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Clinical evaluation of low-level laser therapy and fluoride varnish for treating cervical dentinal hypersensitivity

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SUMMARY **The aim of this study was to evaluate *in vivo* the use of low-level galium–aluminium–arsenide (GaAlAs) (BDP 600) laser and sodium fluoride varnish (Duraphat®) in the treatment of cervical dentine hypersensitivity. Twelve patients, with at least two sensitive teeth were selected. A total of 60 teeth were included in the trial. Prior to desensitizing treatment, dentine hypersensitivity was assessed by a thermal stimulus and patients' response to the examination was considered to be a control. The GaAlAs laser (15 mW, 4 J/cm^2) was irradiated on contact mode and fluoride varnish was applied at cervical region. The efficiency of the treatments was assessed at three examination periods: immediately after first application, 15 and 30 days after the first application. The degree of sensitivity was determined following predefined criteria. Data were submitted to analysis and no statistically significant difference was observed between fluoride varnish and laser. Considering the treatments separately, there was no significant difference for the fluoride varnish at the three examination periods, and for laser therapy, significant difference ($P < 0{\cdot}05$) was found solely between the values obtained before the treatment and 30 days after the first application. It may be concluded that both treatments may be effective in decreasing cervical dentinal hypersensitivity. Moreover, the low-level GaAlAs laser showed improved results for treating teeth with higher degree of sensitivity.**

KEYWORDS: **low-level GaAlAs laser, fluoride varnish, cervical dentine hypersensitivity**

Introduction

Dentinal hypersensitivity is characterized by short, sharp pain arising from exposed dentine in response to stimuli typically thermal, evaporative, tactile, osmotic or chemical and which cannot be ascribed to any other form of dental defect or pathology (Addy, 1990; Wichgers & Emert, 1996; Kimura *et al.*, 2000).

The protective enamel layer can be removed by attrition from occlusal wear, abfractions, parafunctional habits, abrasive tooth brushing or erosion from acidic diet. On the other hand, gingival recession, periodontal disease and also improper tooth brushing can expose root surfaces and hence the thin recovering cementum layer (with approximately 20–50 μm) is easily lost. In all these situations, the underlying sensitive dentinal tissue – containing numerous tubules with the odontoblast processes – is exposed to oral environment and subjected to a great sort of external sources of irritation. Response to these stimuli can range from mild discomfort to extreme pain (Wichgers & Emert, 1996).

Several theories have been proposed to explain the mechanism of dentinal hypersensitivity (Pashley, 1990). According to Brännström's Hydrodynamics Theory (Brännström, 1962), the most widely accepted, dentine hypersensitivity results when stimuli applied to dentine displace the fluid inside dentinal tubules inwardly or outwardly (Wichgers & Emert, 1996). Fluid movement then promotes a mechanical deformation of nerve endings at the pulp/dentine interface (odontoblastic layer and subodontoblastic extract), which is transmitted as a painful sensation. Therefore, it seems appropriate to assume that any substance or technique that reduces dentinal fluid movement or dentine permeability should decrease sensitivity (Pashley, 1986).

Considering the mechanism of action and treatment modalities, the desensitizing agents may be assigned to three main groups: the anti-inflammatory, the therapeutic tubule occlusive agents and those with effect on the depolarization of nerve endings. The products which promote partial or total closure of dentinal tubules, such as oxalates (Wichgers & Emert, 1996; Jain *et al.*, 1997), resin bonding agents (Wichgers & Emert, 1996; Li *et al.*, 2000), formulations containing potassium ions (Greenhill & Pashley, 1981; Muzzin & Johnson, 1989; Martinelli & Pereira, 2000; Orchardson & Gillam, 2000; Santiago & Pereira, 2000; Fitz, Markowitz & Napolitano, 2001) and abrasive dentifrices (Kodaka *et al.*, 2001) are the most commonly used. These agents interfere with the hydrodynamic mechanism, as they act on the exposed sensitive area so as to reduce the number of open dentinal tubules or decrease their diameter thereby minimizing the movement of dentinal fluid. The direct result is the relief of painful symptomatology.

Sodium fluoride (NaF) has also been indicated for treating dentine hypersensitivity and it is available in a variety of forms. The use of fluoridating varnishes with sodium fluoride (in high concentrations) as the active ingredient has been advocated to increase time of action of NaF in contact with exposed dentin, thus aiming to enhance its effectiveness in decreasing dentine sensitivity (Gaffar, 1999; Lan, Liu & Lin, 1999). However, the attempt to provide tubule closure or narrowing is relatively short-lived because the varnish has a gradual therapeutic action (progressive in time) and can be removed during tooth brushing, before its desensitizing effect may be achieved (Lan *et al.*, 1999).

The advent of dental lasers has raised another possible treatment option for dentinal hypersensitivity and has become a research interest in the last decades. The lasers used for the treatment of sensitive teeth may be divided in to two groups. The middle output power lasers – Nd:YAG and CO_2 lasers and the low-level lasers – helium-neon (He–Ne) and gallium–aluminum–arsenide (GaAlAs) (diode) lasers.

The low-level or 'soft' lasers provide cold thermal low energy wavelengths with little temperature increase of < 0·1 °C. These wavelengths are believed to stimulate circulation, cellular activity and to provide various effects such as anti-inflammatory, vascular, analgesic and tissue healing (Gerschman, Ruben & Gebart-Eaglemont, 1994). Additionally, several researches have reported on the effect of the low-level lasers on dentinal hypersensitivity and most studies have used GaAlAs laser therapy (Matsumoto *et al.*, 1985; Nakamura *et al.*, 1986; Fukuoka *et al.*, 1988; Wilder-Smith, 1988; Hoji, 1990; Yamaguchi *et al.*, 1990; Groth, 1993; Gerschman *et al.*, 1994; Walsh, 1997; Coleton, 1998; Kimura *et al.*, 2000).

However, review of literature shows that clinical trials have supported divergent standpoints and found different results. The need for reports on controlled *in vivo* studies with emphasis on the effectiveness of laser therapy in the treatment of cervical dentinal sensitivity is constant and well-recognized. Furthermore, it is also important to compare the efficiency of the laser systems with that of commonly used agents.

Therefore, the aim of this study was to assess, at different examination periods, the clinical performance of a low-level GaAlAs laser and a NaF varnish for treating sensitive teeth.

Material and method

The research protocol was initially submitted to appreciation of Ethics Committee of Ribeirão Preto School of Dentistry, University of São Paulo, Ribeirão Preto, Brazil. As the methodology was approved, patients of the ambulatory clinic at Ribeirão Preto School of Dentistry, University of São Paulo, complaining of cervical dentinal hypersensitivity were examined.

To participate in the trial, patients were required to present a minimal of two teeth with dentinal hypersensitivity. After detailed anamneses interview, radiographic examination and thorough visual inspection (using dental mirror, probe and carbon marker), the investigators ruled out as participants, all individuals that presented as probable aetiological factors for dentine hypersensitivity, parafunctional habits, gastric and/or emotional diseases or frequent ingestion of acidic food. Subjects whose test teeth had evidence of pulpit, carious lesions, defective restorations, facets of attrition, premature contact, cracked enamel or any other factor that could be responsible for sensitivity

Table 1. Degrees of cervical dentinal hypersensitivity

Degree	Sensitivity
0	Without significant discomfort
1	Discomfort with mild pain
2	Sharp pain solely during the application of stimulus
3	Sharp pain during the application of stimulus and continuous after its removal

complaints, were also excluded. After careful evaluation, 12 individuals of both sexes, ranging from 20 to 30 years of age were selected, with a total of 60 test teeth.

Patients were required to be willing and able to return at specified study intervals for follow-up examinations. The nature and objectives of the trial, as well as the possible discomfort and risks, were fully explained and all participants signed the appropriate, approved informed consent documents.

Before the treatments were accomplished, dentine hypersensitivity was assessed by a thermal stimulus and patients' response to this stimulation was considered to be a control. A cold air-blast from a three-way dental syringe was directed to the exposed area for 5 s under relative isolation.

Data were standardized by scoring the teeth following the criteria proposed by Uchida *et al.* (1980), which establishes four degrees for sensitivity, depending on patient's response to stimulation (Table 1).

For each patient, half of sensitive teeth were painted with fluoride varnish and the other half were submitted to laser irradiation, which means that all subjects have been subjected to both types of desensitizing agents. Before desensitizing procedures, teeth surfaces were carefully cleaned with water/pumice slurry in dental prophylactic cups, rinsed and gently dried with absorbent paper. A relative isolation was obtained using cotton rolls and teeth were kept free from humidity with the aid of a high potency saliva ejector.

Laser source (BDP 660)* was a low-level GaAlAs semiconductor diode laser doped with In, emitting a 660 nm wavelength in the infrared spectrum. It consists of a class IIIb laser system (Makinson, 1986) with continuous wave and adjustable output energy ranging from 1 to 30 mW, when measured at the level of the diode laser itself, as the final useable output (from the handpiece) will be less because of losses in the delivery system. The area of the active tip is 3.6 mm^2 and the handpiece is constituted by an optical fibres network.

The sensitive teeth were irradiated on contact mode with the following parameters: 15 mW output power and 4 J cm^{-2} energy density. Laser beam was directed perpendicularly to tooth surface at three points: one apical and two cervical points (one mesio-buccal and one disto-buccal). Each area was irradiated for 10 s (total of 30 s per tooth).

Laser therapy was performed within five sequential appointments with a 72-h interval between each one, as suggested by Groth (1993).

For teeth treated by NaF varnish (Duraphat)†, five applications with a 5-day interval between each one were accomplished. The varnish was painted with a disposable brush at cervical region of both buccal and lingual surfaces. The patients were instructed not to eat for 1 h following varnish application and to re-initiate tooth brushing solely after 12 h, thus enhancing the interaction of fluoride with tooth structure.

The effectiveness of both therapies was assessed (by scoring patients' response to thermal stimulation, following the predefined criteria) at three examination periods: immediately after the first application of the desensitizing agent, 15 and 30 days after the first application.

Data obtained were submitted to statistical analysis using Friedman test ($P < 0{\cdot}05$).

Results

Comparing the desensitizing treatments, the statistical analysis of data revealed no significant difference between laser irradiation and fluoride varnish. Considering the therapies separately, no difference was observed for fluoride varnish at the three examination periods. However, there was statistically significant difference ($P < 0{\cdot}05$) between the values obtained before the treatment was initiated (both varnish and laser) and those registered 30 days after the first application of GaAlAs laser.

The analysis of laser results showed that prior to desensitizing therapy, all test teeth presented cervical dentinal hypersensitivity, at different degrees (Table 2). Immediately after the first application, 13 teeth showed no significant discomfort (degree 0) and no tooth

*MM Optics LTDA, São Carlos, SP Brasil 13560-010.

†Duraphat® – Inpharma A.S., Drammen Norway, Germany, 9801165.

Degree	Before treatment	Immediately after the first application	15 days after the first application	30 days after the first application
0	0	13	18	16
1	10	8	6	12
2	13	9	6	2
3	7	0	0	0

Table 2. GaAlAs low-level laser therapy. Degree of dentine sensitivity at three examination periods

presented sharp pain during thermal stimulation and continuous discomfort after the removal of stimulus (degree 3). At the second evaluation (15 days after the first application), there was an observed increase in the number of teeth with no report of significant discomfort (degree 0). Thirty days after the treatment was initiated, little decline in the relief/absence of painful symptomatology was noticed. However, no tooth showed recurrent sensitivity at degree 3.

The results of fluoride varnish treatment also disclosed that before desensitizing therapy, all test teeth presented dentinal hypersensitivity, at different degrees (Table 3). Immediately after the first application, 11 teeth did not present significant discomfort (degree 0) and three teeth continued to presented sharp pain during cold air-blasting and even after the removal of stimulus (degree 3). Fifteen days after the first application, there was an observed increase in the number of teeth without significant discomfort (degree 0) and a decrease in the amount of teeth with the most severe degree of sensitivity. Nevertheless, at the last recall (30 days after the treatment was initiated), one tooth remained with persistent sharp pain (degree 3).

The overall analysis of scores, performed 30 days after the first application of GaAlAs laser, showed that 70% of teeth which scored 1, 54% of teeth which scored 2 and 14% of teeth which scored 3, did not present a significant discomfort. Additionally, 39% of teeth which scored 2 and 71% of teeth which scored 3 showed discomfort with mild pain, while 14% of teeth which scored 3 showed sharp pain during the application of thermal stimuli. Considering the same examination period (30-day recall), the analysis of scores after fluoride varnish therapy disclosed that that 64% of teeth which scored 1, 62% of teeth which scored 2 and 17% of teeth which scored 3, showed no significant discomfort while 25% of teeth which scored 2 and 33% of teeth scored 3 showed discomfort with mild pain.

Discussion

Despite the great variety of available therapeutic methods, dentinal hypersensitivity still remains a chronic dental problem with a difficult treatment conduct and an uncertain prognostic. A possible elimination of painful symptomatology resulting from the dentine hypersensitivity mechanism, seems to be directly related to the interruption of stimuli transmission to the nerve endings of odontoblast processes by reducing the fluid movement inside the dentinal canalicules, through the narrowing or occlusion of tubules openings (Brännström, 1986). However, other treatment modalities have been proposed, such as 'soft' laser therapy.

Reduction in sensitivity to thermal and tactile stimuli has been widely reported using and He–Ne and GaAlAs lasers (Matsumoto *et al.*, 1985; Nakamura *et al.*, 1986; Yamaguchi *et al.*, 1990; Gerschman *et al.*, 1994; Walsh, 1997; Coleton, 1998; Kimura *et al.*, 2000). Accordingly, in the present investigation, laser therapy promoted a considerable decrease in sensitivity, after 30 days of the first application.

Although low-level lasers and fluoride varnishes present distinct modes of action, in the present study both treatments provided a significant overall relief in

Degree	Before treatment	Immediately after the first application	15 days after the first application	30 days after the first application
0	0	11	15	16
1	11	6	8	9
2	13	10	5	4
3	6	3	2	1

Table 3. Sodium fluoride varnish (Duraphat®) therapy. Degree of dentine sensitivity at three examination periods

dentine hypersensitivity (particularly for the sharpest pains) and showed similar performance.

In the conducted research, it was observed that teeth, which presented exacerbated sharp pain during air-blasting and continuous discomfort after the removal of thermal stimulation before desensitizing treatments were accomplished, showed an accentuated decrease of painful sensation immediately after the first application of low-level laser and even 1 month after initial irradiation. On the contrary, the fluoride varnish provided a gradual decrease in sharp pain and, one patient reported the persistence of painful symptoms (sensitivity) at the 30-day recall.

The gradual action of NaF varnish may be attributed to the reaction that occurs between NaF and calcium ions of dentinal fluid and that leads to formation of calcium fluoride (CaF_2) crystals, which are deposited on the dentinal tubules openings. As the crystal size of CaF_2 is small (about 0·05 micrometers), a single application of NaF would not be effective in narrowing the diameter of dentinal tubules and multiple applications should be required. Also, the patency of sensitive dentine interferes with the action of therapeutic tubule occlusive agents and demands a longer treatment, as the number and width of dentinal tubules in hypersensitive-exposed areas have been shown to be higher than in normal dentine (Absi, Addy & Adams, 1987; Liu, Lin & Lan, 1997; Lan *et al.*, 1999).

On the other hand, the effect of GaAlAs low-level laser relies upon laser-induced changes in neural transmission networks within the dental pulp (depressed nerve transmission), rather than alterations in the exposed dentine surface, as observed with other treatment modalities (Walsh, 1997). The faster desensitizing effect of laser therapy observed in the conducted research may be attributed to that mechanism. Moreover, besides the immediate analgesic effect, the laser therapy – if used within the correct parameters – may stimulate the normal physiological cellular functions. Therefore, at subsequent appointments, the pulpal tissue would be less injured and inflamed and the laser would stimulate the production of sclerotic dentin, thus promoting the internal obliteration of dentinal tubules.

Studies on other laser systems (Liu *et al.*, 1997; Lan *et al.*, 1999; Kimura *et al.*, 2000) showed that the mode of action and the effects on dentine hypersensitivity therapy are different for each type of laser. The morphological analysis of dentine surface using scanning electron microscopy revealed that Nd:YAG laser irradiation causes melting and fusion of dentine and therefore the closure of exposed dentinal tubules (Lan & Liu, 1995). The combined effect of Nd:YAG laser irradiation and sodium fluoride varnish on dentine hypersensitivity was also investigated and the closure of 90% of dentinal tubules was observed. The use of fluoride varnish alone resulted in partially opened dentinal tubules and it was noticed the removal of desensitizing agent during tooth brushing was noticed (Lan *et al.*, 1999).

Regardless of the method and materials employed, the evaluation of treatments for dentine hypersensitivity is not simple. In estimating treatment effects on hypersensitive teeth, investigations may be handicapped by a the difficulty to assess patient's response objectively and are dependent upon the patient's interpretation, which is in turn subjected to suggestion.

Furthermore, placebo effect has been described in clinical dentine hypersensitivity trials (Wilder-Smith, 1988). In the present investigation, the possibility of a placebo effect must also be taken into account, especially as patients' reports were strongly positive immediately after the first application of GaAlAs laser, whereas normally one would expect the cumulative effect of any therapy to provide a gradual lessening of painful sensation from visit to visit. However, it must be emphasized that for teeth on which laser therapy was accomplished, a considerable decrease in sensitivity was observed at the second evaluation (15 days after the first application) and a continued desensitizing effect was noticed at the last recall.

Indeed, the desensitizing agents provide a significant relief in sharp painful symptomatology and can be reapplied, in case of recurrent discomfort, as they consist of non-invasive methods. Nevertheless, the ideal treatment technique, one which should not irritate the pulp, nor cause pain, should be easy and practical to perform, effective for a long period, as well as accessible to the great majority of population, is still to be developed.

There is a need for a more systematic approach to the clinical management of cervical dentine hypersensitivity, particularly in determining the long-tem effect of the currently available desensitizing agents. For more effective treatment, further investigation is required to increase the understanding of the mechanisms and aetiology of dentinal pain. The findings revealed by both laboratory and clinical research are extremely important to support the development or improvement of therapies that may acutely contribute to the treatment of dentinal hypersensitivity sufferers.

Conclusions

Based on the findings of this clinical evaluation, it may be concluded that low-level GaAlAs laser and NaF varnish showed similar overall performance and provided a decrease in cervical dentine hypersensitivity.

Low-level laser showed improved results for treating teeth with higher degree of sensitivity.

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