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ORIGINAL ARTICLE

A randomized clinical trial of the effect of low-level laser therapy before composite placement on postoperative sensitivity in class V restorations

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Abstract This study aimed to investigate the efficacy of low-level laser irradiation when applied just before placement of resin composite on reducing postoperative sensitivity of class V lesions. In this randomized clinical trial, 31 patients with 62 class V cavities were included (two teeth in each participant). The teeth were randomly assigned into laser and placebo groups. After cavity preparation, the teeth in the experimental group were subjected to irradiation from a low-power red laser (630 nm, 28 mW, continuous wave, 60 s, 1.68 J), which was applied for 1 min on the axial wall of the cavity. In the control group, the same procedure was performed but with laser simulation. Then, a self-etch adhesive was applied and the cavities were restored with a microhybrid resin composite. Before treatment and on days 1, 14, and 30 after treatment, tooth sensitivity to a cold stimulus was recorded using a visual analogue scale. Data were analyzed by Friedman and Wilcoxon signed-rank tests ($p<0.05$). Pain scores after restorative procedures were significantly lower in the laser group compared to the placebo application ($p<0.05$). Although both groups experienced a significant improvement in pain and discomfort throughout the follow-up periods ($p<0.001$), the changes in visual analogue scale (VAS) scores between baseline and each follow-up examination were significantly greater in the laser than the placebo group ($p<0.05$). Low-level laser therapy (LLLT) before placement of resin composite could be suggested as a suitable approach to reduce postoperative sensitivity in class V restorations.

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Introduction

In recent years, there has been a great improvement in composite filling materials and polymerization techniques, but postoperative sensitivity still remains an issue of concern in a relatively great percentage of patients undergoing posterior resin-based restorations. Postoperative sensitivity is mainly due to the polymerization shrinkage of dental composites, which can cause residual stress and gap formation between the restorative material and tooth tissue [1–3]. Despite the various techniques suggested to reduce sensitivity following composite restorations, an ideal therapeutic approach has not been achieved to date, and therefore, it is still necessary to search for an effective and applicable alternative to resolve this complication.

For more than 40 years, low-level laser therapy (LLLT) has been employed in medicine and dentistry because of its analgesic, biostimulative, and anti-inflammatory effects and its great benefits in accelerating the healing process. In dentistry, low-level lasers have been applied for the treatment of dentin hypersensitivity, a common clinical problem that has been defined as a short sharp pain with sudden manifestation, arising as a result of thermal, tactile, chemical, or osmotic stimuli. The most commonly accepted explanation for the occurrence of dentinal hypersensitivity is the hydrodynamic theory of Brannstrom [4], which states that fluid movement inside the dentinal tubules, either inwardly or outwardly, leads to the activation of nerve endings at the pulp-dentine interface, and thus promoting pain sensation. Previous studies demonstrated comparable [5–8] and even better efficacy [9, 10] of low-level lasers compared to other desensitizing agents in

decreasing the degree of pain and discomfort in subjects affected with dentinal sensitivity, although some authors reported the controversial findings [11]. In contrast to the conventional techniques that rely on mechanical occlusion of dentinal tubules and thus reducing dentinal permeability, the effectiveness of LLLT in the treatment of sensitive teeth has been ascribed to the blockage of nerve activity at the pulp-dentin complex, thus preventing from pain transmission to the central nervous system [5, 12]. It is also believed that LLLT stimulates odontoblasts to produce tertiary dentine [5, 13], which is a great barrier against thermal stimuli.

Although the efficacy of LLLT for the treatment of dentinal hypersensitivity has been evaluated in several studies, no study investigated the influence of laser irradiation before placement of restorative materials on postoperative sensitivity of restored teeth. Therefore, this study aimed to evaluate the clinical performance of applying a low-power red laser after cavity preparation and just before placement of resin composite on postoperative sensitivity in class V restorations during a 1-month follow-up period.

Methods and materials

The study included 31 patients (9 males and 22 females, age range 15 to 65 years) referring to the Department of Restorative Dentistry of Mashhad Dental School, Mashhad University of Medical Sciences, Mashhad, Iran. The subjects had at least two class V lesions in the buccal surfaces of the premolar teeth with the axial depth of 1.5 to 2.0 mm after cavity preparation as measured by a probe. The selected premolars were in contact with the opposing and adjacent teeth, have not been restored previously, and were not subjected to primary or secondary trauma. Vitality tests and bitewing radiographs were taken for each subject to confirm that the candidate's teeth were vital and free of proximal caries, respectively. The individuals who showed hypersensitivity because of periodontal disease or had deep caries in the selected premolar teeth as well as those with parafunctional habits, TMJ disorders, and emotional diseases were ruled out from the sample. The exclusion criteria also involved subjects who were under analgesic or sedative medications within the 72 h prior to the treatment. The research protocol was reviewed and approved by the Ethics Committee of Mashhad University of Medical Sciences, and it was registered in the Iranian Registry of Clinical Trials (IRCT registration number: IRCT2012072810425N1). The patients signed informed consent documents after being completely aware of the treatment objectives and follow-up requirements.

Before cavity preparation, tooth sensitivity was assessed by a thermal test. For this purpose, the examined tooth was isolated from the neighboring ones with putty impression material (Speedex, Coltene, Alstatten, Switzerland) and then a cold stimulus (Roeko Endo-Frost, Coltene Whaledent, Langenau, Germany) was applied on the middle third of the buccal surface of the tooth for 5 s using a disposable applicator. The patients were requested to present the degree of pain according to a visual analogue scale (VAS), which consisted of a horizontal line with 11 points of discomfort (0 to 10) where the left side (0) indicated no pain and the right side (10) represented the unbearable pain (baseline measurement).

Afterwards, the cavity walls of the class V lesion were cleaned and lightly roughened with a high-speed diamond bur (Brasseler, Savannah, GA, USA) under water spray. The deep caries was removed with a round carbide bur in a low-speed handpiece. Finally, the enamel margins of the cavities were beveled and the shade selection was performed. Relative isolation of the teeth was achieved by cotton rolls and retraction cords.

In each participant, one tooth was randomly assigned to the experimental (laser) group and the other one was assigned to the control (placebo) group. After cavity preparation and just before the restoration placement, the teeth in the experimental group were subjected to irradiation from a low-level red laser (Mustang 2000+, Moscow, Russia), emitting a wavelength of 630 nm in a continuous-wave mode. The output power of the apparatus was 28 mW, and each tooth was irradiated for 60 s. The probe was held in contact with the buccal surface of the tooth, and the beam was directed to the axial wall of the cavity perpendicularly. The total energy delivered was 1.68 J, and the energy density at the surface of the target was about 1 J/cm2, considering both the gaussian profile of the beam and the large surface area of 1.7 cm^2 for the probe (1.5 cm of diameter) compared with the dimensions of the treated cavities. In the control group, the teeth were subjected to the placebo application for the same duration as the laser group, but with the apparatus turning off. The patient was not aware that which tooth received laser irradiation and which one was submitted to the placebo group.

Following laser or placebo treatments, a self-etch adhesive (Clearfil SE Bond; Kuraray Medical Inc., Okayama, Japan) was applied according to the manufacturer's recommendations, and then the class V cavities were restored by a microhybrid resin composite (Clearfil AP-X, Kuraray Medical Inc.). No cavity liner was applied because the deep cavities had been excluded from the sample. The composite was placed using a bulk-filling technique in small cavities and an incremental technique in extensive cavities and cured from the buccal surface of the tooth with a light curing device (Optilux 500, Kerr Corp., Orange, CA, USA) at an output power of 500 mW/cm^2. Each composite layer was polymerized for 40 s. After curing, finishing was accomplished with fine-grit diamond burs (Brasseler) and Sof-Lex polishing disc system (3 M ESPE, St Paul, MN, USA) under water cooling to obtain a smooth surface.

Both class V cavities of each patient were restored at the same appointment and by the same investigator. The patients were advised to maintain good oral hygiene and to use a soft toothbrush without the application of any desensitizing agent.

The postoperative sensitivity was assessed with a cold spray similar to that used in the baseline measurement. The patients were followed up for sensitivity on days 1, 14, and 30 after treatment by another calibrated examiner who was not aware of the treatment applied. In each follow-up, the patients were asked to mark the degree of pain on a visual analogue scale as they did before the restorative procedure.

Statistical analysis

The effectiveness of laser therapy before composite placement was determined by comparing the scores of the laser and placebo groups at each evaluation period. Intragroup analysis was also run to assess the changes in postoperative sensitivity in each group during the experiment. The data were analyzed by Friedman and Wilcoxon signed-rank tests through SPSS (Statistical Package for the Social Sciences, version 16.0, Chicago, IL, USA) software. The significance level of the tests was set at $p<0.05$.

Results

All the patients completed the 1-month follow-up period. No complications such as detrimental pulpal effects were observed during the experiment. Table 1 presents the mean and standard deviation (SD) of postoperative sensitivity in the laser and placebo groups before the treatment and at the three follow-up periods (days 1, 14, and 30). At baseline examination, the mean VAS scores of the experimental and control groups were 6.38 and 6.22, respectively. The degree of discomfort declined throughout the follow-up sessions in both groups, but the decrease was more evident in the laser than the placebo group, as represented in Table 1.

The statistical analysis displayed that the sensitivity to cold stimulus was not significantly different among the two groups at baseline examination (Table 1). Comparison of postoperative sensitivity at the three follow-up periods revealed a significantly lower pain score in patients irradiated with low-power red laser prior to composite placement compared to that of the placebo application (Table 1, Fig. 1).

When each group was considered separately, a significant improvement in sensitivity occurred through the follow-up periods in both the laser ($p<0.001$) and placebo ($p<0.001$) groups. Table 2 presents the mean, SD, and results of statistical analyses regarding the changes in tooth sensitivity of each group from baseline to the three follow-up assessments. Although both groups experienced a significant reduction in discomfort throughout the follow-up periods, the laser group exhibited a significantly higher decrease in VAS compared to the placebo group at all time points, as depicted in Table 2.

Table 1 Descriptive statistics and the results of statistical analysis regarding postoperative sensitivity in the laser and placebo groups at different evaluation points

	Laser group		Placebo group		Statistical significance
	Mean	SD	Mean	SD	
Baseline	6.38	1.78	6.22	1.76	$p=0.498$
1 day	2.38	1.11	4.32	1.37	$p<0.001$*
14 days	1.38	1.02	2.64	1.27	$p<0.001$*
1 month	0.96	0.94	1.48	1.15	$p=0.01$*

*Statistically significant difference at $p<0.05$

Discussion

The visual analogue scale which is a subjective method of pain assessment was used in this investigation to indicate the degree of discomfort after treatment. Class V cavities with similar depths were selected for the purpose of standardization because the occurrence of tooth sensitivity after posterior composite restorations has been correlated to the cavity depth [1, 14, 15] and also to the complexity of the cavity design considering that it was more frequent in class II than class I restorations [16]. The present study indicated that LLLT after cavity preparation is an effective strategy to reduce postoperative sensitivity in patients with posterior resin composite restorations. The improvement was evident from the first follow-up examination in the laser group compared to the placebo application and continued to the 1-month time point, although the differences between the groups declined throughout the experiment.

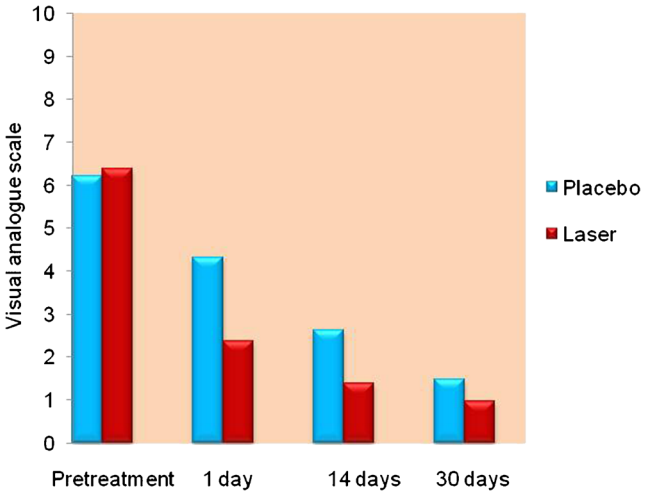

Fig 1 Comparison of tooth sensitivity between the laser and placebo groups before treatment and at the three examination periods after treatment

Table 2 Descriptive statistics and the results of statistical analysis regarding reductions in tooth sensitivity from baseline to the three follow-up assessments for both the laser and placebo groups

	Laser group		Placebo group		Statistical significance
	Mean	SD	Mean	SD	
1 day baseline	4.00	1.65	1.90	1.04	$p<0.001$*
14 days baseline	5.00	1.61	3.58	1.25	$p<0.001$*
1 month baseline	5.41	1.64	4.74	1.45	$p=0.01$*

*Statistically significant difference at $p<0.05$

When the differences in VAS scores between the baseline and each follow-up period was compared among the two groups, it was revealed that the laser group experienced a significantly higher degree of pain alleviation compared to the placebo group at all time points over the experiment.

Laser wavelengths in the range of 400–900 nm are commonly used for LLLT. In the present study, a low-power red laser was selected because of its biostimulative effects and its proven efficacy in improvement of wound healing [13]. The effectiveness of LLLT for reducing post-operative sensitivity may be related to the suppression of nerve transmission at the pulpal-dentin interface which reduces pain sensation [5, 12]. Furthermore, it may stimulate the physiologic function of odontoblasts, thus promoting the formation of sclerotic dentin and obliteration of dentinal tubules [5]. Because of their biomodulative effects, low-power lasers may also be capable to eliminate any injury and inflammation created in the pulp through the cavity preparation process, and in this way, they can reduce patients' pain and discomfort. This may be the main mechanism of action of low-power lasers when used in the current application. In contrast to the short-term effect of low-power lasers on nerve conductivity, the reduction in postoperative sensitivity due to the healing effect on the pulp should be long lasting. Ferreira et al. [13] used a 670-nm low-power laser after class V cavity preparations and reported less intense inflammatory response in the laser group compared to the control teeth. Furthermore, they observed that reactional dentinogenesis only occurred in the irradiated group [13].

Previous studies mainly used infrared gallium-aluminum-arsenide (GaAlAs) lasers (wavelengths 790–830 nm) for the treatment of dentinal sensitivity [9, 17], although visible red laser has also been employed for this purpose by some authors [5]. Ladalardo et al. [18] reported that the therapeutic effects of the 660-nm red laser were greater than those of the 830-nm infrared laser in patients affected with dentinal hypersensitivity. Although red lasers have lower penetration depths than infrared lasers, it should be noted that class V cavities with 1.5 to 2.0 mm depths are very close to the pulp and so the low penetration depth of the red laser wavelength should not make concern regarding its therapeutic effects. The energy density applied in this study was within the therapeutic window as suggested by the Arndt-Schultz law, but it was lower than that used in most of the previous studies [5, 13]. This was related to the low power of the laser apparatus and the large surface area of the probe which reduced energy density (J/cm^2). In most applications, LLLT is repeated several times to provide the optimal result. However, the onetime application of low-power red laser as used in this study also proved to be effective in reducing postoperative sensitivity in class V resin composite restorations. In fact, the current application of LLLT can only be performed one time because vital teeth are usually restored at one visit.

The inclusion criteria of this study allowed simultaneous assignment of laser and placebo groups to each participant. Selection of a placebo group is necessary when one considers the analgesic effects of low-level lasers. This is due to the psychological impact of treatment with a high-technology laser apparatus, which can affect pain perception by the patients [19, 20]. The placebo effect of laser therapy has been demonstrated by previous authors regarding the treatment of dentinal hypersensitivity [21]. In the present investigation, a significant improvement in discomfort also occurred in the placebo group along all times assessed after treatment. Since we did not include a control group without laser or placebo application in the study design, it is not possible to differentiate between the placebo effect of laser therapy and the spontaneous improvement in tooth discomfort which is usually noticed within a few weeks after composite restoration.

Reviewing the literature, there is no study regarding the effect of LLLT before placement of resin composites on postoperative sensitivity of restored teeth; therefore, direct comparison of the outcomes of this study with those of other studies is not possible. However, there are some conflicting reports about the effects of low-power lasers on reducing dentinal hypersensitivity. LLLT was as effective as fluoride varnish in relieving cervical dentine hypersensitivity in a study performed by Corona et al. [5], although teeth with excessively sharp pain showed a more accentuated reduction of discomfort after laser treatment than following fluoride application. Vieira et al. [8] found no significant difference between a low-level GaAlAs laser and a 3 % potassium oxalate gel for reduction of dentinal hypersensitivity. Gerschman et al. [17] reported that the mean value of thermal sensitivity decreased 67 % in the laser group compared to 17 % in the placebo group and the mean value of tactile sensitivity decreased 65 % in the laser group compared with 21 % in the placebo group; both comparisons were statistically significant. In contrast, the study of Tengrungsun and Sangkla [11] revealed that a 30-mW GaAlAs laser had lower efficacy than a dentine bonding agent in treating dentinal hypersensitivity.

The present study introduces a novel approach for reducing postoperative sensitivity of posterior composite restorations. LLLT has multiple applications in dentistry, and its employment after cavity preparation and just before placement of the restorative materials should be considered as a safe, easy, and effective strategy for reducing pain and discomfort following restorative procedures. Further studies with greater sample size are warranted to compare the effects of low-level lasers with other methods of reducing postoperative sensitivity of composite restorations and to elucidate their exact mechanism of action when applied for this purpose.

Conclusions

Under the study conditions, LLLT after cavity preparation and just before composite placement proved to be an effective strategy for reducing postoperative sensitivity in class V restorations.

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