

Evaluation of the Effects of 660-nm and 810-nm Low-Level Diode Lasers on the Treatment of Dentin Hypersensitivity



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Abstract

Introduction: Dentin hypersensitivity is a common oral problem that occurs as a short and sharp pain. There are many techniques to treat this condition, the latest of which is laser treatment. The aim of this study was to evaluate the effect of two types of low-power diode lasers (660 nm and 810 nm) on dentin hypersensitivity in order to achieve an acceptable clinical application by adjusting the effective parameters.

Methods: In this randomized, double-blind clinical trial, sensitive teeth of 7 patients were divided into three groups with a randomized matching method: group I, treated with 660-nm diode laser irradiation, group II, treated with diode laser 810-nm, and group III, the control group. Irradiation parameters for 660-nm and 810-nm diode lasers were the power of 30 mW and 100 mW respectively, in contact and continuous modes, perpendicular to the tooth surface with a sweeping motion. Treatments were carried out in four sessions at weekly intervals. The data obtained were analyzed with SPSS 22, using one-way repeated measures ANOVA and the LSD (least significant difference) test. The significance level was considered as $P \leq 0.05$.

Results: There were no significant differences in visual analogue scale (VAS) score changes between the two laser groups after the intervention in the first, second and third weeks compared to the baseline ($P > 0.05$). These changes in the fourth week were significantly higher in the 810-nm laser group compared to the 660-nm laser group ($P = 0.04$), and in the 660-nm laser group, they were more than the control group ($P = 0.02$). The mean VAS scores at 1-week, 1-month and 2-month postoperative intervals were significantly lower in the 810-nm laser group than in the 660-nm laser group, and in the 660-nm laser group, they were less than the control group ($P < 0.001$).

Conclusion: The use of 660-nm and 810-nm diode lasers with the power of 30 and 100 mW respectively for 120 seconds was effective in reducing pain in patients with dentin hypersensitivity. However, the effect of the 810-nm laser on reducing the dentin hypersensitivity was more long-lasting than that of the 660-nm laser.

Keywords: Dentin hypersensitivity; Laser therapy; Diode laser.

Introduction

Tooth hypersensitivity is a major challenge in dentistry and its prevalence has increased in recent years.¹ Studies have shown that 10%–30% of the general population has tooth hypersensitivity and the rate will increase by increasing the time of teeth remaining in the oral cavity.² In a healthy state, the dentin is covered with enamel or cementum and is not directly affected by irritants. Dentin hypersensitivity occurs due to denuding of dentinal tubules in the cervical area of the root, followed by the

direct effect of various irritants on the dentin surface. One of the characteristics of pain resulting from dentin hypersensitivity is its short nature due to the contact of dentin with thermal, chemical, mechanical or osmotic stimuli, which cannot be attributed to other dental injuries such as trauma, caries, and so forth.³ Pain resulting from dentin hypersensitivity is usually short, acute and immediate at the onset. The most common stimulus for pain in subjects with dentin hypersensitivity is cold.⁴ Currently, the most widely accepted mechanism

to explain tooth hypersensitivity is the hydrodynamic theory which was first introduced by Brannstrom. On the basis of this theory, the displacement of the biologic fluid in the dentinal tubules which have been opened into the oral cavity due to thermal, mechanical and chemical irritants results in the stimulation of odontoblastic nerve endings, leading to a sharp, short and local pain.⁵ Different techniques have been considered for the treatment of dentin hypersensitivity, the most common of which is the use of local home remedies and methods such as the use of adhesives, varnishes, bonding agents, periodontal grafts, and restorative procedures, which yield different results. These techniques are not successful in many cases and none of them has the characteristics of an ideal treatment modality. A proper treatment modality should not irritate the tooth pulp and should not cause pain when it is applied and it also should be easy to apply, be cost-effective, act fast, have long-lasting effects and be resistant to the challenges in the oral cavity. In addition, it should not irritate the oral cavity soft tissues and should not stain teeth; however, the majority of the treatment modalities lack these criteria.^{6,7}

In order to find a solution to this problem, the use of lasers was introduced as an easy, safe and available technique for the treatment of dentin hypersensitivity. Currently, the use of lasers as a new technique has opened new horizons in the treatment of dentin hypersensitivity, and this technique has found ever-increasing applications in dentistry. Some of the advantages of treatment with lasers over other techniques include patients' better reaction, better and longer results, the predictability of the treatment results, and the short chair time for its application. In this context, the smaller size of diode laser units and their lower cost have made them more favorable for use in dental procedures.⁸⁻¹⁰

Due to the high prevalence of dentin hypersensitivity on one hand and appropriate availability of diode lasers on the other hand, the present study was undertaken to evaluate the effects of 660-nm and 810-nm low-level lasers by selecting the effective parameters at different time intervals on decreasing tooth hypersensitivity for the first time as a step to improve this therapeutic treatment. The null hypothesis in this study ran as follows: the two types of low-power diode lasers (660 nm and 810 nm) have no effects on the treatment of dentin hypersensitivity.

Materials and Methods

In the present study, 7 patients (3 males and 4 females) with an age range of 25–45 years, who had cervical dentin hypersensitivity in at least 3 teeth in 3 separate quadrants, were evaluated. The subjects were selected from those referring to different departments of the Faculty of Dentistry, Isfahan University of Medical Sciences. This study was approved by the Isfahan University Ethics Committee under the code 396228 and registered on the Iranian Registry of Clinical Trials website (identifier:

IRCT2017062022699N4; <https://www.irct.ir/>). Sufficient information was provided for the patients about the procedural steps, the number of sessions required in the Faculty of Dentistry, and the duration of the study. All the subjects signed informed consent forms in order to be included in the study. Inclusion criteria were the teeth having dentin hypersensitivity due to open dentinal tubules due to gingival recession. The selected teeth were free of calculus and plaque and if necessary, the subjects underwent a scaling procedure before the study. The selected teeth exhibited sensitivity to cold. Exclusion criteria were patients with teeth showing evidence of irreversible pulpitis or necrosis, carious lesions, crown fractures, cracks, caries or restorations, facets of attrition, premature contact, active periodontal disease, use of analgesics during the 72-hour period before laser application and individuals who had used anti-sensitivity toothpaste during the previous 3-month period. Pregnant women and smokers were excluded from the study.¹¹

To register the severity of pain in the affected teeth, the visual analogue scale (VAS) was used. The VAS is a continuous scale consisting of a horizontal line, generally 10 centimeters in length, anchored by 2 verbal descriptors: "no pain" (score of 0) and "pain as bad as it could be" or "worst possible pain" (score of 10).¹² The patients were asked to mark the VAS line at the point that showed their pain intensity.

This index was recorded after applying dry ice sprayed on a small cotton pallet over the tooth surface. An attempt was made to carry out random assignment (randomized allocation) based on the baseline VAS scores of the teeth after they were recorded. In each patient in group 1, 660-nm diode laser beams were applied to the hypersensitive teeth, and in group 2, 810-nm diode laser beams were applied; in group 3 (control), index radiation was applied. The patients' teeth were grouped in a manner in which all groups existed in each patient.

The teeth in question were dried with gauze pieces and isolated with a saliva ejector tip and cotton rolls. The laser parameters in the 660-nm diode laser group (Polaris 2, ASTAR, Bielsko-Biata, Poland) were as follows: the power of 30 mW, in contact with and perpendicular to the surface, continuous irradiation for 120 seconds with a forward and backward (sweeping) movement. The laser parameters in the 810-nm diode laser group (Laservision GmbH A.R.C. Siemensstr, Germany) were as follows: the power of 100 mW, in contact with and perpendicular to the tooth surface, continuous irradiation for 120 seconds with a forward and backward movement. The teeth in the control group were not laser-irradiated and for the purpose of blinding, they were only exposed to index radiation. Treatment was rendered in four sessions with a one-week interval in a similar manner in all the four sessions. The VAS was used to evaluate pain severity before treatment and immediately after laser irradiation at the first, second, third and fourth sessions (immediately

after it and at 1-week, 30-day and 60-day postoperative intervals). The data were analyzed with one-way ANOVA, paired-samples t-test and the least significant difference (LSD) test, using SPSS version 22 (SPSS Inc., IL, USA).

Results

The study was carried out on 96 hypersensitive teeth. Dentin hypersensitivity scores were determined at the specified time intervals. One-way ANOVA showed no significant differences in the mean dentin hypersensitivity scores before treatment in the first week between the 3 groups ($P=0.53$). In other words, at the baseline, the 3 groups were the same in terms of dentin hypersensitivity. Table 1 presents the mean dentin hypersensitivity scores at different intervals in all the 3 groups before and after the treatment. Paired-samples *t* test showed that the mean dentin hypersensitivity scores at all the intervals and in all the 3 groups after the treatment were significantly less than those before the treatment ($P<0.05$); however, such a decrease in the control group was less than that in the two other groups. Table 2 presents the mean changes in dentin hypersensitivity scores at different time intervals after the intervention compared to the baseline in all the 3 groups. One-way ANOVA showed significant differences in the mean scores of dentin hypersensitivity before and after the treatment at all the time intervals between the 3 groups ($P<0.05$). The LSD test showed no significant differences in the mean dentin hypersensitivity scores at the baseline

and at 1-, 2- and 3-week postoperative intervals between the 810-nm and 660-nm diode laser groups ($P>0.05$). However, the mean changes in the dentin hypersensitivity scores in both groups were significantly higher than those in the control group ($P<0.05$). The mean changes in the dentin hypersensitivity scores in the fourth week in the 810-nm diode laser group were significantly higher than those in the 660-nm diode laser group ($P=0.04$), which in turn were higher than those in the control group ($P=0.02$).

Table 3 presents the mean dentin hypersensitivity scores at different time intervals after the intervention in all the 3 groups. One-way ANOVA showed significant differences in all the mean dentin hypersensitivity scores at 1-week, 1-month and 2-month postoperative intervals between the 3 groups ($P<0.05$). The LSD test showed that the mean dentin hypersensitivity scores at all the 3 intervals in the 810-nm diode laser group were significantly less than those in the 660-nm diode laser group, which in turn exhibited lower scores compared to the control group ($P<0.001$). In other words, although both lasers resulted in significant decreases in dentin hypersensitivity, the effect of 810-nm diode laser was more long-lasting compared to the 660-nm diode laser.

Discussion

The null hypothesis of the present study was rejected because 810-nm laser beams resulted in better and more long-term effects. The laser parameters that affect the energy applied to the surface include power, irradiation time, the pulse or CW mode, energy density, the distance from the surface, and the angle between the surface and the fiber tip. The most important consideration in the treatment with laser beams is to determine proper laser beam parameters in order to achieve the most favorable result with no detrimental side effects.¹³ In the present study, the power parameter of 660-nm and 810-nm laser beams was determined at 30 and 100 mW respectively, based on previous studies carried out in recent years and also our pilot evaluation.¹⁴⁻¹⁷ It has been claimed that the mechanism of improvement in dentin hypersensitivity with the use of low-level lasers is through their effect on nerve endings and at the level of living cells by the induction of cellular proliferation and differentiation.

This explains why the majority of studies on low-level lasers have been carried out clinically. However, high-

Table 1. The Mean Dentin Hypersensitivity Scores at Different Intervals in the 3 groups Before and After the Treatment

Group	Interval	Before Intervention		After Intervention		P Value
		Mean	SD	Mean	SD	
810-nm laser	Week 1	8.8	1.6	6.5	1.6	<0.001
	Week 2	6.7	1.7	5.1	1.2	<0.001
	Week 3	5.2	1.6	4	1.7	<0.001
	Week 4	3.7	1.4	2.1	1.1	<0.001
660-nm laser	Week 1	8.4	1.4	6.2	1.7	<0.001
	Week 2	6.8	1.6	5.2	1.5	<0.001
	Week 3	5.4	1.7	4.4	1.3	<0.001
	Week 4	4.5	1.5	3.5	1.2	<0.001
Control	Week 1	8.4	1.8	7.9	1.9	0.034
	Week 2	8.4	2.1	7.9	2	0.03
	Week 3	8	1.7	7.4	1.7	0.042
	Week 4	7.8	1.8	7.3	1.8	0.04

Table 2. The Mean Changes in Dentin Hypersensitivity Scores at Different Time Intervals After the Intervention Compared to the Baseline in All the 3 Groups

Interval	810-nm Laser		660-nm Laser		Control		P Value
	Mean	SD	Mean	SD	Mean	SD	
Week 1	-2.3	0.17	-2.2	0.20	-0.7	0.15	<0.001
Week 2	-1.7	0.20	-1.6	0.17	-0.6	0.12	<0.001
Week 3	-1.1	0.15	-1.03	0.17	-0.6	0.13	0.02
Week 4	-1.5	0.18	-1.1	0.14	-0.5	0.16	<0.001

Table 3. The Mean Dentin Hypersensitivity Scores at Different Intervals After the TREATMENT in the 3 Groups

Interval	810-nm Laser		660-nm Laser		Control		P Value
	Mean	SD	Mean	SD	Mean	SD	
One week after the intervention	2.5	1.03	3.9	1.01	8.2	1.6	<0.001
One month after the intervention	1.5	0.9	3.1	1.1	7.8	1.7	<0.001
Two months after the intervention	0.8	0.7	2.2	0.8	7.8	1.9	<0.001

power lasers melt the dentin at the orifice of dentinal tubules, resulting in their occlusion. It should be pointed out that when high-power laser beams are used, attention should be paid to the effects of an increase in temperature on the dental pulp. It appears the immediate effect of low-level lasers is mediated through their effect on nerve endings through blocking the depolarization of C fibers and the stimulation of the sodium-potassium pump in the cell membrane, resulting in an increase in nerve impulses and increasing the pain threshold.^{18,19}

The delayed effect of those lasers, too, is related to the mechanism of the obstruction of dentinal tubules by the synthesis of secondary dentin and tertiary (reparative) dentin.^{20,21} An important and common problem in studies on dentin hypersensitivity is an improvement in all the treatment groups even in the control groups.²² The placebo effect in clinical studies on dentin hypersensitivity has been reported to be strong, which might be due to the effect of the placebo itself, spontaneous recovery, or the possible regression of the condition.²³ This effect, which depends on the relationship between the patient and the dentist to a great extent, might result from a combination of psychological and physiological factors.²⁴ Researchers believe that patients experience relief due to the placebo effect without receiving any treatment, the extent of which has been reported to be 20%–60% in clinical studies on dentin hypersensitivity.²⁵ The results of the present study showed improvements in the control group only during the early stages of the study and at other intervals, the control teeth consistently exhibited high dentin hypersensitivity scores. In this context, the treatment groups (660-nm and 810-nm laser groups) exhibited significant differences from the control group ($P < 0.05$). Considering the results of previous studies, it should be pointed out that the patient's response to different stimuli is subjective and depends on the patient's threshold of pain and tolerance, and this affects the results of clinical studies in this field; under clinical conditions, the answers of politeness and experimental subordination could make individuals report less pain.^{26,27} However, it has been reported that the placebo effect is not cumulative in nature; therefore, its mechanism is different from the mechanism of the effect of intervention.²⁸

The results of the present study showed that both 660-nm and 810-nm diode lasers significantly improved dentin hypersensitivity. Considering the varieties of parameters, different studies have used different laser

parameters. However, most of these studies have reported the efficacy of these two diode lasers.^{3,5,14} Nonetheless, it should be pointed out that since the 660-nm diode laser is a new type of laser and has recently been introduced to dentistry, only a limited number of studies have evaluated the 660-nm diode laser. An important point that should be discussed is the formation of secondary dentin at follow-up intervals, which results in spontaneous recovery and protection of the pulp against irritants.²⁹ It is important to note that different mechanisms, including the natural formation of the sclerotic dentin, the tertiary or reparative dentin and the formation of the smear layer and calculus, decrease tooth hypersensitivity naturally over time.³⁰

Dentin hypersensitivity recurrence after treatment has been reported in different studies, and its prevalence rate for diode lasers is 6%–75%.²⁵ The routine daily activities such as tooth brushing or intake of foods containing carbohydrates and acids result in the recurrence, exacerbation, and continuation of such hypersensitivity; therefore, it will be useful for patients to observe oral hygiene measures and a proper diet.³¹

In clinical and in vitro studies, 635-nm to 830-nm diode lasers have been used for the evaluation of the effect of low-level lasers on the treatment of dentin hypersensitivity.^{24,32} These laser wavelengths have some effects, including the stimulation of circulation, increasing the biologic activity of cells and also analgesic and anti-inflammatory effects, with the induction of muscular rest.^{33,34} Based on physiologic evaluations, the immediate effect of low-level lasers on relieving pain due to hypersensitivity is mediated through the blocking of depolarization of C nerve fibers.³⁵ In addition to the immediate effect of low-level diode laser beams, the selection of appropriate parameters can help increase the metabolic activity of odontoblasts, resulting in the occlusion of dentinal tubules through an increase in the synthesis of tubular dentin and irregular tertiary dentin.^{16,36} Therefore, it has been suggested that low-level diode lasers are effective in the long-term and short-term alleviation of dentin hypersensitivity through the mechanisms mentioned above. Based on what was discussed in the present study and ever-increasing advances in laser technology, it appears in the future it will be possible to extensively use lasers to treat dental problems, including dentin hypersensitivity, considering its high prevalence. In this context, clinical studies with longer follow-up periods can help improve the quality of treatment and resolve the relevant problems. Currently,

considering structural advances in laser units and equipment, the use of lasers in the dental field is on the increase. However, one of the limitations of the use of lasers is the treatment of hypersensitive surfaces in the proximal areas, while gels and toothpaste can also be applied in these areas due to their proper flowability.

Conclusion

In the present study, the proper use of 660-nm and 810-nm diode lasers with 30- and 100-mW powers respectively was effective in decreasing pain in patients with dentin hypersensitivity in the short term. However, the effect of the 810-nm laser was more long-lasting than that of the 660-nm laser in decreasing dentin hypersensitivity.

Ethical Considerations

The present randomized clinical trial was approved by the Isfahan University Ethics Committee under the code 396228 and registered on the Iranian Registry of Clinical Trials website (identifier: IRCT2017062022699N4; <https://www.irct.ir/>).

Conflict of Interests

The authors declare no conflict of interest.

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