



# Clinical Effects of Low-intensity Laser vs Light-emitting Diode Therapy on Dentin Hypersensitivity

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**Purpose:** Dentin hypersensitivity is a common complaint associated with high dental pain. Low-intensity laser therapy (LILT) can minimize this clinical problem without causing any discomfort to patients. A new LED-based (light-emitting diode) light source has been used as an experimental tool in some studies. The main objective was to compare the effects of LILT and LED on dentinal hypersensitivity.

**Materials and Methods:** A total of 144 teeth with cervical hypersensitivity were treated in 6 sessions, consisting of 3 irradiation sessions and 3 follow-ups. This single-blind study compared a control group (placebo) and two test groups: low-intensity laser and an LED system, emitting in the same spectral band (red, from 630 to 660 nm) but using different operation modes (coherent and non-coherent beam). Two vitality tests (cold and heat) and one sensitivity test (air blast) was used.

**Results:** In the first and third sessions, all of the treatments were similar; in the second session LILT and LED performed similarly, both showing better treatment results than the control. In the follow-up of 15 days, all of the treatments were similar and effective; after 60 days, all the teeth given LILT showed the best results, with absence of pain in the air blast tests.

**Conclusion:** These results showed that two sessions seem to be enough for this treatment. In conclusion, given this protocol, LILT and LED treatment were effective in reducing dentin hypersensitivity. However, with these parameters, LILT seemed to be the best therapeutic method.

**Keywords:** low-intensity laser therapy, light-emitting diode therapy, dentin hypersensitivity, pain relief.

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Cervical dentin hypersensitivity can be caused by external stimuli such as cold, heat, solutions (sweet and sour), and pressure, if the exposed dentin surface is in contact with any irritating agent. The more accepted theory regarding the mechanism of dentin sensitivity is the hydrodynamic theory of dentinal pain,

proposed by Brännstrom in 1982. According to this theory, dentin hypersensitivity can be reduced by sealing the dentinal tubules.<sup>1-3</sup>

Low-intensity laser therapy has been widely applied in cervical dentin hypersensitivity treatment, minimizing the discomfort caused by this clinical problem. In



**Fig 1** The laser system used (Twin Laser, MMOptics; Sao Carlos, Brazil).

the long term, this acts at the cellular level, increasing the cellular respiration with production of energy (ATP), thus increasing the production of tertiary dentin and consequently sealing the dentinal tubules.<sup>4,5</sup>

However, the pain relief or analgesia mechanism due to infrared laser irradiation occurs when the light acts on the cell membrane, leading to a hyperpolarization, which is a photo-physical change as a result of the biological light/cell interaction. The cytoplasmic membrane permeability increases for the  $\text{Ca}^{++}$ ,  $\text{Na}^{++}$  and  $\text{K}^{+}$  ions where there is an increase in the cell membrane receptor activity. As a consequence, endorphin synthesis and neural cell action potential are increased, while there is a decrease in the bradykinin concentration as well as in the activity of the C fibers, which conduct pain stimuli.<sup>6</sup> This sequence of events results in pain relief.

In addition, laser irradiation in the red spectral band induces photoexcitation changes in the reduction potential of the oxidizing C cytochrome and also in the flavin components, leading to other reduction reaction changes (redox) and modulations in biochemical reactions through the cell membrane.<sup>6</sup> For this, two mechanisms have been suggested: reduction-oxidation regulation and ATP intracellular control.<sup>6</sup> The diverse

effects of low-intensity laser irradiation on the respiratory chain are based on the light's interaction with the redox regulation mechanism, which may be fundamental for certain irradiation effects on the chronic inflammation process, ischemia, and chronic wounds, where all are characterized by acidosis and hypoxia.<sup>6</sup>

With the advent of new LED-based (light-emitting diode) light sources, the need for clinical trials to compare their effectiveness is paramount. The therapeutic use of LED systems can be termed LEDT – light emitting diode therapy.

According to Ostuni et al,<sup>7</sup> considering the phosphorylase oxidation process, an LED-based system ( $\lambda = 650 \pm 20 \text{ nm}$ ; power output 0.20 mW) irradiating an enzymatic solution decreased the NADH and oxoglutarate concentration by ca 25% when compared with the control and laser groups (HeNe laser, 632.8 nm, with power settings of 1.7 and 10 mW). This means that compared to this laser, the LED system is more effective in stimulating the NADH oxidation process to  $\text{NAD}^{+}$ . However, the free  $\text{H}^{+}$  ion excess inside the mitochondria changes its membrane electric potential, disrupting the proton motive force, which leads to edema and consequently disequilibrium of the cell metabolism.

With the use of an LED system, the same or even better results are expected than with LILT, if both present similar wavelengths. If the LED system is as effective as the LILT system, the same type of treatment can be possible, with the same effectiveness but less cost.

The objective of this clinical study was to compare the effectiveness of a low intensity laser emitting at wavelength of 660 nm and an LED-based system emitting at  $630 \pm 10 \text{ nm}$  in treating cervical dentin hypersensitivity. Both light sources emit at the same spectral band (620 to 660nm), but differ regarding coherence.

## MATERIALS AND METHODS

A total of 144 teeth in male and female patients with cervical dentin hypersensitivity were selected. Exclusion criteria were indication for or already performed endodontic treatment, extensive restorative treatment, decay, and severe periodontal disease.

In the initial evaluation, a strong air blast was applied to the cervical region to determine sensitivity. Following this, the patients were randomly divided into three groups: group A (LILT), group B (LEDT), and group C (placebo, no irradiation), with 37 (25.69%), 43 (29.86%), and 64 (44.44%) teeth, respectively. All groups underwent 3 irradiation procedures at 7-day in-



**Fig 2** LED system (MMOptics; São Carlos, Brazil).

tervals, and 3 follow-up sessions were conducted at 15, 30, and 60 days after the last application. All the patients received oral hygiene instruction throughout the study, which consisted in the daily use of an alcohol-free oral rinse (Malvatricin Branqueador, Daudt; Divisão Odontis, Brazil), daily dental floss use, and correct brushing technique.

### Laser System (LILT - low-intensity laser therapy)

The low intensity laser device used was a Twin Laser (MMOptics, Divisao Laser; Sao Carlos, SP, Brazil), equipped with two handpieces, one emitting in the infrared (780 nm) and one in the red (660 nm) band (Fig 1). The 660-nm handpiece with a power setting of 40 mW was chosen. The laser beam spot diameter was 4.0 mm<sup>2</sup>.

### LED System (LEDT - light-emitting diode therapy)

The LED-based system used in this study was a prototype specifically designed for this experiment (MM Optics, Divisao Laser; Sao Carlos, Sao Paulo, Brazil). This device emits at a spectral band of 630 ± 10 nm, presenting a constant power of 230 mW (Fig 2). The spot size of 4.0 mm<sup>2</sup> is equivalent to that of the low-intensity laser system.

Both systems have the same delivery tip; only the lens differs, in order to focus the light beam from the laser source to the target tissue. These tips, at the end of the handpiece, do not possess any acrylic or glass



**Fig 3** Irradiation groups.

nozzles. The delivered power was measured at the handpiece end, covered by a PVC film (Cristal clear PVC film, Goodyear, Americana; Sao Paulo, Brazil), using a power meter (Fieldmaster, Coherent; Palo Alto, CA, USA) in order to ensure the real power output of low-intensity laser was 25 mW and 230 mW for the LED.

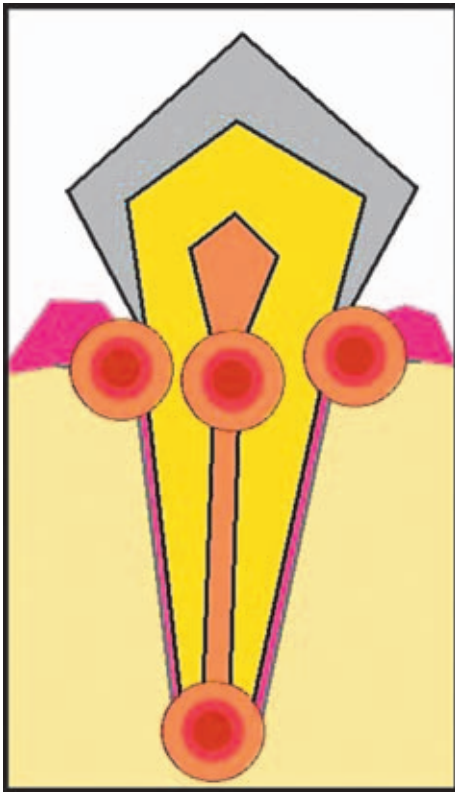
### Dosimetry

For the energy density (D) [J/cm<sup>2</sup>] calculation, the formula shown below was used, where the area (A) [cm<sup>2</sup>] corresponded to the laser beam spot size at the handpiece tip, the power (P) [W] corresponded to the constant and maximum power of the sources (25 mW or 0.025 W, and 230 mW or 0.23 W), and the time (T) was measured in seconds.

$$D(\text{J}/\text{cm}^2) = \frac{P(\text{W}) \times T(\text{s})}{A(\text{cm}^2)}$$

### Irradiation Protocols

The teeth were randomly assigned to 3 application groups as shown in Fig 3. They were divided into groups of 6 elements with a total of 6 groups, the maxillary and mandibular anterior teeth were in placebo groups (Twin Laser handpiece turned off); the maxillary right and mandibular left teeth received LEDT, and mandibular right and maxillary left teeth underwent LILT.

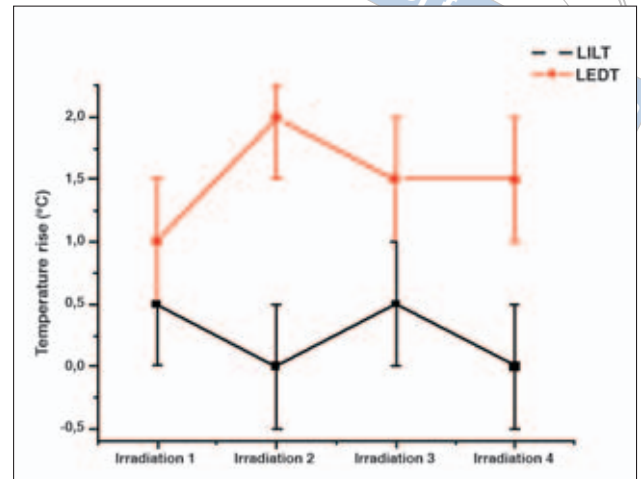


**Fig 4** Irradiation sites (3 at the cervical area and 1 at the apex).

The irradiation was applied in contact mode to the cervical area of the hypersensitive teeth at three cervical sites, and to one apical spot (Fig 4), following the methodology suggested by Groth<sup>8</sup> and Donato-Boracks.<sup>9</sup> The purpose of LILT at the tooth apex was to biomodulate the C fibers, while LILT at the cervical area aimed to reach the A-delta fibers of the dentin.<sup>4</sup>

In the first and last sessions (60 days after the last irradiation), thermal tests (cold and heat) were applied in order to verify tooth vitality. The pulpal response was considered normal (positive vitality, if presented sensitivity) or with reversible dentin hypersensitivity when the pain caused by the thermal tests disappeared soon after the tests. The vitality was considered negative when no tooth response was observed or when it presented irreversible hypersensitivity, in other words, when the pain persisted after the tests.<sup>10,11</sup>

Based on previous hypersensitivity studies, an air blast was used to evaluate hypersensitivity. According to Brännstrom,<sup>2</sup> the 3-s air blast generates a dentinal tubule fluid dehydration, and the nerve fibers and odontoblasts are stretched or torn off. This is the most frequently used test in dentin hypersensitivity studies.



**Fig 5** Temperature change during low-intensity laser and LED irradiation. Vertical bars represent a standard deviation of 5°C.

For the pain measurement procedure, a “+” signal was used for better results and a “-” signal for worse results. This was applied to measure the pain reaction from each patient on specific days and at specific moments as closely and as individually as possible. Due to the subjective nature of the pain sensation, the use of another evaluation form or even a VAS (visual analog scale) – widely used by many other authors – would have been extremely limited and not accurate enough.<sup>12,13</sup>

As the difference in the obtained results based on the wavelength (red or infrared) used is often not apparent in the literature,<sup>14-17</sup> more readily comparable variables were explored in the present study, ie, power output, energy density, and light source coherence wavelength.<sup>18</sup>

The irradiation parameters for LILT were 660 nm wavelength, 25 mW power output, 10 s duration per point, 6.0 J/cm<sup>2</sup> energy density (minus 10% because of the PVC film, resulting in 5.4 J/cm<sup>2</sup> for the irradiation spot) and for LEDT 630 ± 10 nm wavelength, 230 mW power output, 10 s per point, and 57.5 J/cm<sup>2</sup> energy density (minus 10% because of the PVC film, resulting in 51.75 J/cm<sup>2</sup> for the irradiation spot).

Since the LED-based system presents a coherence wavelength less than that of the laser, an initial assumption of this study was that if the power setting used was around 10 times higher, then the low coherence could be compensated in the therapeutic effect.

Throughout the study, the same devices were used. All the patients signed an informed consent form for

the treatment, describing the risks and benefits of the respective treatments.

There were a total of three treatment sessions, every 7 days (sessions 1, 2, and 3), with three follow-up appointments at 15, 30 and 60 days from the last application (sessions 4, 5, and 6, resp).

The following treatment protocol was employed in sessions 1 to 3: prophylaxis with pumice stone and 3% hydrogen peroxide, vitality test (first and last session), sensitivity test, irradiation or placebo treatment, sensitivity test; and in sessions 4 to 6: prophylaxis with pumice stone and hydrogen peroxide (10vol%), sensitivity test. In the sessions 1 and 6, the vitality tests were executed as the first step.

### Temperature Mapping

Thermal mapping was done at the surface of extracted teeth during irradiation with laser and LED. Three freshly extracted premolars were mounted in a modeling mass coupled with an infrared thermometer (MT-350, Minipa; São Paulo, Brazil), where the temperature generated at cervical and apical areas of the tooth surfaces was registered. The measurements were repeated four times; each time, the four pre-established spots as in the clinical protocol were irradiated. The devices as well as the parameters previously described were used for these irradiation processes.

Although these measures were carried out inside the laboratory at an ambient temperature of 25°C and did not simulate the clinical situation, it is important to clarify that the objective was to compare the two light sources in terms of superficially generated temperature change.

## RESULTS

### Temperature Mapping

Figure 5 shows two curves with standard deviation bars of 0.5°C, which was related to the thermometer used. The red curve represents the temperature change generated by the LED prototype and the black curve represents the laser equipment. The average temperature change was ca 2.0°C for the LED and ca 0.5°C for the laser. These values were expected, because the LED device's power output was around ten times higher than that of the laser, and power over 100 mW may cause a discrete heating when the light source presents a certain wavelength coherence.

### Changes in Dentin Hypersensitivity

The obtained data concerning the improvement (+) and worsening (-) of hypersensitivity were statistically analyzed using Fisher's test. Table 1 presents the results found immediately after irradiation in each treatment session. Table 2 shows the results from the 15-, 30-, and 60-day follow-up sessions.

Table 1 and Figs 6 to 8 show that all treatments decreased the pain in the first session even with the use of air blast, without significant differences between them.

It was observed that the LILT and LEDT groups were similar at the second session, and better than the placebo group; finally, a similarity among the three experimental groups was noticed in the third session. A 95% confidence interval was used for all analyses.

It is important to highlight that for the placebo group, the prophylaxis routine on exposed dentin may have caused a slight irritation, perhaps stimulating the formation of secondary dentin.<sup>19</sup>

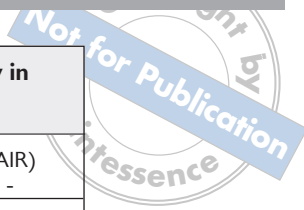
## DISCUSSION

The doses applied in this study did not promote pulp necrosis, because the vitality of all teeth was preserved throughout the treatment and follow-up sessions.

The placebo group might have shown improvement due to the sensitivity tests and prophylaxis in all the sessions, which might have stimulated the production of secondary dentin. However, Figs 7 and 8, which depict results of the second and third weeks, show that the placebo group had more worsened than improved results. An explanation for this may be that, although removing the bacterial biofilm may provide a stimulus for secondary dentin formation, it is not capable of providing any type of immediate analgesia; it only diminishes irritation from the bacterial acids.

The low-intensity laser effect is well known. LILT increases the pain threshold and accelerates cell activity through biostimulation. Initially, an enhancement of the inflammation of the pulpal tissue was observed the first session (Fig 6), allowing greater production of secondary dentin by the odontoblasts in the irradiated area. This phenomenon has been shown previously in other studies.<sup>20</sup> As a consequence, since the biofilm is under professional care, the LILT probably reinforces an analgesia effect in the second session, presenting a superior behavior when compared with LEDT and placebo groups (Fig 7).





**Table 1 Number of teeth with improved or worsened hypersensitivity in each treatment session by group**

	1st session(AIR)		2nd session(AIR)		3rd session(AIR)			
	+	-	+	-	+	-		
Placebo	39	15	Placebo	19	35	Placebo	20	34
LILT	22	8	LILT	19	11	LILT	15	15
LEDT	23	12	LEDT	18	17	LEDT	12	23

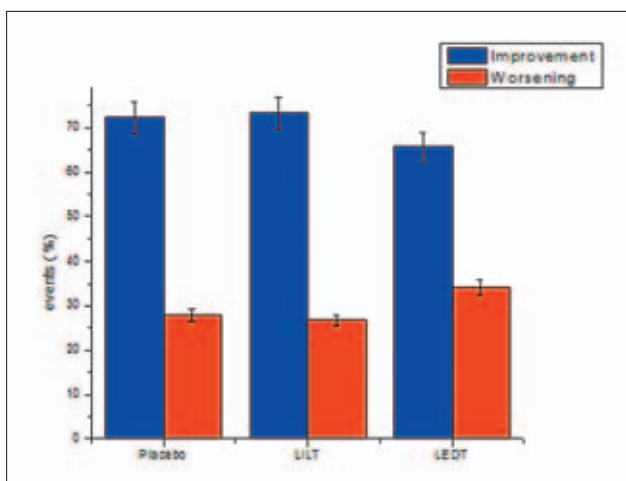


Fig 6 Results from the first session (after the treatments).

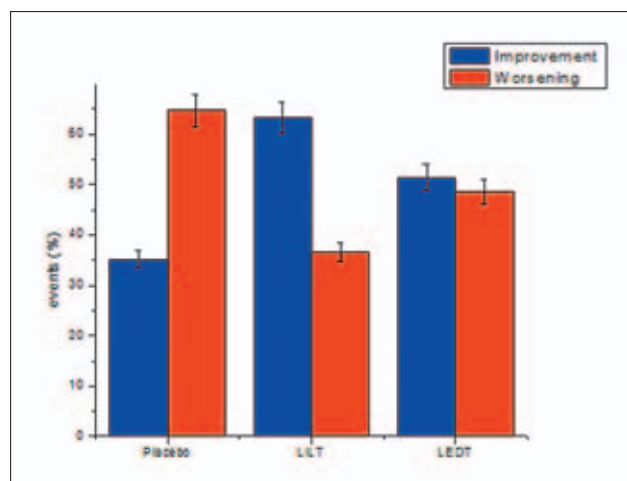


Fig 7 Results from the second session (after the treatments).

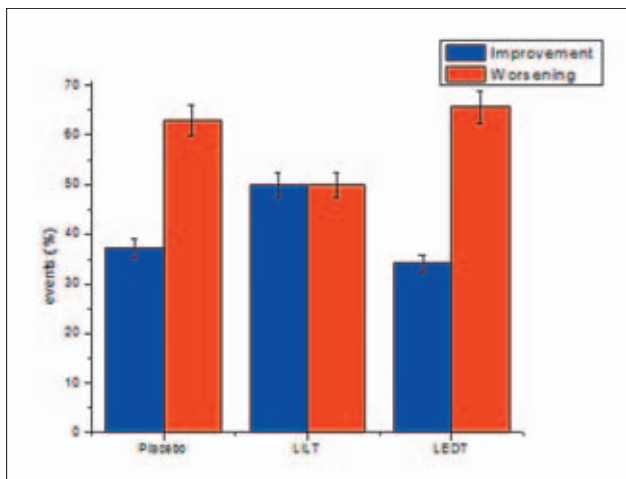


Fig 8 Results from the third session (after the treatments).

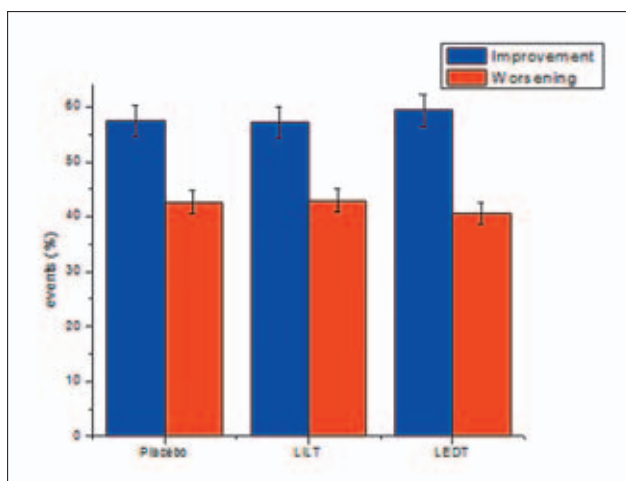
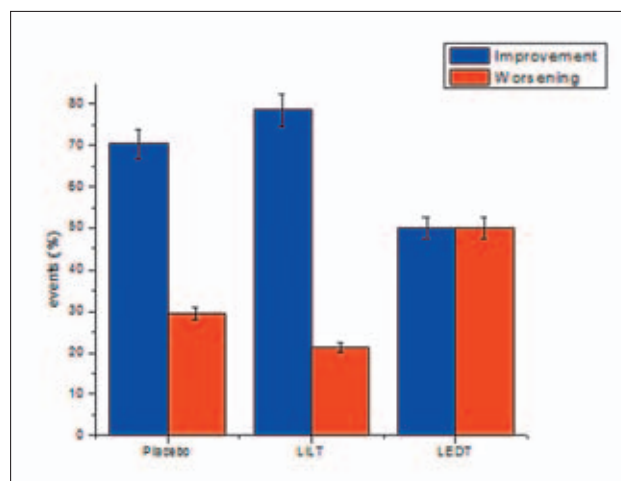
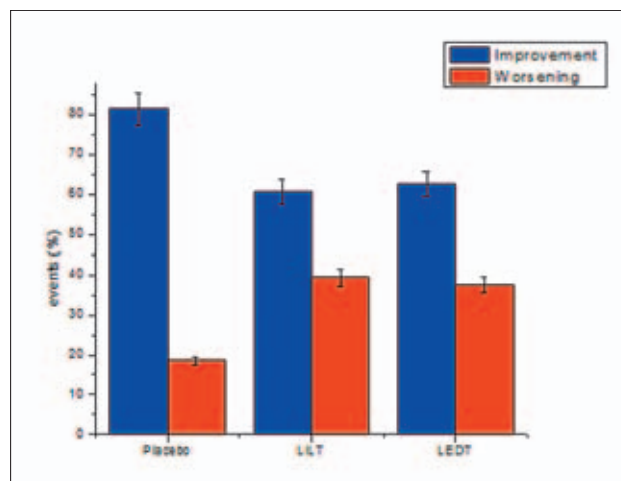
However, if the cervical area is exposed to aggressive stimuli which lead to painful sensitivity, the inflammation process will be restarted as a normal physiological response. The aim is to understand the duration of the irradiation effect, until a new inflammatory event is initiated.

In contrast to other studies in the literature,<sup>8,14-17</sup> the interval between the treatment sessions was 7 days. That might have influenced in the final result in terms of secondary dentin formation. The time between treatment sessions should be less than 1 week, probably around 3 days.

**Table 2** Number of teeth with improved or worsened hypersensitivity at each follow-up session by group

	15 days (AIR)		30 days (AIR)		60 days (AIR)	
	+	-	+	-	+	-
Placebo	31	22	38	15	44	9
LILT	16	12	22	6	17	11
LEDT	19	13	16	16	20	12

No significant difference was observed among the three groups with air blast test in the 15-, 30-, and 60-day follow-up sessions, also shown in Figs 9 to 11.

**Fig 9** Results from the 15-day follow-up.**Fig 10** Results from the 30-day follow-up.**Fig 11** Results from the 60-day follow-up.

It was clear at the third session that the LILT could be discontinued once it no longer showed any influence. The LEDT was not effective at that point (Figs 7 and 8), which may seem to considerably worsen the clinical status (Figs 8 and 11). Because of the light-wave conducting crystalline nature of teeth,<sup>21</sup> it is likely that

LED irradiation with 230 mW average power (with associated heat generation) reached the pulpal tissue without significant attenuation, causing pain and discomfort. Thus, these phenomena may have worsened the pulpal tissue inflammation, over-irritating it and hindering the tissue healing process. Therefore, any light

source used for treating dentin hypersensitivity should optimally be similar to the LILT used in the present study and not generate heat, which promotes pulpal irritation.

The systemic effect of the low-intensity laser therapy might have influenced the results of the placebo and LEDT groups. This means that it would be better if each treatment were done in a separate patient or on different schedules in order to avoid biasing results for each type of treatment.

## CONCLUSIONS

The model used and the parameters applied in the present study suggest that the LILT system was the most effective treatment for cervical dentin hypersensitivity. More studies are needed to prove to real effectiveness of LEDT of dentin hypersensitivity.

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