the discharge of urine glucocorticoid, a synthetic inhibitor of endorphin, to generate an analgesic effect[21]. Da Cunha et al., on the other hand, thought that the local irradiation of LLLT could stimulate the microcirculation of peripheral nerve tissues and block the pain sensation to achieve the analgesic effect[15]. Moreover, some studies found that LLLT could increase the generation of adenosine triphosphate in the mitochondrion. This reaction provides the energy for local metabolism and inhibits the release of endogenous pain-producing substances, such as histamine acetylcholine and bradykinin, to decrease the synthesis of pain factors[16, 21]. Therefore, the analgesic mechanism of LLLT is still unconfirmed. Our review study found that LLLT has a pain relief effect in treatment of TMJ pain, regardless of whether it is the TMJ or tender point of the masticatory muscle that is irradiated.

Table 3 demonstrates the parameters of LLLT and the analgesic ES in a meta-analysis. In fact, the analgesic ES in the laser groups with wavelengths of 830 nm and 780 nm from the reviewed articles was moderate or superior. For example, de Cunha et al. indicated that a laser with a wavelength of 830 nm could penetrate the soft tissue to a depth of 1 to 5 cm, so it was suitable for treatment of TMJ pain[15]. Cetiner et al. performed a study after this and utilized the same laser wavelength and dosage (830 nm, 7 J/cm^2). Their results also showed that a laser with a wavelength of 830 nm was able to treat TMJ pain[20]. In addition, Mazzetto et al. suggested that a laser with a wavelength of 780 nm is also appropriate for treatment of TMJ pain, since such a laser was not easily absorbed by tissues, provided better penetration, and caused no thermal effect or metabolic response in tissues[19]. However, Emshoff et al. argued that a laser with a shorter wavelength can provide better penetration but that laser treatment a wavelength of 632.8 nm did not generate the desired analgesic effects[16]. They believed the outcome was caused by 20 treatment sessions being insufficient to have the desired effects[16]. Furthermore, most of the scholars considered the analgesia of LLLT to depend on the laser wavelength and the radiation dosage when using LLLT to treat TMJ pain[16, 18–21]. Radiation dosage was determined by the irradiation time and treatment course. The key to an effective treatment is the adequacy of the dosage delivered to the tissue. In addition, although the pain in the TMJ is relieved after treatment with LLLT, Venancio et al. found that the activity of the TMJ increased significantly ($p < 0.05$) and that the pain was obviously relieved at a two-month follow-up[21]. The alleviation of pain in the TMJ may be caused by reformation of the occlusal function, and this is similar to the segmental result in other studies[18, 19]. Da Cunha and Venancio explained that irradiation with a low-level laser could excessively stimulate the proprioception receptors in joint capsules, changing the secondary afferent signals, which can relax masticatory muscles, so the damage to the TMJ was reduced[15, 21].

Application of LLLT to the masticatory muscle or joint capsule of the TMJ had a moderate analgesic effect. The evidence from the articles suggested that the analgesia mechanism was possibly photobiomodulation that decreased the inflammatory factors. It also suggested that nerve stimulation via LLLT occurs that changes the activity of the masticatory muscle. However, the optimal parameters for LLLT to treat TMJ pain have not been confirmed. More clinical studies of RCTs are required to find more answers.

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