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Effects of Diode Low-Level Laser Therapy of 810 Nm on Pulpal Anesthesia of Maxillary Premolars: A Double-Blind Randomized Clinical Trial

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ABSTRACT

Objective: The purpose of this study was to investigate the pulpal effect of diode low-level laser therapy (LLLT) of 810 nm on the alleviation of pain in patients requiring dental procedures.

Methods: The current study was a double-blind randomized clinical trial carried out on twenty participants. The electric pulp testing (EPT) was recorded at baseline. Patients were randomly divided into sham laser and laser group respectively receiving low-level laser with placebo and active probes. Low-level laser at 810 nm, 200 MW constant power, 30s irradiation time and energy dose of 6 J was used. The electric pulp testing (EPT) method was again adopted to assess the rate of induced anesthesia. Laser and sham laser treatments were carried out in two different sessions with a one-week interval to ensure avoiding the potential false placebo results. Data were analyzed in SSPS-24 using Chi-square test and t-test. The p-value was set at 0.05.

Results: A low-level laser at 810 nm significantly alleviate EPT-induced pain compared to the pain before laser irradiation ($P \leq 0.001$). While the difference of EPT-induced pain before and after sham laser irradiation was not significant in control group ($P>0.05$). There was no correlation between the anesthetic effects of a laser application at 810 nm and other variables including age and gender ($P>0.05$).

Conclusion: An 810 nm low-level laser is a powerful device for induced anesthesia applications in patients requiring dental procedures. It also lessens the patients' fear of dental procedures.

Keywords: Anesthesia, dental pulp, dental pulp testing, low-level laser (light) therapy (LLLT), premolar teeth, semiconductor lasers

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HIGHLIGHTS

- Fear and anxiety of dentistry prevent patients from visiting dental clinics.
- Laser have pain-relieving and anti-inflammatory effects.
- If the purpose is merely to raise the pain threshold, the use of laser is effective.
- Laser lessens the patients' fear of dental procedures.

INTRODUCTION

Fear and anxiety of dentistry procedures are influential factors that prevent patients from visiting dental clinics at the right time, which is largely resulted from the experience of pain during dental procedures; there is a significant association between painful experiences during dental treatments in childhood and anxiety and fear of dental procedures in adulthood (1, 2).

The dental pulp is an oral tissue composed of multiple neural elements. In modern dentistry, local anesthesia of pulpal tissue during treatment has been proven to block the pathway of pain sensation (or transduction) (3). But, drug injection itself can intensify anxiety and fear, particularly in younger patients (4). However, according to some studies, the effectiveness of anesthesia has not been completely effective, which together with the fear and anxiety of drug injection, overshadows the continued application of this procedure (5). Besides these, other complications and/or consequences of this procedure include needle breakage, paresthesia, facial nerve paralysis, hematoma, systemic consequences on the cardiovascular system, liver disease, allergies, drug overdose, and limitations of local anesthesia in pregnant women and some of the patients with systemic complications (6-9).

Laser therapy is currently at the experimental and research stages. Remarkable results have been achieved using this procedure in the treatment of conditions such as dentine hypersensitivity, temporomandibular joint (TMJ) syndrome, inferior alveolar nerve (IAN) paresthesia caused by surgical removal of 3rd molars, trigeminal neuralgia, herpes labialis, aphthous ulcers and inflammation after chemotherapy (10-15). The advantages of this procedure include diminished bleeding during and after treatment (and thereby efficient access and monitoring), pain-relieving and anti-inflammatory effects, stress-less intervention, diminished gingival swelling through closing lymphatic vessels, no need for sutures and no scarring after surgery (16-18).

According to some studies, the process of pulpal anesthetic may be affected by diode laser irradiation (19). Some researchers have also stated that Photobiomodulation Therapy (PBMT) can affect both C and Aδ nerve fibers, whilst other studies have reported that only C fibers are affected (20). Also, a literature review has presented reliable evidence regarding the mechanism of nerve function blockage using PBMT by diode laser for pain and anesthesia (21).

Therefore, and given the easy access to the 810 nm diode laser, this study was designed and conducted to investigate effects of diode low-level laser therapy (LLLT) of 810 nm on pulpal anesthesia of maxillary premolars regarding the importance and efficient implementation of anesthesia in dental procedures and the development of lasers, which is evident in most dimensions of dental treatments, as well as the contradictory results of previous studies on the performance and effectiveness of LLLT at 810 nm on dental anesthesia.

This study was designed with the null hypothesis that the induction of pulpal anesthesia to the maxillary premolars would be similarly effective in both the control and the treatment groups.

MATERIALS AND METHODS

This is a parallel- group, prospective, double-blind randomized trial. Ethical clearance was obtained from University Ethics Committee (UEC). CONSORT 2010 guidelines were applied. Eligibility criteria and method were not changed during the study. All patients were also asked to sign the informed consent form.

The sample size was calculated to be 20 according to Bahramian (2011) with a standard ratio of 1:1 (P=0.85), but in total 25 patients were included regarding the probable dropouts in the study population.

Participants were patients with at least two permanent maxillary premolars without dental caries and repair and/or other dental defects, and also without cardiac arrhythmia or a history of using a cardiac pacemaker, malignant tumors, epilepsy and pregnancy, local infection, blood pressure diseases, photophobia, dental orthodontics, and dental hypersensitivity. Patients who did not attend the second session were excluded from the study.

Premolars were initially isolated with a cotton roll. The treatment randomly performed on the first chosen premolars as described earlier. The electric pulp testing (EPT) device (Epell's Parkell, Inc, Edgewood, New York, USA) was utilized to assess potential alterations in action potentials at the nerve terminals before and after treatment. The EPT electrode was placed on the buccal cusp of the premolar teeth and prophylaxis paste was used at the point of contact of the device's tip to facilitate the flow of electrical energy (20). Each patient was asked to immediately remove his/her hand over the metal handle of the EPT device after feeling tingling, burning, itching, moderate or slight electric shock in teeth, and pain. And the EPT number was recorded by the operator. To ensure the accuracy of the results, the patient's sense of EPT was examined on a different tooth previous to the study under precise isolation to introduce the patient with the sensations experienced during the study.

Two symmetrical teeth on the left and right sides were tested to evaluate sham laser and low power diode laser at 810 nm. All patients underwent both laser and sham laser treatments randomly. A coin dropping method was adopted to determine which of the laser and sham laser should be randomly applied firstly for each patient. Then a coin dropped for the second time to determine which tooth would undergo the first treatment using laser or sham laser.

To ensure blindness, the laser light-emitting medium was removed from the device in the placebo mood, but both the operator and the patient were hearing laser emission warning sound, and hence the patient could not recognize the laser emission. Except for the operator, neither the patient nor the recorder (who was someone other than the operator) had any information about the type of laser probe utilized.

The performance of a specialized low-power laser (Konftec, Corporation, New Taipei City, Taiwan) was confirmed once on buccal surface and once on the palatal surface of the tooth perpendicular to the longitudinal axis and the intermediate line of the hypothetical line between the tip of the cusp and the cervical line of the given tooth at 810 nm, and under constant power of 200 MW, the irradiation time of 30 s, and a cross-sectional area 0.5 cm^2. The total energy transferred or the dose of laser irradiation to the tooth was equivalent to 6 J. Also, the energy density for each irradiation and in total was respectively 12 J/cm^2 and 24 J/cm^2. The laser was applied following safety principles of international standards, such as the installation of a patient warning sign at the entrance to the room during irradiation and the use of radiation shielding glasses particularly at 810 nm.

Pulpal reactions to EPT were assessed immediately under foregoing considerations following laser and sham laser treatment (15, 16). Laser and sham laser treatments were carried out in two different sessions with a one-week interval to ensure avoiding interfere with the biochemical effects of the laser in reducing or increasing the potential secretion of various mediators and enzymes such as prostaglandin, bradykinin, etc. and consequently, the potential false placebo results.

Data were analyzed using SSPS-24 (IBM SPSS Inc., Chicago, IL). Descriptive data were calculated as mean and standard deviation (SD). To analyze the normality of the data the Shapiro–Wilk test was applied. The distribution of responses was independently compared between the laser irradiation and sham laser groups using the Chi-square test. An independent t-test was adopted to investigate the significant differences between the two groups. Values for the places of interest in patients were evaluated before and after treatment. The p-value was set at 0.05.

RESULTS

Clinical features

Of the 25 patients, 5 were excluded because they were lost to follow-up. In total, twenty patients with a mean age of 31.65±11.07 years (20 to 67 years) were included in this study, out of which 14 (70%) were female and 6 (30%) were male (Fig. 1).

In each patient, two teeth were examined, one of which was in the sham laser group and the other was in the laser group receiving laser with placebo and active probes respectively. EPT records were also examined in each group before and after treatment. In the sham laser group, despite the same conditions, the probe applied did not emit laser light. The results of this test revealed that the mean EPT in the sham laser and laser groups before treatment is respectively 3.45±1.35 and 2.95±1.19. After applying the probe-less laser in the sham laser group, the EPT was 3.7±1.26. Paired t-test results showed that there is no significant difference between EPT records obtained from the sham laser group before and after treatment with a passive laser probe (P>0.05). On the other hand, the results of the laser group showed that the EPT record after treatment with an active laser probe is 6.1±2.61. The results showed that there is a significant difference in EPT before and after treatment in patients undergoing active laser probe treatment (P<0.001).

In the next step, changes in EPT before and after treatment in patients were examined. The results of the sham laser group showed that the value of mean changes and the standard deviation (SD) is respectively 0.25 and 0.55. Also, these values in

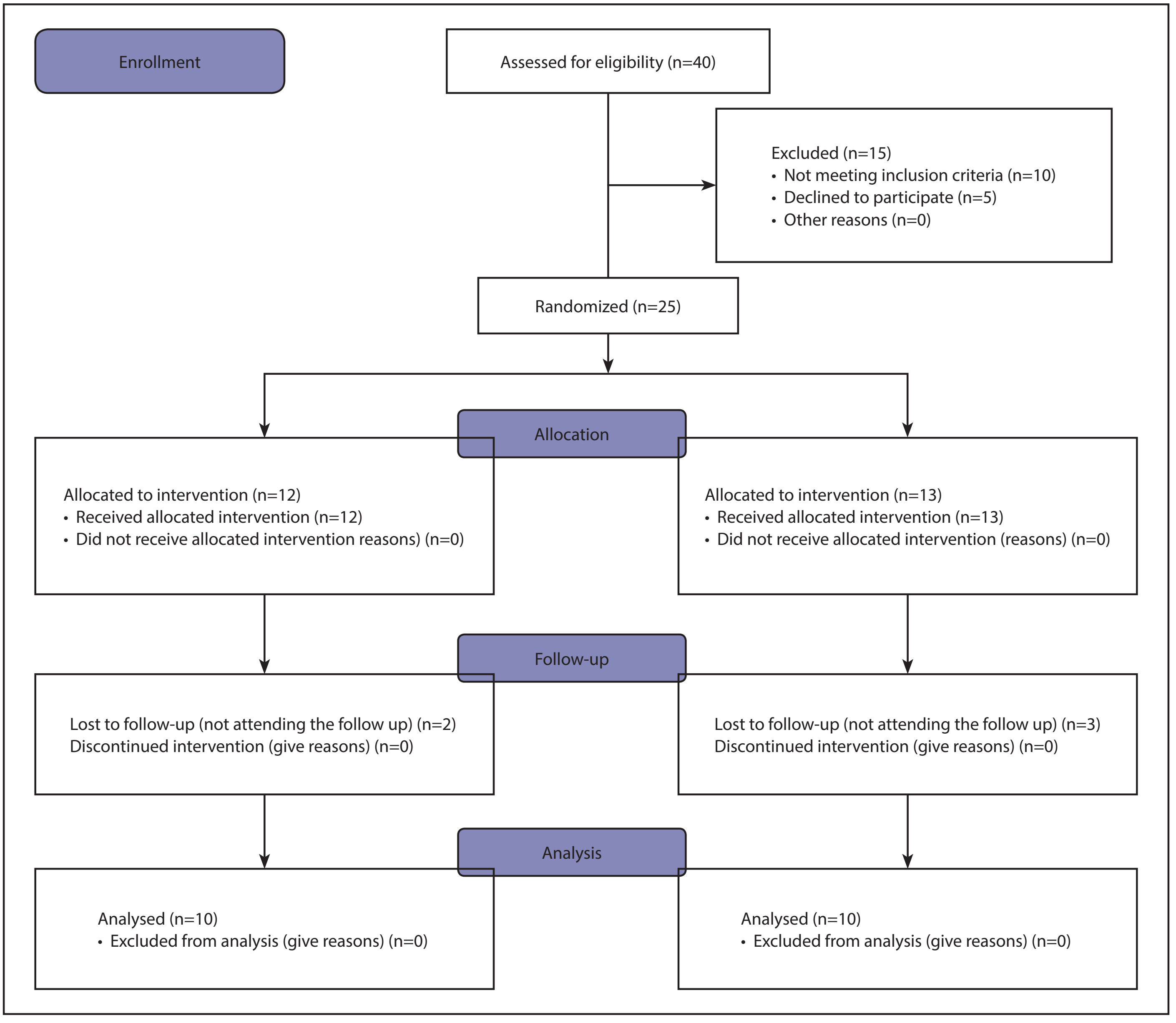

Figure 1. Consort 2010 flow diagram

the laser group treated with active laser probe were 3.3 and 1.08, respectively. In this study, only one patient in the sham laser group (only 5% of the group) experienced a reduction in EPT, but none of the patients in the laser group experienced a reduction in EPT. The t-test results when comparing these changes between the two groups revealed that changes in EPT in the laser group is significantly higher than the sham laser group (P<0.001).

In the final step, we examined the correlation between demographic factors and changes in EPT and found that there is no significant correlation between demographic factors and EPT changes in the study groups. Pearson correlation test showed that there is no correlation between age and EPT score (P>0.05; r=0.41; 95% COI=–0.6732 to 0.7374).

DISCUSSION

The control over the patient's fear and anxiety is an important task in dentistry. About 40% of patients are concerned about visiting a dentist and 20% of them are afraid of it. The patients' anxiety and fear of dental procedures, especially during the injection of anesthetic agents, may lead to less pursuing and even no referral for following dental procedures. To overcome this problem, the use of psychoanalysis to induce anesthesia and needle-free compression anesthesia systems has been introduced, but their effectiveness is questionable compared to conservative injection techniques (1, 2). The purpose of this study was to evaluate the effect of the low-level laser at 810 nm on pulpal anesthesia. The EPT was used to evaluate anesthesia as in other studies. Previous studies have confirmed that EPT is more effective in predicting potential anesthesia problems in endodontics. The purpose of EPT is to induce healthy Aδ nerves in the pulp-dentine complex by applying an electrical current to the tooth surface. The positive response results from the ionic change in the dentinal fluid of the tubules. This results in local depolarization and consequently the generation of action potentials in intact and healthy δA nerves (22).

Chan et al. reported an accuracy of 97.7 % for EPT. Therefore, in this study, EPT was adopted to evaluate the anesthesia induced by a diode laser at 810 nm (23). Weisleder et al. showed that EPT can be suitable to examine vital pulp (up to 97% positive response) and less accurate to examine necrotic pulp (up to 90% negative response) (24). Given the vitality of pulp in this study, EPT may be a relevant test for pain assessment.

This study used laser irradiation at 810 nm and energy density slightly beyond the therapeutic window to investigate the effect of laser anesthesia on patients through EPT. The results revealed that laser irradiation at 810 nm can significantly induce pulpal anesthesia concerning EPT results. Also, the EPT score of patients underwent laser irradiation at 810 nm is significantly increased. The null hypothesis that the LLT of 810 nm would be effective pulpal anesthesia in both study groups was accepted.

The use of laser irradiation to diminish dental hypersensitivity as well as the induction of dental anesthesia have been recommended in recent studies (22, 25). A discussion over the use of laser in dental anesthesia is mainly around the selection of the most effective laser type and laser parameters including duration, mean power, frequency, energy density, and wavelength. For instance, researchers believe that the use of diode lasers is more effective than solid-state lasers. On the other hand, the use of near-infrared wavelengths can be more efficient in inducing anesthesia (26). Efficiency in inducing analgesia and anesthesia and also the availability compared to other lasers were the reasons for the choice of the diode laser in this study. Ueda (27) is presumably the first researcher that reported this experimental effect of the laser at 830 on periodontal ligament fibroblasts. This study showed that this type of laser inhibits the production of Interleukin 1 beta (IL-1β) antibody and Prostaglandin E2 (PGE2) (27). In their study, Eslamian et al. showed that the use of laser at 810 nm can significantly reduce orthodontic pain (28). Experimental studies have shown that PBM can disrupt by affecting axonal flow, cytoskeletal organisms, and decreased ATP levels. This study presents reliable evidence for the destruction of nervous function as a mechanism for clinical use of PBM in pain relief and anesthesia (29). Aras et al. stated that low-level lasers can more efficiently affect the induction of anesthesia than other lasers. On the other hand, this type of laser can also assist in greater absorption of injected materials such as anesthetic agents as well as increase the rate and volume of regeneration of the damaged tissue through increasing vessel diameter and inhibition of inflammatory factors (30).

Studies of dental desensitization have shown that laser irradiation at 810 nm to 830 nm can positively affect pain relief in patients. Dilsiz et al. used a diode laser at 808 nm with an energy density of 250 mJ/cm^2 (25). Corona et al. reported positive results in reducing pain with a GaAlAs diode laser at 660 nm for 30 seconds under an energy density of 450 mJ/cm^2 (22). Liang et al. reported similar results. They investigated dental anesthesia by EPT using GaAs diode laser at 904 nm for 60 seconds with a mean power of 30 mW and an energy density of 3.6 mJ/cm^2 (20). They found that anesthesia is induced following PBMT in 66.7% of patients, whilst remaining patients are experienced increased dental hypersensitivity (20). In this study, patients underwent laser therapy using a diode laser at 810 nm for 30 seconds with a continuous power of 200 mW and an energy density of 12 mJ/cm^2. The results of EPT showed that anesthesia is induced in patients by 95% and the mean score is increased from 2.95 to 6.25, indicating a deeper induction of anesthesia in the patients. Such greater anesthesia may be attributed to changes in parameters between studies such as higher energy density and different laser wavelengths than in a similar previous study.

The irradiation sites in the study conducted by Liang et al. have been cervical (20 s) and apex (10 s) zones (20). Dilsiz et al. have mesiodistally radiated the laser beams on the surface of the root of the tooth appearing in the oral cavity (25). In this study, the laser was radiated perpendicular to the longitudinal axis and the intermediate of the hypothetical line between the tip of the cusp and the cervical line of the tooth having a high density of dental pulp.

CONCLUSION

The results of this study confirmed that laser irradiation at 810 nm can significantly reduce pain during EPT assay in patients;

however, these results should be taken with caution since the sample size was small which is a limitation of the current study. There was no correlation between the capacity of the laser at 810 nm to induce anesthesia and gender and age and this wavelength can be used to induce anesthesia. Since pain control is a challenging task in dentistry, laser beams with indicators in the inhibitory phase markers may be an alternative factor in future dental treatments, according to the results of this study. Also, in cases where there is no need for deep anesthesia and the purpose is merely to raise the pain threshold, the use of laser considering indices of this study may eliminate or reduce the need for using topical anesthetics in dentistry, but more research is needed to verify this theory.

Disclosures

Conflict of Interest: Authors declare no conflict of interest.

Ethics Committee Approval: This study was approved by the Guilan University of Medical Science. [IR.GUMS.REC.1397.439]

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