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Original Article

Evaluation of the effects of 980 and 810-nm high-level diode lasers in treating dentin hypersensitivity: A double-blinded randomized clinical trial

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ABSTRACT

Background: Dentin hypersensitivity is a prevalent problem, manifested as a short sharp pain. Researchers have used different lasers to treat this condition. The present study aimed to evaluate the effect of 980 and 810-nm high-level diode lasers on dentin hypersensitivity to determine proper laser parameters for clinical applications.

Materials and Methods: In this double-blinded randomized clinical trial, seven patients with 60 teeth affected by dentin hypersensitivity were selected for the present double-blind, randomized clinical trial. The patients' teeth were randomly matched and assigned to three groups: Group 1: 980-nm diode laser; Group 2: 810-nm diode laser; and Group 3: Control, which received only the guiding beam. The laser parameters were 1-W power, continuous wave mode, a distance of 1 mm, no contact, a 45° irradiation angle, and a 30-s exposure time using to-and-fro movements. The treatment consisted of two sessions with a 1-week interval. Pain severity was determined with the visual analog scale (VAS) at all the study intervals using a dry ice spray. The data were analyzed with SPSS version 20 using one-way ANOVA, repeated measures ANOVA, and least significant difference tests. Significance level was set at $\alpha = 0.05$.

Results: The changes in VAS were significant only in the first stage ($P = 0.046$). The mean VAS scores decreased over time in the 810-nm and 980 laser groups. A comparison of VAS changes relative to the baseline revealed significant changes in VAS scores at all the time intervals with both lasers. The two 810 and 980-nm laser groups did not exhibit any significant differences for 2 months postoperatively ($P = 0.098$).

Conclusion: The application of 810 and 980-nm diode lasers at 1-W power and an exposure time of 30 s was effective in decreasing pain in patients with dentin hypersensitivity, with no significant difference between these two lasers.

Key Words: Dentin sensitivity, laser therapy, lasers, pain

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INTRODUCTION

Dentin hypersensitivity is a worldwide problem due to the denuding of dental tumbles in the root's cervical area, typically in response to chemical agents, and thermal, tactile, or osmotic stimuli

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that cannot be explained by other dental defects or pathologies.[1,2] It is noteworthy that after periodontal treatments (especially periodontal surgeries), the incidence of this condition increases significantly, possibly from 9%–23% to 55%.[3] The patients affected by this condition exhibit a lower oral health-related quality of life (OHRQoL) than the general population.[4]

Dentin hypersensitivity pain is usually short and acute, with an immediate onset. Different theories have been proposed to explain the mechanism of dentin hypersensitivity. The mechanism that is most cited currently is the hydrodynamic theory, which was proposed by Brännström. According to this theory, the fluid movement in the denuded dentinal tubules irritates the pulp's mechanical receptors. This theory is consistent with the clinical and laboratory data concerning dentin hypersensitivity, and most treatment modalities suggested to treat this condition rely on this theory.[5,6]

A promising treatment modality should not irritate the pulp and cause pain, should be easy to apply, should bring about fast pain relief, and should have long-lasting effects, with no tooth discoloration. Most treatment options have one or more than one of the above properties. Treatment modalities currently used for dentin hypersensitivity exert their effect through several mechanisms; some decrease calcium solubility; some claim to occlude dentinal tubule orifices; and some claim that they stabilize the neuron cell membranes, preventing the potential action in the face of irritants. It has been recommended that the denuded root surfaces be covered with composite resin restorations, veneering the tooth, or the use of gingival grafts. In some cases, root canal treatment is the last resort due to severe pain.[7-9]

Laser beam application has been suggested to treat dentin hypersensitivity.[10-13] However, despite the significant success, considering the diversities in the use of laser beams, it is still impossible to apply lasers as a reliable and definitive treatment modality for this condition. Despite the application of different laser techniques, relative success has been reported in this respect.[14-16]

In vitro studies have mentioned different parameters for diode laser beams. Besides, some studies have reported different results on the effect of diode lasers in treating dentin hypersensitivity. Diode laser with a wavelength between 655 and 980 nm can accelerate wound healing, promote angiogenesis, improve the release of growth factors, and prevent root surface abrasion. The small size of diode laser units and their low cost are considered their advantages. Diode lasers with 980 and 810-nm wavelengths are the most commonly used laser beams in dentistry, especially in the fields of endodontics and periodontics.[17-19]

Considering what was discussed above, the high prevalence of dentin hypersensitivity, and ready availability of diode laser units, the present study was undertaken to evaluate and compare the effects of two high-level diode lasers with 980-nm and 810-nm wavelengths on dentin hypersensitivity to achieve the best and effective laser parameters for clinical applications.

MATERIALS AND METHODS

Trial design

This single-center, parallel-design, double-blind, randomized, controlled clinical trial was conducted in the Department of periodontics, Dental School of Isfahan University of Medical Sciences.

Inclusion and exclusion criteria

The subjects were selected from those referring to the general and specialty sections of the Department of Periodontics, Faculty of Dentistry, Isfahan University of Medical Sciences, with at least three teeth with cervical dentin hypersensitivity. The selected teeth were free of calculus and plaque and underwent a scaling procedure before the study, if necessary. The selected teeth exhibited sensitivity to the cold test. Smokers were not included in the study due to the effect of nicotine on the cold test response. Besides, pregnant women were excluded due to the possible adverse effects of laser beams. The selected teeth did not have active periodontal disease, crown fractures, cracks, caries, or restorations. Not existing trauma from occlusion and occlusal interferences were also assessed. Patients having taken analgesics during the 72 h period before laser therapy, and patients having used antisensitivity toothpastes during the 3-month period before the study were excluded.

Sample size calculation

The sample size was calculated at $n = 23$ for each group at a significance level of 0.05, a study power of 80%, and a clinical value difference of 0.5, expecting to achieve a mean difference of $d = 0.5$ between measurement techniques at $\alpha = 0.05$.

$$n = \frac{(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta})^2(\sigma_1^2 + \sigma_2^2)}{d^2}$$

$$\alpha = 0.05 \rightarrow Z_{1-\frac{\alpha}{2}} = 1.96$$

$$1-\beta = 0.80 \rightarrow Z_{1-\beta} = 0.84$$

$$\sigma_1, \sigma_2 = 0.6$$

$$d = 0.5$$

Groups allocation and randomization

Finally, seven patients were selected based on inclusion and exclusion criteria, with an age range of 30–50 years, consisting of one male and six females. The patients received adequate explanations about the procedural steps and the number of sessions required and the study's duration. The patients signed informed consent forms to be included in the study. All the patients received oral hygiene instruction and scaling and root planing treatment if necessary.

A visual analog scale (VAS) was used to determine the pain severity in the affected teeth. Dry ice spray (FriscoSpray, ad-Arztbedarf, Frechen, Germany) irritation with a swab was used to elicit a pain response. A horizontal line was drawn on a piece of paper, with "0" indicating no pain and "10" indicating severe unbearable pain (similar to labor pain or limb amputation). The patients were asked to indicate their pain severity on this line.

After recording the VAS scores, an attempt was made to match the subjects based on the baseline VAS scores, followed by random assignment of the subjects to the study groups (randomized matching). The random numbers table was used for random allocation. On each patient's hypersensitive teeth, in Groups 1, 2, and 3 (control), 980-nm diode laser beams (Fox Laser, A. R. C. Laser, Nürnberg, Germany), 810-nm diode laser beam (Fox Laser, A. R. C. Laser, Nürnberg, Germany), and guiding beams were applied, respectively. Each patent's teeth were grouped so that all the three treatment modalities were applied in each patient in three different quadrants.

Intervention

The teeth were dried with a piece of gauze and isolated by cotton roll. The laser beam parameters in both laser therapy groups were a power of 1 Watt, continuous wave mode, a distance of 1 mm with no contact, and a radiation beam angle of 45° for 30 s using a to-and-fro movement. Irradiation speed and fiber diameter were 1 mm/s and 320 μm, respectively. Power density and energy density were 311.52 W/cm^2 and 10.37 J/cm^2, respectively. The teeth in the control group were not irradiated with laser beams and underwent the guiding beam radiation for blinding purposes. The treatment was rendered in two sessions in the same manner with a 1-week interval [Figure 1].

Data collection

Pain severity was evaluated with VAS before treatment, 15 min after the first treatment session, 15 min after the second treatment session, and at 1-week, 1-month, and 2-month postoperative intervals.

Data analysis

The data were analyzed with one-way ANOVA, repeated-measures ANOVA, and *post hoc* least significant difference (LSD) tests, using SPSS version 20 (SPSS Inc., Chicago, IL, USA).

Ethical considerations

The patients signed informed consent forms before being included in the study, and after they were provided with the necessary information about the study procedures. The study protocol was approved by the Ethics Committee of Isfahan University of Medical Sciences under the code 394844. The study was registered in the Iranian Registry of Clinical Trials under the code IRCT20120901010703N3.

The laser therapy procedures with mentioned parameters did not inflict any harm to the patients.

At the end of laser therapy, if a patient was not satisfied with treatment outcomes, other available treatments were suggested.

RESULTS

After initial examinations, seven patients (six females and one male) with an age range of 30–50 with dentin hypersensitivity in at least three teeth were included in the study. Finally, the study was carried out on 69 sensitive teeth. After the intervention, dentin hypersensitivity was evaluated 15 min after the first and second sessions and at 1-week, 1-month, and 2-month postoperative intervals. Table 1 compares the mean VAS scores of pain severity at different intervals in the three groups. Comparisons were made at different intervals in each group and at the same time intervals between different groups.

Figure 1: (a) Evaluation of initial visual analog scale, (b) Diode laser desensitization 810 nm, (c) Diode laser desensitization 980 nm

One-way ANOVA showed no significant differences in mean VAS scores between the three groups ($P = 0.41$) before treatment.

However, 15 min after the first session, there were significant differences between the three groups ($P = 0.005$). Besides, there were significant differences between the three study groups in mean VAS scores 15 min, 1 week, 1 month, and 2 months after the intervention ($P < 0.001$). Repeated measures ANOVA showed no significant differences in mean VAS scores between the different time intervals in the control group ($P = 0.1$). However, there were significant differences in the mean VAS scores between the different time intervals in the 810-nm ($P < 0.001$) and 980-nm ($P < 0.001$) laser groups.

Table 2 presents the results of two-by-two comparisons of the study groups in terms of the time intervals. *Post hoc* LSD tests showed significantly lower mean VAS scores at all the intervals after intervention in both laser groups than the control group, with no significant difference between the two laser groups ($P > 0.05$).

Table 3 presents the mean VAS changes at postoperative intervals compared to the baseline in the three groups. One-way ANOVA showed significant differences in the mean VAS changes at all the postoperative intervals compared to the baseline in all the three groups. *Post hoc* LSD tests showed significant decreases in VAS scores at all the time intervals in both laser groups, with no significant differences between the two laser groups up to 2 months ($P = 0.098$).

Table 1: The mean visual analog scale scores of pain severity at different time intervals in the three study groups (confidence interval 95%)

Time interval	Control group	810-nm laser group	980-nm laser group	*P*
Before treatment	4.78±1.97	5.17±1.43	4.48±1.85	0.41
Immediate effect				
First session				
After 15 min	4.13±2.2	2.83±1.66	2.3±1.74	0.005
Second session				
After 15 min	3.83±2.1	1.74±0.4	1.39±0.3	<0.001
Late effect				
After 1 week	4±1.9	1.65±0.3	1±0.2	<0.001
After 1 month	3.83±1.92	1.13±0.3	1.3±0.3	<0.001
After 2 months	3.87±1.96	1.09±0.3	1.39±0.3	<0.001
P	0.1	<0.001	<0.001	

DISCUSSION

The objective of the present study was to compare the effects of two types of diode lasers 810 and 980-nm in the treatment of dentin hypersensitivity. Our results revealed that both 810-nm and 980-nm diode lasers are effective in relieving pain in patients with dentin hypersensitivity, however, there were no significant differences between these two lasers.

Many studies have been carried out on the use of low-level diode laser for treating dentin hypersensitivity.[20-23] Since limited studies are available on the use of high-power diode laser in the treatment of dentin hypersensitivity, the present comparative study was undertaken to evaluate the effect of 810-nm and 980-nm high-power diode lasers in treating dentin hypersensitivity.

Occluding the dentinal tubules is necessary to decrease patients' complaints and prevent pulpal irritation due to bacterial invasion from the dentin surface.[24] Some researchers believe that laser therapy can be a reliable treatment modality with a 90% relative success.[12] The decrease in dentin hypersensitivity due to laser irradiation depends on two mechanisms. In the first mechanism, the laser beams directly affect the pulp–dentin nerve endings, and in the second mechanisms, laser desensitization depends on a change in the structure of dentinal tubules through melting and combining the hard structure with the smear layer, resulting in the occlusion of dentinal tubules.[25]

Table 2: Two-by-two comparisons of visual analog scale scores between the study groups at different time intervals (confidence interval 95%)

Group	Time interval (*P*)					
	Before treatment	15 min after the first session	15 min after the second session	1 week after treatment ended	1 month after treatment ended	2 months after treatment ended
810-nm laser group with the control group	0.456	0.022	<0.001	<0.001	<0.001	<0.001
980-nm laser group with the control group	0.652	0.002	<0.001	<0.001	<0.001	<0.001
810-nm laser group with the 980-nm laser group	0.187	0.352	0.518	<0.167	0.726	0.539

Table 3: The mean visual analog scale changes at different postoperative intervals relative to the baseline in the three study groups (confidence interval 95%)

Time interval	Control group	810-nm laser group	980-nm laser group	*P*
15 min after the first session	−0.6±0.3	−2.3±0.5	−2.2±0.5	0.016
15 min after the second session	−0.9±0.5	−3.4±0.4	−3±0.4	<0.001
After 1 week	−0.7±0.3	−3.5±0.3	−3.4±0.5	<0.001
After 30 days	−0.7±0.3	−4±0.4	−3.1±0.5	<0.001
After 60 days	−0.9±0.3	−4±0.4	−3±0.5	<0.001

The laser parameters affecting the laser energy applied on each surface include power, irradiation time, pulse or CW mode, energy density, distance from the surface, and the angle between the surface and the fiber tip. The most important consideration in laser therapy is determining appropriate parameters to achieve the best outcomes with no adverse thermal effects, cracks, and carbonization.[26] In the present study, the power parameters of both 810 and 980-nm diode lasers were determined using the results of studies carried out in recent years[19,27] and based on a pilot study at 1 W. It is claimed that the mechanism of an improvement in dentin hypersensitivity at low powers depends on the effect on nerve endings, while high-power lasers occlude or tighten the dentinal tubules, and much higher laser powers occlude more dentinal tubules. However, when high-power laser beams are used, the effect of increased temperature on tooth pulp should be taken into account.[28,29]

Umana *et al.*[19] evaluated the effective diode laser parameters on dentin hypersensitivity treatment *in vitro* and concluded that 810 and 980-nm diode laser beams with 0.8–1-W power and continuous wave mode at 1 mm/s speed for 10 s resulted in the occlusion or narrowing of dentinal tubules. They reported that lasers with higher power and energy might destroy dentin, irritating the tooth pulps.

Kreisler *et al.*[27] carried out an *in vitro* study and reported that irradiation of laser beams with 1-W power or lower than that rarely does exert adverse effects on the root surface; however, laser beams with higher powers (1.5, 2, and 2.5 W) lead to complete or partial carbonization of the root surface.

Concerning 980-nm laser beams, Liu *et al.*[30] carried out an *in vitro* study using an electron microscope and concluded that 2-W power provided an ideal energy level to rapidly seal the dentinal tubules without irritating odontoblasts and tooth pulp. However, it appears that due to the high energy level of this power, there is the risk of injury to the tooth structure and increased pulpal temperature. Therefore, the parameters used in the present study were similar to recent studies,[19,27] and the exposure time was adjusted at 30 s because in the pilot study, 30 s exposure time resulted in better desensitization with no side effect compared to shorter exposure times.

Many researchers have already reported the efficacy of 810-nm laser beams in treating dentin hypersensitivity;[21-23,31] however, the laser parameters used in the present study were somewhat different from theirs.

George *et al.*[21] used 0.5-W power, CW mode, 0.5-mm distance, and an expensive time of 60 s to evaluate the effect of 810-nm laser. Mittal *et al.*,[20] too, used 0.5-W power and 2-min exposure time to evaluate the efficacy of 810-nm diode laser beams. Both studies showed the efficacy of 810-nm diode laser at 0.5-W power. However, Hashim *et al.*[23] evaluated the effect of 810-nm diode laser with 1-W power. Two groups were irradiated for 30 and 60 s. Both groups exhibited significant improvements, with a higher effect with 60 s exposure time. The study above was similar to the present study concerning the laser power and 30 s exposure time; however, considering previous *in vitro* studies[19] on the subject, the 60 s exposure time might negatively affect tooth structure.

In the group treated with 980-nm laser beams, a comparison of VAS scores at follow-up intervals

with the period before treatment revealed significant differences at all the intervals ($P < 0001$). Umberto *et al*.,[32] too, compared the effects of 980-nm GaAlAs laser and local sodium fluoride gel in treating dentin hypersensitivity and reported the efficacy of 980-nm diode laser. In that study, too, 0.5-W low-level laser beams were evaluated with a 1 min exposure time.

It appears that the immediate effect of laser beams can be attributed to their effect on nerve endings, and the late effects can be attributed to the occlusion of dentinal tubules.[25] However, sometimes, the hypersensitivity persists despite the occlusion of dentinal tubules, indicating that in the neuronal irritation, in addition to the hydrodynamic mechanism, other mechanisms, too, might be involved.[33]

In the control group, the VAS scores decreased significantly after one treatment session; however, the decrease was not significant at subsequent intervals ($P > 0.05$) [Table 3]. Yilmaz *et al*.[31] did not report significant changes in VAS scores in their control group. However, Jokstad[34] evaluated studies on the effect of laser beams on decreasing dentin hypersensitivity in a systematic review and concluded that the placebo effect could not be ignored. A common and significant problem in studies on dentin hypersensitivity is the improvement in all the study groups, even in the control group. A strong placebo effect has been reported in clinical studies on dentin hypersensitivity, which might be attributed to the placebo effect, spontaneous recovery, or a possible regression of the conditions. This effect, which strongly depends on the patient–clinician relationship, might be due to a combination of psychological and physiological factors.[35] Researchers believe that patients experience relief without any treatment due to the placebo effect, the extent of which for dentin hypersensitivity has been reported between 20% and 60% in clinical studies.[36] The present study results revealed an improvement in one stage in the control group, and the control group teeth consistently exhibited higher discomfort levels at all the other intervals. However, a comparison of treatment groups (810 and 980-nm lasers) with the control group revealed significant differences between them. Concerning the results of studies on the subject, it should be pointed out that the patient's response to stimuli is subjective and depends on the patient's pain threshold and tolerance, which might affect the results of clinical studies.[37] In clinical situations, it is possible for the patients to report less pain due to the intervention and out of politeness.[38]

Therefore, the present study showed that both 810 and 980-nm diode lasers significantly improved dentin hypersensitivity. Different studies have used different laser parameters; however, many such studies have reported the efficacy of these two diode laser types.[20-23,32] However, Gholami *et al*.[39] carried out an *in vitro* study and concluded that the 810-nm diode laser was less effective than other lasers (CO_2 and Er, Cr:YSGG) in sealing the dentinal tubules, with a minor effect on desensitization.

One of the essential considerations to be discussed is the secondary dentin formation at follow-up intervals, which leads to a spontaneous improvement and protection of the pulp against irritants. It is necessary to note that different mechanisms decrease tooth hypersensitivity naturally over time, including the formation of sclerotic dentin or secondary dentin, tertiary or reparative dentin, and calculus and the smear layer.[40]

Comparisons of VAS scores of the treatment groups (810-nm and 980-nm diode lasers) at different time intervals with the control groups showed significant differences in both treatment groups at all the postoperative intervals [Table 2]. However, there were no significant differences between the two treatment groups at any postoperative interval [Table 2].

In the present study, changes in the VAS scores in both groups at different time intervals were compared with the baseline scores. The two groups exhibited significant decreases in VAS scores at all the time intervals, with no significant differences between the two groups up to 2 months.

Laser beams with 800–980-nm wavelengths are absorbed in water and hydroxyapatite to some degree, resulting in the diffusion, scattering, and diffuse transfer of the laser beams in the dentin, with thermal effects. The energy absorbed by the dentin surface leads to an adequate increase in temperature to decrease the diameter of the dentinal tubules or occlude them. The laser wavelength determines its absorption rate and tissue effects. The 980-nm wavelength is absorbed by water at a higher rate, and the 810-nm wavelength is absorbed by melanin at a higher rate. The 980-nm wavelength leads to less thermal effects on the tooth pulp than the 810-nm wavelength.[19]

In the present study, the two diode lasers did not exhibit significant differences in dentin hypersensitivity treatment. Since previous *in vitro* studies in this field have shown that the 980-nm diode laser has lower thermal effects on the tooth pulp than the 810-nm diode laser, the use of 980-nm diode laser might be more beneficial in the treatment of dentin hypersensitivity, with fewer side effects. It should be noted that the mechanism of the effect of diode lasers on treating dentin hypersensitivity has not been completely elucidated,[41] and further studies are necessary on the subject. One of the main limitations of the present study is the relatively small sample size that can be attributed to strict inclusion and exclusion criteria defined, moreover, clinical studies with longer follow-up periods are suggested to help to improve the quality of treatment and resolve related problems. At present, considering structural developments in laser units and equipment, the use of lasers in the dental field is increasing. However, one of the limitations of the use of lasers is the treatment of hypersensitive surfaces in the interproximal areas, while gels and toothpastes can be applied in these areas, too, due to their good flow ability.

CONCLUSION

Based on the present study results, the use of 810 and 980-nm diode lasers is a very useful technique to relieve pain in patients with dentin hypersensitivity with no significant difference between these two lasers. It appears that 1-W power of the laser and 30 s exposure time are appropriate parameters for treatment.

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Conflicts of interest
The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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