LASER THERAPY IN THE TREATMENT OF DENTAL HYPERSENSITIVITY ~A Histologic Study And Clinical Application

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Dentinal hypersensitivity has been studied for several years. It is reported as a strikingly painful condition that originates from the exposure of dentinal tubuli when the thickness of the enamel or cement is significantly reduced. Usually the exposed area is subjected to several kinds of stimuli, resulting in sharp acute pain. The aim of this study was to evaluate the efficacy of low level laser therapy (LLLT) in the treatment of patients with dentinal hypersensitivity. A total of 1102 teeth of 388 patients were treated with LLLT between 1995-2000. Ninety-eight males and 290 females aged 30 to 45 years old were treated. For LLLT, a 780nm continuous wave diode laser was used at an output of 40mW, elliptical area of the beam, 2mm^2, and exposure time per point of 25s. This corresponds to an equivalent dose of 50 J/cm^2 at each point (considering the area of the spot). If a 1 cm^2 area is considered, the total dose per tooth was 4J/cm^2. With the 830nm CW 50mW diode laser, the elliptical area of the beam was 2mm^2, and exposure time per point was 20s. This corresponds to an equivalent dose of 50J/cm^2 at each point (considering the area of the spot). If a 1cm^2 area is considered, the total dose per tooth was 4J/cm^2. The results showed 403 (36.57%) out of 1102 teeth required a single session for complete remission of the symptom, 255 (23.14%) needed two sessions; 182 (16.51 %) three sessions; 107 (9.7%) four sessions; and 59 (5.35%) five sessions. Ninety-six (8.71%) did not respond to LLLT and the patients were re-assessed and treatment changed. The more affected tooth was the lower premolar (301 - 27.4%), followed by lower molars (163 - 14.8%), upper premolar (149 - 13.5%), lower incisive (148 - 13.4%), upper canine (119 - 10.7%), upper incisive (108 - 9.9%), lower canine (62 - 5.6%), and upper molars (52 - 4.7%). The result of the present investigation demonstrates that LLLT, when used with the correct irradiation parameters, is effective in treating dentinal hypersensitivity, as it quickly reduces pain and maintains a prolonged pain-free status in 91.27% of the cases. Previous studies carried out by the authors examined the histological reaction of the dentinal pulp in rats after application of LLLT. The LLLT was shown to be effective in stimulating odontoblasts, producing repaired dentine and closing dentine tubuli.

KEY WORDS: Dental Hypersensitivity , Laser therapy, LLLT

Introduction

Dentinal hypersensitivity has been studied for several years and it is reported as a painful condition that originates from the exposure of dentinal tubuli when the thickness of the enamel or cement is significantly reduced. Usually the exposed area is subjected to several kinds of stimuli, resulting in sharp acute pain. This painful condition makes eating and oral hygiene very difficult. [30]

LLLT has been shown to have anti-inflammatory, analgesic and cellular effects in both hyperemic and inflammation of the dental pulp. The awareness of the disease and the use of correct parameters of LLLT are essential for the success of treatment. Amongst the several types of pain of dental origin, this condition is the most common. It has a high prevalence rate among patients that are 30 to 45 years old, and it occurs even among patients with outstanding oral hygiene.[10,16,24]. There are several reports on how healthy teeth or the presence of a gingival retraction or small abrasion predispose this condition. Several authors believe that the presence of inter-dentinal nervous fibers (18.000 to 40.000 tubes per mm^2) which are exposed to the oral environment and susceptible to local stimuli is what causes the symptoms. [21,29] (Fig. 1).

Both animal and human studies of the innervation of teeth have established a relationship between sensitivity and dentin tubuli exposure. Reducing the number of open tubuli or decreasing their diameter would, therefore, be an objective of treatment for sensitive teeth. [1,9,19,21].

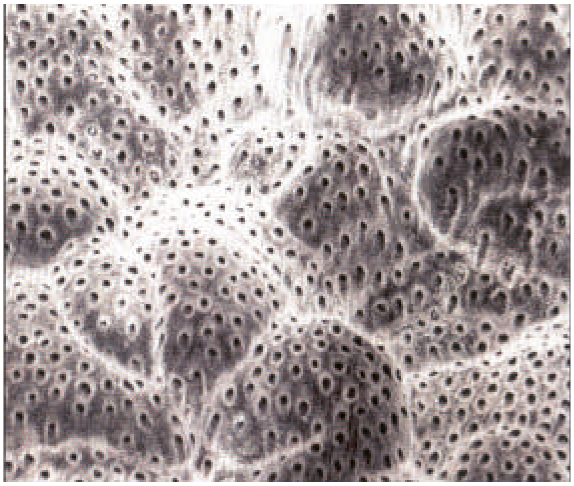

Figure1. *Human tooth, shows numerous canaliculi of dentin tubuli. X 900. (Courtesy of Prof I. Watanabe. Scanning Eletron Microscopy atlas of cells and tissue of the oral cavity, 1988)*

On the other hand Brannstrom et al [3], proposed a hydrodynamic theory to explain the mechanism of hypersensitivity associated with exposed dentine. The hypothesis is that movement of fluid in the dentine tubuli is capable of stimulating pulp nerve tissue. Consequently, root surface areas with an increased number of exposed (or open) dentine tubuli should have an increased potential for dentine fluid flow, hence dentinal hypersensitivity.

The Brännstrom theory [4] assumes that other mechanisms, e. g. psychological stress and neurological conditions, and morphological changes, may predispose the disease.[3,4,8,19,20]. The Brännströn [3,4,5] theory is more widely accepted by researchers. Brugnera Jr. [5] classifies the main causes of hypersensitivity as: 1) mechanical - caused by scaling; oral habits and abrasion 2) thermal - sudden temperature changes, especially cold stimulation 3) chemical, caused by dehydrating agents such as sugar or salt and bacterial products 4) Barotrauma or Barostress, i.e., dental pain originating from pressure variations, e.g., aboard airplanes and submarines and 5) Abfraction - Oclusal hyperfunction or parafunction which may promote disruption of apatite crystals in the cervical regions of teeth. Other authors have classified these causes differently, but because of the importance of barotrauma and abfraction as causes of dentine hypersensitivity, we feel the need to emphasize these conditions. [8,12,13,15]. Chemical treatments are most common. However, they have limited efficacy in maintaining pain control. Moreover, they require periodic application of the chemical agent. This problem prompted the authors to use LLLT as an experimental treatment of dentinal hypersensitivity.

Materials And Methods

Clinical Application

This retrospective study reports the use of LLLT on the treatment of patients suffering from dentinal hypersensitivity seen at the Laser Center of the Camilo Castelo Branco University, Sao Paulo, Brazil. A total of 1102 teeth of 388 patients were treated with LLLT (Laser Beam Company - Brazil) between 1995-2000. Ninety-eight males and 290 females aged 30 to 45 years old were treated. All personnel involved in the study were well-trained graduates. All of the procedures and applications were overseen by professors of the laser center and safety procedures were respected. [22,23]. Initial examination included an interview; assessment of the vitality of the tooth with thermal stimuli (Endo-Frost®) (Fig. 2) and soft professional dental cleaning.

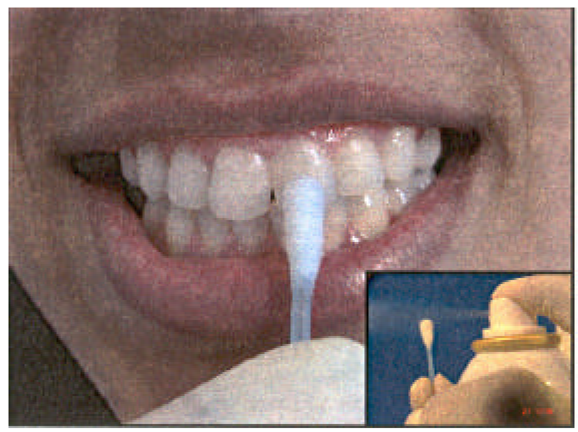

Figure2. *Assessment of the vitality of the tooth with thermal stimuli (Endo-Frost®).*

An analog visual scale was used to score pain and the tooth was then gently dried with a cotton roll before applying LLLT. LLLT was applied perpendicular to the long axis of the tooth point by point. Four points of application were chosen on each tooth. Three points on the vestibular surface of the incisor and canine teeth and one point on the lingual surface. In the premolar and molars: 2 points on the vestibular surface and 2 points on the lingual suface(Fig. 3). The pain score was again recorded as described previously and repeated 7, 14 and 28 days after the last irradiation. If the patients no longer complained of pain after the first session the irradiation was not repeated, but, they were reassessed up to 28 days after the first treatment. For LLLT, a 780nm, CW, 40mW, diode laser was used, producing an elliptical beam area of $2mm^2$. Exposure time per point was 25s. This corresponds to an equivalent dose of 50 J/cm^2 at each point (considering the area of the spot). If a $1cm^2$ area is considered, the total dose per tooth is $4J/cm^2$. With the

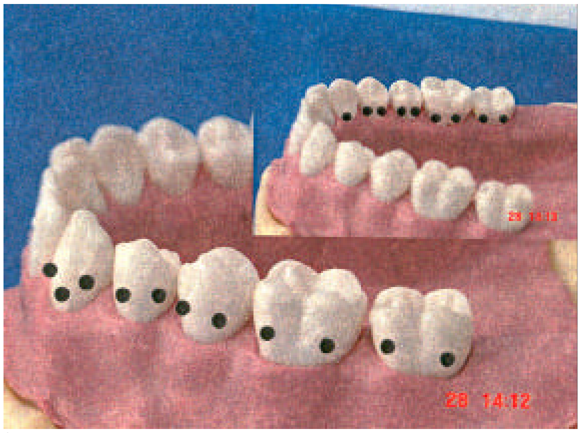

Figure3. *Four points of application were chosen in each tooth. Three points in the vestibular surface of the incisors and canine teeth and one point in the lingual surface. In the premolar and molars: 2 points in the vestibular surface and 2 points in the lingual surface.*

diode laser 830nm, CW, 50mW, the elliptical area of the beam 2mm², exposure time per point was 20s. This corresponds to an equivalent dose of 50J/cm² at each point (considering the area of the spot). If a 1cm² area is considered, the total dose per tooth is 4J/cm². (Fig. 4).

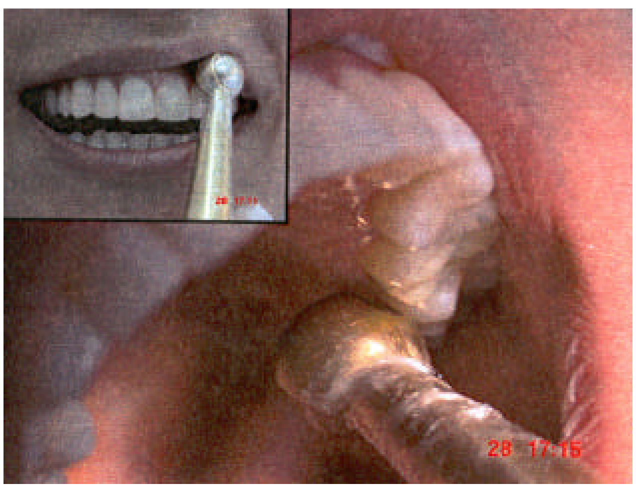

Figure 4. *LLLT applied perpendicular to the long axis of the tooth, point by point.*

Of the 1102 teeth, 58% were treated with 780nm laser, 42% with 830nm. All teeth were treated weekly at 4J/cm² as described previously. All lasers were certified and emission control was verified every 6 months.

Results

Four aspects were considered in the analysis of the results: 1) The number of sessions required for reduction of the symptoms; 2) the number of teeth treated; 3) the most affected tooth; and 4) the number of sessions needed to improve the condition. Four hundred and three (36.57%) out of 1102 required a single session for complete remission of the symptom. Two hundred and fifty-five (23.14%) needed two sessions; 182 (16.51 %) three sessions; 107 (9.7%) four sessions; and 59 (5.35%) five sessions. Ninety-six (8.71%) did not respond to LLLT and the patients were re-assessed and treatment changed. (Table 1)

Table 1 *- Number of sessions needed to reduce the symptoms (Note that 8.71% did not respond to treatment).*

Number of teeth (Total = 1102)	Percent (%)	Number of Sessions
403	36.57	1
255	23.14	2
182	16.51	3
107	9.70	4
59	5.35	5

The most affected tooth was the lower premolar (301 - 27.4%), followed by the lower molars (163 - 14.8%), upper premolar (149 - 13.5%), lower incisive (148 - 13.4%), upper canine (119 - 10.7%), upper incisive (108 - 9.9%), lower canine (62 - 5.6%), and upper molars (52 - 4.7%). (Table 2)

Table 2: *Ratio of hypersensitivity in teeth studied.*

Group of Teeth	Number of Teeth	Percent (%)
Lower premolar	301	27.4 %
Lower molars	163	14.8 %
Upper premolar	149	13.5 %
Lower incisive	148	13.4 %
Upper canine	119	10.7 %
Upper incisive	108	9.9 %
Lower canine	62	5.6 %
Upper molars	52	4.7 %
Total	1102	100 %

Histological Study

Previous studies were carried out by the authors [23] to evaluate histologically the reaction of the dentinal pulp in rats after application of LLLT. Thirty-two upper molars from albino rats with mechanically exposed dental pulps with standardized abrasion on the occlusal surface were treated with number 2 diamond burrs exposing dentinal tissues (appr. 1cm²). The parameters of laser were CW HeNe, 632.8nm, 6mW output, beam cross section 1.8mm², exposure time of 240s in scanning mode each tooth, considering an occlusal area of approximately 1cm². These were divided into 4 groups and were treated weekly. (Table 3).

The results showed that irradiated animals presented an increased production of dentine and shutting of dentinal tubuli. On the other hand, non-irradiated subjects still showed signs of intense inflammatory reaction and even necrosis at the same experimental time points. Irradiated teeth did not show cell degeneration. The LLLT was shown to be effective in the stimulation of odontoblasts, producing repaired dentine and closing dentine tubuli.[6,28] (Fig. 5).

Table 3. *Classification of groups number of applications, dose per application and days till humanely killed.*

Group	Number of treatments per tooth	Dose (J/cm²)	Days for humanely killed after irradiation
1	1	1.44	7
1C	0	0	7
2	2	1.44	7
2C	0	0	7
3	2	1.44	14
3C	0	0	14
4	3	1.44	14
4C	0	0	14

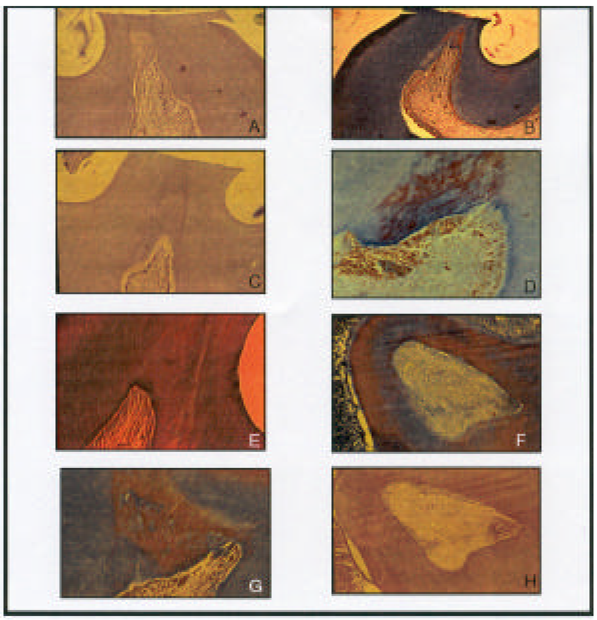

Figure 5. *The intensity of the dentin neoformation in Figures 5A, 5C, 5E, 5G. The non-irradiated side in Figure 5B and 5D showed intense inflamatory process. The non-irradiated side in Figure 5F and 5H showed an intense degeneration evolving towards necrosis.*

Discussion

There is no previous report in the literature with this number of teeth treated with LLLT. It is important to consider that only 388 (39.95%) of 972 patients referred to as suffering from dentinal hypersensitivity were properly diagnosed. Villa et al [28] evaluated histologicaly the reaction of the dentinal pulp in rats after application of LLLT. Their results showed that irradiated animals presented an increased production of dentine and shutting of dentinal tubuli. Matsumoto et al [17] carried out a histological study in monkeys (64 teeth) with exposed pulps (class V cavities). A 704nm diode laser was used, CW, 30mW, and exposure time of 30s for each tooth. Thirty-two teeth were irradiated along with controls. Histological analysis showed a significant difference between groups, the irradiated ones were considered better than the non irradiated ones. In a clinical study, the same authors used a 780nm diode Laser, 30mW, with an exposure time of 30s per tooth. They reported improvement in 85% when the irradiation was carried out directly over the dentine.

In another group, the authors irradiated the tooth in the apical region and in these cases, the efficacy was about 60%, compared to other points of application. Matsumoto et al [17] in another study, used a HeNe, CW, 6mW, and exposure time of 60s, beam cross section, 0.75mm. In 90% of the cases the treatment was considered effective when irradiation was carried out directly on the cervical area. When irradiation was carried out at other points the effect was below 60% when compared to other sites of application. Direct irradiation of the pulp wall also favors an increased proliferation of odontoblasts and consequently higher production of dentine. Aun et al [2] reported a clinical study on the treatment of dentinal hypersensitivity using an HeNe laser, CW, 6mW, beam cross section 1.8mm², with an exposure time of 4min per tooth in scanning mode on the vestibular area. Test samples consisted of 64 teeth. The patients received three applications with an interval of seven days. The average time of pain duration under cold stimulation before and after irradiation was smaller. The initial duration of 6s was reduced to about 2s immediately after the first application. After the second and third application, the average time was reduced to 1s, a six-fold decrease in value. It was also observed that between the first and second sessions (a week interval), the response time to stimuli was similar. Friedman's ANOVA showed a significant difference between the time before and after laser irradiation. These results confirmed that there was no pain between the sessions, demonstrating that improvement is long lasting.

Brugnera Jr. et al [7] have described the effect of laser therapy on hypersensitive teeth as follows: 1) Primary or immediate effect - remission of painful symptoms; and 2) secondary or late effect - intense cellular metabolic activity, proliferation of odontoblasts, production of dentine and physiologic occlusion of the dental tube. According to Wakabayashi [27], the immediate effect of LLLT is often reported by the patient immediately after treatment. There is an increase in the nerve ending threshold for pain, attributed to the maintenance of the receptor membrane potential and the suppression of the nerve ending fiber pulp potential. Kasai et al [14] justified the immediate analgesic effect as a consequence of the interruption of the nerve impulse path in the affected nerve fiber, concluding that laser acts as a reversible suppressor directly on the neuronal activity.

As Mezawa et al [18] reported, the neuro-physiological mechanism responsible for the analgesic effect of the laser treatment comes from diminished frequency of nerve ending stimuli observed in tests with electrodes on thermal nerve endings in cat tongues after irradiation with laser. LLLT interferes with transmission of peripheral nerve signals to the central nervous system, where the signals are interpreted. The maintenance of this analgesic state of the dentine comes from sealing of dentinal tubuli, which impedes the internal communication of the pulp with external oral fluids. The authors concluded that LLLT was effective in 97% of the cases. It was observed in the literature that several reports did not present all the parameters, which makes comparison even more difficult.

It has to be considered that a recent study by Sommer [26] indicates that light energy density and intensity are biologically independent irradiation parameters, suggesting that the success or failure of LLLT may be linked to the method of irradiation. Many authors have questioned if the laser light actually reached the dental pulp. Sommer et al [25] have clarified this point. These authors also observed that the light reaches the pulp without losing practically any energy, thereby clearly showing that laser light is conducted through the inter-tubular dentine and the highly orderly structure of the dentine. It is important to note that light travels parallel to the tubuli, but not through the tubuli. [11,25,26]. In Fig. 6, we show two histological studies investigating light transmission through human dentine (courtesy of Sommer) This is an important finding which adds weight and credibility to the use of laser on teeth.[11,25,26]

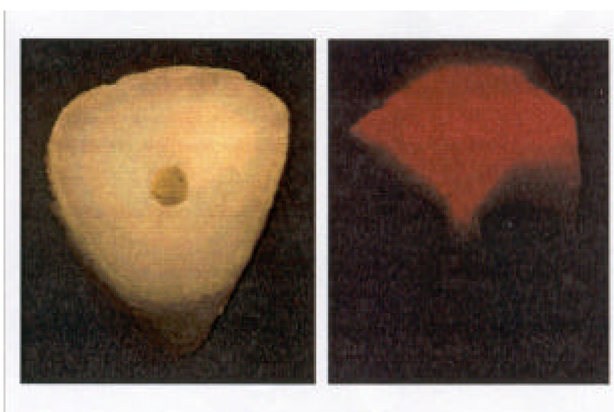

Figure 6. *Transmission of Laser Beam into the tooth - Courtesy Sommer*

Conclusion

The result of the present investigation demonstrates that LLLT, when used with the appropriate treatment parameters, is effective in treating dentinal hypersensitivity as it quickly reduces pain and maintains a prolonged pain-free status in 91.27% of the 1102 cases studied.

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