UNIVERSIDADE DE SÃO PAULO

FACULDADE DE ODONTOLOGIA DE BAURU

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Clinical evaluation of the effect of diode Laser irradiation on exposed roots, associated or not with fluoride varnish, in the control of dentin hypersensitivity and its impact on quality of life: A randomized controlled clinical trial.

Avaliação clínica do efeito da irradiação com Laser de diodo sobre raízes expostas, associados ou não ao verniz fluoretado, no controle da hipersensibilidade dentinária e seu impacto na qualidade de vida: Estudo clínico controlado randomizado.

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Orientador: Prof. Dr. Sérgio Kiyoshi Ishikiriama

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Dedico a minha tese de doutorado à minha família.

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ABSTRACT

Clinical evaluation of the effect of diode Laser irradiation on exposed roots, associated or not with fluoride varnish, in the control of dentin hypersensitivity and its impact on quality of life: A randomized controlled clinical trial.

This study aimed to present two papers that show the effect of diode Laser irradiation, associated or not with fluoride varnish treatments to control dentin hypersensitivity (DH) and its impact on quality of life. The first study aimed to evaluate the pain response (VAS) to evaporative stimuli on exposed roots before and after treatment with 3 different protocols (fluoride varnish, diode Laser irradiation, and the combination of these two) through 180 days of control (measured immediately and after 7, 30 and 180 days of the treatment). The sample was composed of 57 patients with DH on exposed roots that were divided in 3 groups for the different treatments. The statistical analysis was obtained through a two-way ANOVA for repeated measures ($p<0,05$). The second study aimed to evaluate the impact of the same 3 treatments on quality of life through the DHEQ-15 questionnaire. The sample and group distribution was the same as the first study, however, the variable response was obtained only before and 180 days after each treatment. The statistical analysis was obtained through Kruskal-Wallis test for comparison between groups and Wilcoxon test for comparison before and after treatment within each group. ($p<0,05$) The results showed that the 3 treatment protocols were effective up to 30 days, but only the Laser groups showed reduced pain response at 180 days evaluation. The varnish alone group had higher pain values at every control from day 7 onwards. All 3 treatments provided an improve in quality of life, but with no difference between them. This study showed that Laser irradiation may be a safe, efficient, and long-lasting treatment for DH and it may also improve the patients' quality of life.

Keywords: Dentin Sensitivity. Lasers. Fluorides. Quality of Life

RESUMO

Avaliação clínica do efeito da irradiação com Laser de diodo sobre raízes expostas, associados ou não ao verniz fluoretado, no controle da hipersensibilidade dentinária e seu impacto na qualidade de vida: Estudo clínico controlado randomizado.

O propósito deste estudo foi apresentar dois artigos que mostram o efeito do tratamento de irradiação com Laser de diodo, associado ou não a verniz fluoretado para controle da hipersensibilidade dentinária (HD) e seu impacto na qualidade de vida. O primeiro estudo foi proposto para avaliar a reposta dolorosa (VAS) a estímulos evaporativos em raízes expostas antes e após o tratamento em 3 diferentes protocolos (verniz fluoretado, irradiação com Laser de diodo e a combinação dessas duas técnicas) durante 180 dias de controle (medidos imediatamente e após 7, 30 e 180 dias do tratamento). A amostra foi composta de 57 pacientes com HD em raízes expostas e foram divididos e 3 grupos dos diferentes tratamentos. A análise estatística foi obtida através do teste ANOVA a dois critérios para medidas repetidas ($p<0,05$). O segundo estudo foi proposto para avaliar o impacto desses mesmos 3 tratamentos na qualidade de vida, mensurada através do questionário DHEQ-15. A amostra e distribuição de grupos foi a mesma do primeiro estudo, entretanto, a variável resposta foi obtida somente antes e 180 dias após os tratamentos. A análise estatística foi realizada através dos testes de Kruskal-Wallis para comparação entre grupos e Wilcoxon para comparação entre antes e após tratamentos dentro de cada grupo ($p<0,05$). Os resultados mostraram que os 3 protocolos de tratamento foram eficazes até o controle de 30 dias, porém somente os grupos com irradiação com Laser mantiveram sua eficácia até o controle de 180 dias. O grupo de tratamento com somente verniz apresentou maiores valores de dor a partir do 7º dia em diante. Todos os 3 tratamentos proporcionaram melhora na qualidade de vida, sem diferença estatística entre eles. Este estudo mostrou que a irradiação com Laser de diodo pode ser uma solução segura, eficiente e duradoura no tratamento da HD além de melhorar a qualidade de vida dos pacientes.

Palavras-chave: Hipersensibilidade da Dentina. Lasers. Flúor. Qualidade de Vida.

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1 Introduction

1 INTRODUCTION

Dentin hypersensivity (DH) is a common oral condition with multifactorial etiology oftenly described as a short lasting intense pain on the teeth commonly in response to thermal (hot or cold), chemical (acidic fruits, spicy foods, sugar and salt), mechanical (brushing) and/or evaporative (air jets) stimulus applied on clinically exposed dentin. Technically to be considered DH it cannot be attributed to any other defect or pathology (GILLAM et al., 1999). Many theories were created to explain the occurrence mechanism of this pain and the most widely accepted theory is the Hydrodynamic or Fluid Movement theory that states a fluid movement inside dentinal tubules caused by stimuli on the teeth that trigger mechanoreceptors on the pulp resulting in the perception of pain (BRANNSTROM et al., 1967).

Although there are many therapies described for the treatment of DH, there is no substance or treatment that effectively eliminates the painful sensation and does not relapse (NAYLOR et al., 2006). This relapse occurs due to the multifactorial characteristic of DH and its causal factors (abrasion, erosion, dental malformations, periodontal treatments and iatrogenesis) (TORRES et al., 2014) Several studies seek to evaluate the DH control over several periods of time, in order to attest to the longevity of treatments (BIRANG et al., 2007; DILSIZ et al., 2010; YILMAZ et al., 2011; UMBERTO et al., 2012), but no definitive treatment has been described yet. Blocking the dentinal tubules opening is a common way to prevent the stimuli for even reach and cause fluid to move and can be done with many techniques such as proteins and particles precipitation, occlusion with

restorative materials, high power Laser irradiation and even gingival surgery to cover the exposed root dentin (MIGLANI et al., 2010). Another approach that can be done is desensitizing the nerve endings inside the pulp to avoid triggering the electric impulse that will be perceived as pain. It may be achieved with the use of some potassium-containing products or the bio-modulator effect of low power Lasers (SCHMIDLIN and SAHRMANN, 2013)

Therapy with high-power Lasers seek the physical obliteration of open dentinal tubules as a primary effect, and depending on the parameters used, “dentin melting” may occur due to the increase in the superficial temperature during irradiation, with consequent obliteration and disorganization of the dentin surface (LIN et al., 2001; BERGMANS et al., 2006). Seeking a better clinical result, some authors have studied the association of fluoride varnishes with Laser irradiation, in order to increase the interaction of the Laser with the dentin surface and obtain greater and long lasting tubule obliteration. This association has shown more effective results than just one of the treatments performed alone (UMBERTO et al., 2012; GERALDO-MARTINS et al., 2013).

A previous study was conducted with the objective of studying, in vitro, the effects of a 980nm Laser irradiation, associated or not with a fluoride varnish, on dentin permeability. The results obtained were quite satisfactory, with a significant reduction in dentin permeability, especially when the irradiation was performed at a higher power (0.7 and 1W) and associated with fluoride varnish (RIZZANTE et al., 2016). This reduction in permeability is desired and is expected to be clinically associated with a reduction in the symptoms of DH.

Another important factor related to DH that justifies the patients search for effective and long-lasting treatments is related to the impact of this acute pain on their wellbeing. A new definition of Oral Health states that it is multifaceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expressions with confidence and without pain, discomfort, and disease of the craniofacial complex (HESCOT, 2017). Thus, a clinician should not only restore oral function, but know, understand, and support the wellbeing of the patient, considering the important relation between oral health and quality of life (QoL).

Although there are few studies on the effects of DH on quality of life (BEKES and HIRSCH, 2013), most patients seeking treatment for DH reported substantial impact on their QoL regarding their habits of eating, drinking, and oral hygiene (BEKES et al., 2009). However, the long-term impact of DH on the QoL of treated patients remains unclear (GOH et al., 2016).

Therefore, this study aims to clinically evaluate the efficacy of 980nm diode Laser irradiation on exposed roots in the treatment of DH, in the short and long term, as well as the association between irradiation and the application of fluoride varnish and its impact on the QoL before and after DH treatments.

2 Articles

2 ARTICLES

• ARTICLE 1 – Effect of diode Laser irradiation on exposed roots, associated or not with fluoride varnish, to control dentin hypersensitivity: Randomized controlled clinical trial.

• ARTICLE 2 – Evaluation of the impact of dentin hypersensitivity treatment on quality of life through DHEQ-15 method: a random clinical study.

The articles presented in this thesis were written according to the Journal of Periodontology and Journal of Clinical Periodontology instructions and guidelines for article submission respectively.

2.1 ARTICLE 1

Effect of diode Laser irradiation on exposed roots, associated or not with fluoride varnish, to control dentin hypersensitivity: Randomized controlled clinical trial

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Short Tittle: Laser and fluoride varnish to control dentin hypersensitivity

Key findings: Diode Laser irradiation is an efficient method to control dentin hypersensitivity

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Abstract

Background: Dentin hypersensitivity (DH) is a multifactorial clinical condition characterized by acute painful response to external stimuli in areas where dentin is clinically exposed. Its treatment is complex, and there is no fully effective control protocol to date. The objective of this study was to evaluate the effectiveness of 980nm diode Laser irradiation, associated or not with fluoride varnish, on clinically exposed dentin, to reduce the DH.

Methods: 57 patients with gingival recession and sensitivity were selected and the exposed roots treated according to three different protocols (irradiation with 0.8W diode Laser; 0.8W diode Laser irradiation over fluoride varnish or just fluoride varnish). The diode Laser was irradiated on the exposed roots at a 10 Hz frequency, with energy density standardized at 99.17J/cm^2. DH assessment was performed using the visual analogue scale (VAS) scale, prior to treatment, immediately, 7, 30 and 180 days after treatment. The data obtained were subjected to the analysis of variance (ANOVA) with 2 criteria for repeated measures ($p < 0.05$).

Results: The varnish group showed a reduction in DH up to the 30-day control, whereas the Laser and Laser + varnish groups showed a reduction in DH up to the 180-day control and showed no difference between them. The Laser and Laser + varnish groups were superior to the varnish group after the 30-day control.

Conclusion: The irradiation of exposed roots with diode Laser alone or associated with fluoride varnish, in the parameters used in this study, was effective in reducing DH up to six months.

Keywords: Dentin Sensitivity; Lasers; Fluorides, Topical

Introduction

Dentin Hypersensitivity (DH) is a clinical condition with multifactorial etiology and can be described as an acute painful response to thermal (hot or cold), chemical (acidic fruits, spicy foods, sugar and salt), mechanical (brushing) and evaporative (air jets stimuli) applied on exposed dentin, due to the presence of open dentinal tubules[1,2,3]. Prevalence studies have shown that DH affects 11.5% of individuals on average, but that in certain populations it can present a percentage of up to 92.1%[4]. The most widely accepted theory is the Hydrodynamic or Fluid Movement theory that states a fluid movement inside dentinal tubules caused by stimuli on the teeth that trigger mechanoreceptors on the pulp resulting in the perception of pain[5]. This theory underlies most available treatments.

Although there are many therapies described for the treatment of DH, there is no substance or treatment that effectively eliminates the painful sensation and does not relapse[6]. This relapse occurs due to the multifactorial characteristic of DH and its etiological factors (abrasion, erosion, dental malformations, periodontal treatments and iatrogenesis)[7]. Several studies seek to evaluate the DH control over several periods of time, in order to attest to the longevity of treatments[8,9,10,11,12], but no definitive treatment has been described yet.

Therapy with high-intensity Lasers seek the physical obliteration of open dentinal tubules as a primary effect, and depending on the parameters used, “dentin melting” may occur due to the increase in temperature during irradiation, with consequent obliteration and disorganization of the dentin surface[13,14]. Seeking a better clinical result, some authors have studied the association of fluoride varnishes with Laser irradiation, in order to increase the interaction of the

Laser with the dentin surface and obtain greater and long lasting tubule obliteration. This association has shown more effective results than just one of the treatments performed alone[11,15].

A previous study was conducted with the objective of studying, in vitro, the effects of a 980nm Laser irradiation, associated or not with a fluoride varnish, on dentin permeability. The results obtained were quite satisfactory, with a significant reduction in dentin permeability, especially when the irradiation was performed at a higher power (0.7 and 1W) and associated with fluoride varnish[16]. This reduction in permeability is desired and is expected to be clinically associated with a reduction in the symptoms of DH.

Therefore, this study aims to clinically evaluate the efficacy of 980nm diode Laser irradiation on exposed roots, in the treatment of DH, in the short and long term, as well as the association between irradiation and the application of fluoride varnish. The null hypothesis tested were: 1) There will be no difference in the reduction of DH at the different evaluation times; and 2) There will be no difference in the reduction of DH, considering the different treatments.

Materials and Methods

Experimental design

This study used a 3x5 factorial design having as study factors the treatment technique in three levels (fluoride varnish, Laser irradiation and fluoride varnish + Laser irradiation); and the control time (before treatment, immediately after treatment, 1 week, 1 month and 6 months after treatment). The response variable was the pain intensity after evaporative stimulus measured through a Visual Analogue Scale (VAS).

Sample size

With an expected standard deviation of 1,4[17] and a minimum detectable difference in means of 1,5, three groups with 19 subjects each would achieve a test power of 84% with alpha of 0,05.

Clinical trial registration and research ethics committee

This clinical trial is registered at ReBEC by the number RBR-7q7gyd, UTN code U1111-1254-9691

This study project was submitted to the research ethics committee of Bauru School of Dentistry - University of São Paulo (FOB/USP) and approved under the CAAE: 49808715.5.0000.5417.

Selection of volunteers

The patients were selected by a previously calibrated operator who selected a total of 57 patients with gingival recession (ages between 18-50), of both genders, following the inclusion and exclusion criteria described below. The

volunteers were evaluated in the Clinical Research Center of the Bauru School of Dentistry, University of São Paulo (FOB-USP) and the proposed treatments and post-operative controls were carried out in the same place.

Inclusion criteria

Subjects of both genders, aged between 18 and 50 years;

- Present at least 1 tooth with an exposed root with dentin sensitivity greater than 3 on the Visual Analogue Scale (VAS), measured after evaporative stimulus (air jet at 1 cm from the root surface for 3 seconds);

- Present gingival recession only on the buccal surface, Miller´s[18] class I or II, that is, without root exposure on the interproximal surfaces, with an extension between 2 and 5 mm.

Exclusion criteria

- Active caries lesions in any tooth;

- Make chronic use of medications with analgesic, anti-inflammatory or drugs with central effect (anxiolytics and antidepressants);

- Be under psychological counseling;

- Make use of desensitizing agents (at home) in the last 3 months or in the office (6 months);

- Pregnancy;

- Allergy to any of the treatment components;

- Being under orthodontic treatment;

- Presence of removable or fixed prosthesis in the teeth under analysis;

- Presence of Miller's class III and IV recessions;

- Patients with active periodontal disease;

- Recession on the palatal and / or proximal surfaces;

- Presence of a furcation lesion in the selected teeth;

- Daily use of mouthwashes (fluoride).

- Presence of deep, non-carious cervical lesions that need root restoration.

To identify the baseline dentinal sensitivity of each patient, the most sensible tooth was selected and isolated from the others with cotton rolls and an evaporative stimulus (air jet) was applied by the same operator on the clinically exposed root, to guarantee the standardization of the tests[19,20,21,11].

An air jet was used, with the aid of a triple syringe directed perpendicularly to the cervical area with dentin exposure, at a distance of 1 cm, for 3 seconds. Immediately after removing the stimulus, patients reported the pain intensity on the Visual Analogue Scale (VAS)[22] as shown in Figure 1. The subject should mark a trace on a 10cm line regarding the pain where the left end represented absolutely no discomfort and the right end represented the worst pain imaginable. The line was measured from the left end to the trace marked to obtain a VAS value.

All patients underwent dental prophylaxis with a prophylaxis rubber cup and fluoride-free toothpaste prior to treatment.

Sample randomization

The 57 patients were randomized to three study groups. Two factors were considered: size of the recession (area) and intensity of pain when exposed to the evaporative stimulus. Both factors were recorded in the initial examination, and patients were randomized using the Microsoft Excel program.

Treatment protocols

1) Fluoride varnish

The fluoride varnish used was Clinpro™ White Varnish (3M, Campinas, São Paulo, Brazil) which is a compound based on colorless sodium fluoride (5% concentration, 22,600 ppm of fluoride), applied with the aid of a mini Brush (Kg Sorensen, Cotia, São Paulo, Brazil) over the total area of clinically exposed dentin. The varnish was applied in a single layer on the dry dentin surface in partial isolation. Five minutes after application, the patient was instructed to moisten the region with a tongue to activate the product according to the manufacturer's instructions and avoid drinking fluids for 1 hour.

2) Diode Laser

The diode Laser used was the DClase (DC International LLC, Wellington, FL, United States), with 970nm wavelength, capable of generating a power ranging between 0.5 and 7W. With relative isolation, the Laser was irradiated over the exposed root surface through an optical fiber 200μm in diameter, in contact mode perpendicular to the root dentin, with a standardized sweeping movement in a zigzag pattern such that the Laser passes only once at each point on the tooth surface (Figure 2).

To standardize the energy density in all roots, regardless of the exposed area to be irradiated, all roots were photographed with a digital camera (Nikon 5200, ISO 100, f / 29, 1/160, Flash Twin TTL) with a periodontal probe positioned over the coronary portion of the tooth. The captured images were analyzed using the ImageJ program (National Institute of Health, USA), where it was possible to

calculate the exposed root area. The periodontal probe was used to calibrate the measurements within the program.

The irradiation parameters were: 0.8W power, with 10Hz frequency and total energy density of 99.17J/cm^2. These parameters were taken from the previous laboratory study[16] where the best results of dentin sealing were obtained with energy density of 99,17 J/cm² irradiating 1W over a surface of 0,3025 cm² during 30 seconds. To maintain the same energy density, the following formula was used to determine the irradiation time regarding the different areas of the exposed roots:

Irradiation Time = (37.5 x area) / 0.3025

3) Diode Laser + fluoride varnish

For the groups that combined the 2 treatments, the colorless fluoride varnish was applied as already described, followed by irradiation on the varnish, with the tip in contact with the root dentin. At the end of each irradiation, due to impregnation of the optical fiber tip with varnish, it was cut with a specific device.

For all three groups, soon after irradiation, the dental element was again isolated with cotton rolls and the trace on the VAS was again marked by the patient after the evaporative stimulus. This same evaluation was repeated after 7 and 30 and 180 days.

Statistical analysis

The results obtained by VAS in all evaluation times were subjected to a two-way Analysis of Variance (ANOVA) for repeated measures ($p = 0.05$).

Results

The results are described in table 1.

According to the results obtained, all treatments were effective in immediate pain relief, however some differences were observed at post-treatment controls (Table 2).

Within the Varnish group, it can be observed that there was a decrease of pain in Times 1, 7 and 30 with no statistical difference between times. However, no significant difference was observed between Time 180 and baseline. This suggests that the treatment had total recurrence after 180 days. Despite the similarity between times 30 and 180, the gradual increase of VAS values was such that it was no longer different from baseline.

For the Laser and Varnish + Laser groups, results were similar. There was significant reduction in VAS values at Time 1 and this reduction kept stable through all controls with no statistical difference between them. This suggests that the treatment maintained its effectiveness for the 180 days analyzed.

When the comparison between groups within the same Time was evaluated (Table 3), it was observed that in Time 0 and 1 the groups showed no difference between them. This shows that the stratified randomization was satisfactory since similar baseline values were found for all groups. All treatment promoted a significant immediate reduction in VAS values as showed in time 1 in comparison with baseline, without significant difference between them.

For Time 7, the Varnish group showed an increase in VAS values, although without significant differences in relation to the other groups. However, for time 30, the VAS values for the varnish group increased even more and

started to show significant differences in relation to the other groups, which remained without significant differences between them.

For time 180, the Laser and Laser + Varnish groups remained with low VAS values, with no significant differences between them. The Varnish group showed an increase in VAS values, without significant differences in relation to the control group, showing total recurrence after 180 days.

Discussion

Dentine hypersensivity (DH) is a common oral condition oftenly described as a short lasting intense pain on the teeth commonly associated with cold stimuli. However, not all exposed dentin is sensitive to stimuli. Large portions of exposed dentin may not respond to stimuli, while microscopic exposures can be extremely sensitive[23].

Its defined according to Holland et al[24] as a short and sharp pain in exposed dentin that should not be associated with any other form of dental defect or pathology, therefore its mechanisms of action must be completely related to normal dynamics of human physiology. In the present study, only patients with DH in exposed roots without the presence of any other potential pain-causing pathological agent were selected.

The three main hypotheses already disclosed about the mechanisms of pain associated with DH are: the theory of the mechanism of dentinal receptors[25], where nerve endings would extend through the dentinal tubules and would be stimulated by aggressive agents on the external surface of dentin; the theory of the odontoblastic transduction mechanism[26], where odontoblasts would act as receptor cells, through synaptic junctions with nerves; and the hydrodynamic theory[27], in which stimuli occur due to the movement of fluids inside dentinal tubules. However, the first two are not well accepted and there are studies that showed their inconsistencies[28].

The hydrodynamic theory presented by Brännström[27] in the 1960s is the most accepted today and the main treatments for DH that have been developed so far are based on its premises. Possible treatments include nerve

desensitization, protein precipitation, dentinal tubule occlusion, anti-inflammatory effects and dentin surface coverage by restoration or periodontal surgery[29].

The vast majority of strategies are based on the physical occlusion of the dentinal canaliculi: use of gels based on potassium oxalate[30], application of fluoride in high concentration[31], sealing with fluoride varnish[32], among many other forms. Another promising treatment that has also been extensively researched is the association of irradiation of different types of Laser on exposed dentin, also in search of the referred occlusion of the dentinal tubules[33] through the heating-dependent melting of the dentin surface. The clinical effectiveness evaluation of Laser irradiation was evaluated in the present study.

The Laser technology comprises a beam of light amplified through stimulated radiation emission[34] that can interact with tissues in several ways, depending on the type and parameters established in its generation. Among the most used in Dentistry are those of CO_2 (Carbon Dioxide), Nd: YAG (Neodymium - Itrium-Aluminum-Granada), Er: YAG (Erbium - Itrio-Aluminum-Granada), Er, Cr: YSGG (Erbium - Granada-Yttrium-Scandium-Gallium sensitized with chromium), GaALAS (Gallium Arsenide and Aluminum) and others of diode[35,36], each with its particularities, benefits and limitations.

CO_2 Laser, for example, has a great affinity for water, resulting in a fast removal of soft tissue and hemostasis with very shallow penetration, but it can promote destruction of hard tissues and its equipment in general is large and expensive[37]. Nd: YAG, on the other hand, is highly absorbed by pigmented tissues, which also makes it effective in surgeries that require cutting soft tissues and hemostasis, without so much damage to hard tissues, but its equipment is also generally expensive[38]. The Lasers of the Erbium family have great affinity

for hydroxyapatite and high water absorption, which makes it ideal for treatment on the surface of dental tissues, but may not be very effective in deeper tissues[39]. For dental procedures, diode Lasers (GaAs, GaAlAs) have many advantages such as the possibility of tissue incision, coagulation and hemostasis combined with the benefits of biostimulation, activation of fibroblasts and osteoblasts[40] and their equipment is more portable and has a lower cost when compared to other types.

In order to investigate efficient and easy-to-execute clinical solutions, the present study aimed to compare methods of dentin hypersensitivity treatment associated with diode Laser, precisely because of their therapeutic advantages combined with greater accessibility by dentists.

In recent years, several studies have been conducted with the objective of evaluating and comparing treatments for DH, most of which include treatment with products based on Sodium Fluoride (NaF) and Laser irradiations[10,41,42,43]. In these studies, it was possible to observe that Laser treatment proved to be effective at all times of assessment up to 3 months of follow-up, which is in accordance with the results found in the present study. Based on the results, the treatments with the diode Laser (with and without varnish) were satisfactory for the reduction of DH intensity of both in short and long time assessment. In the group with only fluoride varnish, the reduction also occurred, but with recurrence after 30 days, probably due to its removal from the root surface by the friction of toothbrush and food, in addition to the dissolution caused by the saliva.

Yilmaz et al[10] compared treatments based on NaF and diode Laser to control DH and found results similar to the present study, although NaF has been shown to be equivalent to Laser up to the 30-day control. In the present study,

this similarity occurred only until the 7-day control. Dantas et al[44] also compared treatments for DH with NaF and diode Laser, but found that treatment with fluoride varnish proved to be more efficient than that with Laser in control for up to 72 hours. This difference may be explained due to the difference in the irradiation parameters used, the energy density used in the study (4 J/cm²) was much lower than that used in the present study (99,17 J/cm²).

Bal et al[45] carried out a study comparing the treatment of DH using desensitizing toothpaste based on arginine and calcium with the treatment using diode Laser irradiation with, as well as the combination of the two treatments. Just like this study, the results obtained showed that the use of Laser alone or in conjunction with another desensitizing agent was equally effective.

Low-power Laser irradiation promotes several biochemical effects at the cellular level, such as the modulation of substances released in the phenomena of pain and inflammation, such as prostaglandins, histamine, serotonin and bradykinin, and promotes the balance of plasma pressure and anti-inflammatory action with reduction of painful symptoms[46]. Even though the present study used an energy density very close to that considered high power, considering that a large part of the irradiation energy is absorbed on the root surface, some energy may also reach deeper tissues, exerting a secondary therapeutic effect on the dental pulp with a similar effect to that of low-power Lasers, in which there is a biomodulator effect and intensification in the production of tertiary dentin[47].

Other studies sought to analyze the effectiveness of the association of Laser in high power regime for the treatment of DH. Dilsiz et al[9] compared 3 types of Laser: Er: YAG, Nd: YAG and diode Laser and found that the 3 types are effective in reducing DH, however Nd: YAG was significantly more effective than

the other types. The authors stated that light interacts with substrate in four ways: reflection; streaming; absorption and spreading, absorption being the main responsible for the tissue alterations due to the thermal process that promotes a dentinal “melting” and consequent obliteration of the tubules. The effects of transmission may also have had an important effect in reducing HD because they have potentially induced the formation of sclerotic dentin and blocked the depolarization of the afferent C-fibers of pain transmission. However, Ishikiriama et al[48] identified that Nd: YAG has a greater potential to cause damage to pulp tissue due to increase of temperature when compared to diode Laser.

Rizzante et al[16]. conducted an in-vitro study that evaluated dentin permeability after submitting specimens to the application of fluoride varnish with and without diode Laser irradiation at various intensities, in addition to verifying the performance of the treatments in the face of acid challenges. The results showed that a higher energy density is more effective in reducing permeability, probably due to occlusion of the dentinal tubules and that the association of Laser with fluoride varnish promotes greater stability in the face of acid challenges. This possibly explains the fact that the present study found that the fluoride varnish alone had an inferior behavior in face of the effects of brushing, feeding and dilution in saliva while Laser irradiation were not only more effective but also more lasting.

Osmari et al[43] studied the difference between treatments with fluoride varnish and high-intensity diode Laser and found that treatment with Laser was not effective until the 15-day control when it then presented results similar to fluoride varnish, suggesting that treatment with Laser would not be efficient in the first days of its application, however it differed from the present study regarding

the power of 1W whereas this present study employed 0,8W. In addition there is a difference in wavelength of the device, 810nm in the work of the authors mentioned and 980nm in the present study. Despite the similar energy density employed (100J/cm²), these differences may have promoted a significant difference in the way that the energy was absorbed by the dentin surface and possibly resulted in an immediate pain response of the pulp not allowing immediate relief, with only the biomodulating effect of the pulp acting after 15 days to reduce DH.

Thus, it was possible to observe that the treatment of DH with diode Laser irradiation in the suggested protocol, associated or not with fluoride varnish, was effective both immediately and in its prolonged effect for up to 6 months.

Conclusion

Treatment with fluoride varnish was effective in reducing HD in the short term, but it had a long-term recurrence.

Treatments with diode Laser stand-alone and its combination with fluoride varnish were effective in reducing HD up to the 180-day control.

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Figure Legends

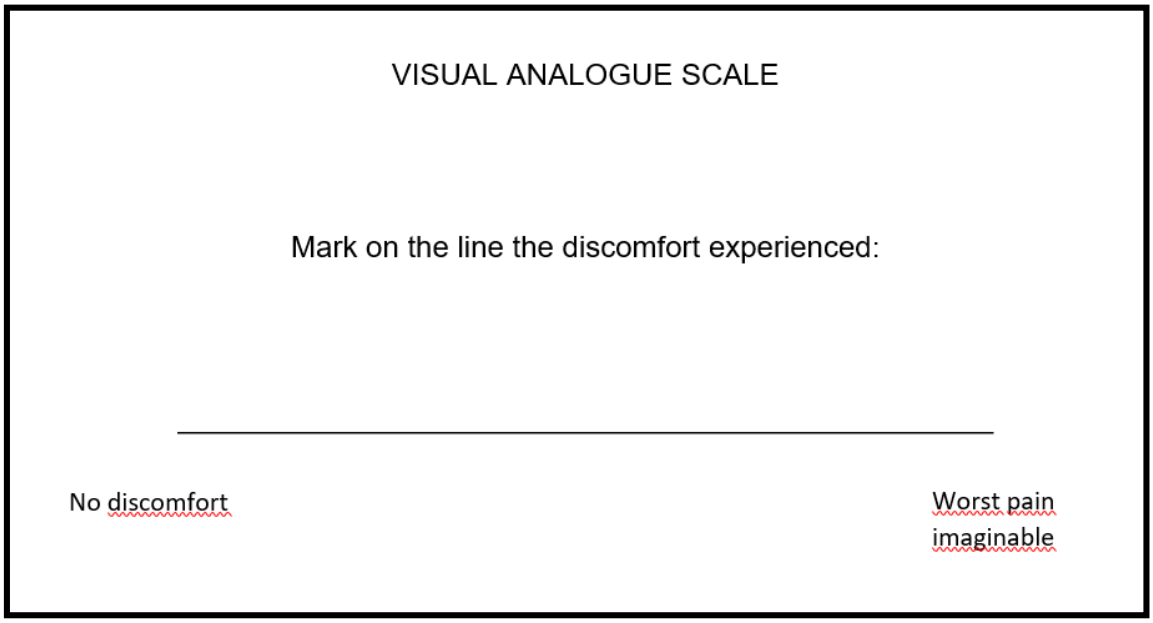

Figure 1 – Visual Analogue Scale

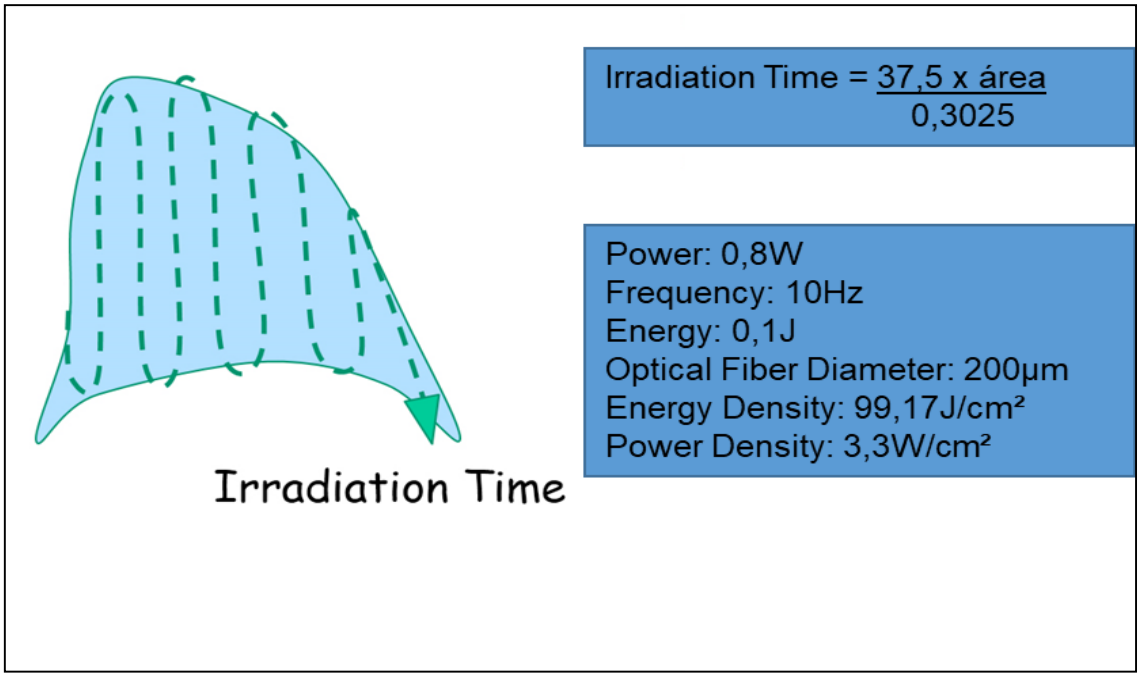

Figure 2 - Schematics of Laser irradiation pattern.

Tables

Table 1: Mean and standard deviation of pain intensity values (VAS) registered by patients after evaporative stimulus (n = 19).

Group	VAS0	VAS1	VAS7	VAS30	VAS180
Varnish	5,92 ± 2,27	3,24 ± 2,69	3,74 ± 2,58	4,18 ± 2,72	5,22 ± 2,27
Laser	6,03 ± 2,00	2,26 ± 1,66	1,92 ± 1,65	1,86 ± 1,76	1,92 ± 1,63
Varnish + Laser	5,96 ± 1,88	1,32 ± 1,08	1,48 ± 1,14	1,45 ± 1,00	1,42 ± 1,05

VAS0 – Baseline – pre-treatment
VAS1 – Immediately after treatment
VAS7 – 7 Days after treatment
VAS30 – 30 Days after treatment
VAS180 – 180 Days after treatment

Table 2: Statistical analysis of the results ordered by group

Group	Time	Mean	A	B	C	D	E
Varnish	VAS0	5,92					****
Varnish	VAS1	3,24	****	****	****		
Varnish	VAS7	3,74		****	****		
Varnish	VAS30	4,18			****	****	
Varnish	VAS180	5,22				****	****
Laser	VAS0	6,03				****	****
Laser	VAS1	2,26	****	****	****		
Laser	VAS7	1,92	****	****			
Laser	VAS30	1,86	****	****			
Laser	VAS180	1,92	****	****			
Varnish + Laser	VAS0	5,96				****	****
Varnish + Laser	VAS1	1,32	****				
Varnish + Laser	VAS7	1,48	****				
Varnish + Laser	VAS30	1,45	****				
Varnish + Laser	VAS180	1,42	****				

**** in the same column represent no difference between groups (p> 0.05)

Table 3: Statistical analysis of results ordered by time

Group	Time	Mean	A	B	C	D	E
Varnish	VAS0	5,92					****
Varnish + Laser	VAS0	5,96				****	****
Laser	VAS0	6,03				****	****
Varnish + Laser	VAS1	1,32	****				
Laser	VAS1	2,26	****	****	****		
Varnish	VAS1	3,24	****	****	****		
Varnish + Laser	VAS7	1,48	****				
Laser	VAS7	1,92	****	****			
Varnish	VAS7	3,74		****	****		
Varnish + Laser	VAS30	1,45	****				
Laser	VAS30	1,86	****	****			
Varnish	VAS30	4,18			****	****	
Varnish + Laser	VAS180	1,42	****				
Laser	VAS180	1,92	****	****			
Varnish	VAS180	5,22				****	****

**** in the same column represent no difference between groups (p> 0.05)

2.2 ARTICLE 2

Evaluation of the impact of dentin hypersensitivity treatment on quality of life through DHEQ-15 method: a random clinical study.

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Abstract

Aim: The objective of this study is to evaluate the impact of Dentin Hypersensitivity on the quality of life, through the Dentine Hypersensitivity Experience Questionnaire, before and after three different treatments.

Materials and methods: 57 patients with gingival recession and sensitivity were selected and the exposed roots treated according to three different protocols (diode Laser irradiation, fluoride varnish and the combination of Laser irradiation over fluoride varnish) DH assessment was performed using the visual analogue scale, and questionnaire was applied prior to treatment and 180 days after it. Statistical analysis was performed through one-way ANOVA, paired t-test, Kruskal-Wallis and Wilcoxon test with level of significance of 5%.

Results: There was a significant reduction in pain for the treatments with Laser and Laser associated with varnish, but no difference between them. Scores of quality of life were significantly better after treatment for all the three groups although there was no difference between the three groups both before and after treatment.

Conclusions: The three treatments had positive impact on quality of life but with no difference between them.

This clinical trial is registered at ReBEC by the number RBR-7q7gyd.

Keywords: Quality of Life; Dentin Sensitivity; Lasers; Fluorides, Topical

Introduction

Dentin hypersensitivity (DH) is a common oral condition oftenly described as a short lasting intense pain on the teeth commonly associated with cold stimuli. Technically to be considered DH it cannot be attributed to any other defect or pathology (Gillam and Newman, 1993). Many theories were created to explain the occurrence mechanism of this pain and the most widely accepted is the Hydrodynamic or Fluid Movement theory that states a fluid movement inside dentinal tubules caused by stimuli on the teeth that trigger mechanoreceptors on the pulp resulting in the perception of pain. (Brännström et al, 1967) One of the challenges of dentistry is to find some treatment that prevents this mechanism of happening in an effective long lasting way.

Blocking the dentinal tubules opening is a common way to prevent the stimuli for even reach and cause fluid to move and can be done with many techniques such as proteins and particles precipitation, occlusion with restorative materials, high power Laser irradiation and even gingival surgery (Miglani et al, 2010) Another approach that can be done is desensitizing the nerve endings inside the pulp to avoid triggering the electric impulse that will be perceived as pain. It may be achieved with the use of some potassium-containing products or the bio-modulator effect of low power Lasers (Schmidlin and Sahrmann, 2013).

Regardless the chosen method, patients tend to seek for treatment of DH to reduce the negative impact that the acute pain may cause in their quality of life. (Bekes et al, 2009). According to the World Health Organization, Quality of Life (QoL) can be defined as an individual’s perception of his/her position in life, in the context of the culture and value systems in which he/she lives, and in

relation to his/her expectations, goals and concerns (WHOQOL, 1993). Whereas someone could ponder about life decisions and behaviors to avoid consuming cold foods and beverages, it may be presumed that the concerns with DH occurrence impact on an individual QoL. It is not only the physical limitations of the pain, but all the social and emotional factors involved that may be impacted (Soares et al, 2021).

There are several ways to evaluate the impact of different oral problems on QoL, some more comprehensive and other more specific addressing the many issues that a specific occurrence may cause. For example, the Dentine Hypersensitivity Experience Questionnaire (DHEQ) (Boiko et al, 2010) and its modification DHEQ-15 (Machuca et al, 2013) are based on affirmatives exclusively related to DH that can measure its effect on QoL.

The objective of this study is to evaluate the impact of DH on the QoL, through the DHEQ-15, before and after three different DH treatments.

Materials and Methods

Experimental design

This study used a 3x2 factorial design having as study factors the treatment technique in three levels (fluoride varnish, Laser irradiation and fluoride varnish + Laser irradiation); and the control time (before treatment and 180 days after treatment). The response variable was the scores obtained through a questionnaire (DHEQ-15) with 15 items answered after evaporative stimulus on the tooth with DH, before and 180 days after treatment.

Clinical trial registration and research ethics committee

This clinical trial is registered at ReBEC by the number RBR-7q7gyd, UTN code U1111-1254-9691

This study project was submitted to the research ethics committee of Bauru School of Dentistry - University of São Paulo (FOB/USP) and approved under the CAAE: 49808715.5.0000.5417.

Selection of research subjects

The patients were selected by a previously calibrated operator who selected a total of 57 patients (ages between 18-50 years), of both genders, following the inclusion and exclusion criteria described below. The participants were evaluated in the clinics of the Clinical Research Center of the Bauru School of Dentistry, University of São Paulo (FOB-USP) and the proposed treatments and controls were carried out in the same place.

Inclusion criteria

Subjects of both genders, aged between 18 and 50 years;

- Present at least 1 tooth with an exposed root with sensitivity greater than 3 on the Visual Analogue Scale (VAS) (Melzack and Wall, 1965), measured after evaporative stimulus (air jet at 1 cm from the region to be analyzed);

- Present gingival recession only on the buccal surface, class I or II of Miller´s gingival recession classification (Miller, 1985), that is, without root exposure on the interproximal surfaces. With an extension between 2 and 5 mm.

Exclusion criteria

- Active caries lesions in any dental element;

- Make chronic use of medications with analgesic, anti-inflammatory or drugs with central effect (anxiolytics and antidepressants);

- Be under psychological counseling;

- Make use of desensitizing agents (at home) in the last 3 months or in the office (6 months);

- Pregnancy;

- Allergy to any of the treatment components;

- Being under orthodontic treatment;

- Presence of removable or fixed prosthesis in the teeth under analysis;

- Presence of Miller's class III and IV recessions;

- Patients with active periodontal disease;

- Recession on the palatal and / or proximal surfaces;

- Presence of a furcation lesion in the selected teeth;

- Daily use of mouthwashes (fluoride).

- Presence of deep, non-carious cervical lesions that need restoration.

To identify the dentinal sensitivity of each patient, the selected tooth was isolated with cotton rolls and an evaporative stimulus (air jet) was used, performed by the same operator on the clinically exposed root, to guarantee the standardization of the tests. An air jet was used, with the aid of a triple syringe directed perpendicularly to the cervical area with dentin exposure, at a distance of 1 cm, for 3 seconds. Immediately after removing the stimulus, patients reported the pain intensity on the Visual Analogue Scale (VAS) as shown in Figure 1. The subject should mark a trace on a 10cm line regarding the pain where the left end represented absolutely no discomfort and the right end represented the worst pain imaginable. The line was measured from the left end to the trace marked to obtain a VAS value.

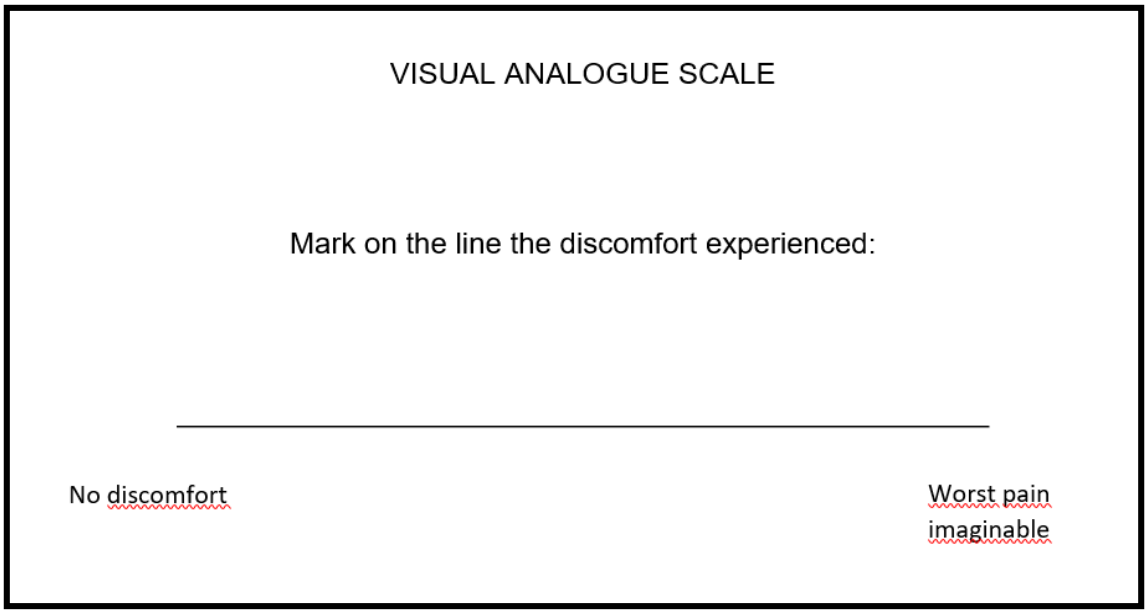

Figure 1 – Visual Analogue Scale

Sample randomization

The 57 patients were randomized to three study groups. Two factors were considered: size of the recession (area) and intensity of pain when exposed to the evaporative stimulus. Both factors were recorded in the initial examination, and patients were randomized using the Microsoft Excel program.

Treatment protocols

1) Fluoride varnish

The fluoride varnish used was Clinpro ™ White Varnish (3M, Campinas, São Paulo, Brazil) which is a compound based on colorless sodium fluoride (5%

concentration, 22600 ppm of fluoride), applied with the aid of a small disposable brush (Kg Sorensen, Cotia, São Paulo, Brazil) on clinically exposed dentin. The varnish was applied in a single layer on the dentin surface in partial isolation with cotton rolls. The exceeding material was removed with a clinical probe. After application, the patient was instructed to moisten the region with a tongue to activate the product and avoid drinking fluids for 1 hour.

2) Diode Laser

The diode Laser used was the DClase (DC International LLC, Wellington, FL, United States), with 970nm wavelength, capable of generating a power ranging between 0.5 and 7W. Through partial isolation with cotton rolls, the Laser was irradiated over the exposed root surface through an optical fiber 200μm in diameter, in contact mode perpendicular to the root dentin, with a standardized sweeping movement in a zigzag pattern such that the Laser passes only once at each point on the root surface.

The irradiated energy density was standardized to all roots, 0.8W power, with 10Hz frequency and total energy density of 99.17J / cm2. These parameters were taken from the previous laboratory study where the best results of dentin sealing were obtained with this configuration (Rizzante et al, 2016)

3) Diode Laser + fluoride varnish

For the groups that combined the 2 treatments, the colorless fluoride varnish was applied as already described, followed by irradiation on the varnish, with the tip in contact with the root dentin. At the end of each irradiation, due to impregnation of the optical fiber tip with varnish, it was cut with a specific device.

Questionnaire

The patients were submitted to the Dentine Hypersensitivity Experience Questionnaire reduced to 15 questions (DHEQ-15) as proposed by Machuca et al, (2013) containing the following items:

1. Having sensations in my teeth takes a lot of the pleasure out of eating and drinking
2. It takes a long time to finish some foods and drinks because of sensations in my teeth
3. There have been times when I have had problems eating ice cream because of these sensations
4. I have to change the way I eat or drink certain things
5. I have to be careful how I breathe on a cold day
6. When eating some foods, I have made sure they don't touch certain teeth
7. Because of the sensations I take longer than others to finish a meal
8. I have to be careful what I eat when I am with others because of the sensations in my teeth
9. Going to the dentist is hard for me because I know it is going to be painful as a result of sensations in my teeth

10. I have been anxious that something I eat or drink might cause sensations in my teeth
11. The sensations in my teeth have been irritating
12. The sensations in my teeth have been annoying
13. Having these sensations in my teeth makes me feel old
14. Having these sensations in my teeth makes me feel damaged
15. Having these sensations in my teeth makes me feel though I am unhealthy

To each affirmative, the patient should say one of the following statements:

Strongly agree (7),

Agree (6),

Agree a little (5),

Neither agree or disagree (4),

Disagree a little (3),

Disagree (2)

Strongly disagree (1).

The DHEQ-15 is divided in 5 major aspects of dentine hypersensitivity experience being Functional Restriction (items 1-3), Coping (items 4-6), Social (items 7-9), Emotion (items 10-12) and Identity (items 13-15)

This questionnaire was applied before and after 180 days of the selected treatment.

Statistical Analysis

It was performed a one-way analysis of variance (ANOVA) to compare the three treatment groups for the variables of pain, evaluated through a Visual Analogic Scale, and patients own perception of oral health and quality of life as they can be considered parametric variables and showed normal distribution.

A paired t-test was conducted to compare the variable of pain (VAS) before and 180 days after treatment.

As the scores obtained through DHEQ-15 are a non-parametric variable, all the comparison between groups at a given time were performed by a Kruskal-Wallis test and the comparison of the scores before and after treatment within each group was performed by a Wilcoxon test.

To compare the scores for the many aspects of dentine hypersensitivity experience in a given time a Kruskal-Wallis test was performed with Tuckey test for multiple comparison.

All the tests considered a level of significance of 5% ($p<0,05$).

Results

Table 1. Means (Standard Deviation) of related pain through VAS before (BT) and after (AT) treatment as the comparison between groups (row and column) n=19.

Group	Pain BT (VAS)	Pain AT (VAS)	p
Varnish	5,92(2,26)	5,22(2,26)	0,09
Laser	6,03(1,99)	*1,92(1,62)	<0,01
Varnish + Laser	5,96(1,88)	*1,42(1,05)	<0,01
	p = 0,97	p < 0,01	

* in the same column indicates no statistical difference between groups

Table 2. Medians (Q1 and Q3) of scores obtained through DHEQ-15 before (BT) and after (AT) treatment as the comparison between groups (row and column) n=19.

Group	DHEQ-15BT	DHEQ-15AT	p
Varnish	66*(60,78)	41º(36,46)	<0,01
Laser	67*(62,69)	38º(35,42)	<0,01
Varnish + Laser	65*(61,69)	39º(36,42)	<0,01
	p = 0,62	p = 0,29	

* and º in the same column indicates no statistical difference between groups

The three groups presented no difference at the baseline for all evaluated variables which shows that the sample was well randomized and stratified. There

was a significant reduction in pain for the treatments with Laser and Laser associated with varnish, but no difference between them. Varnish alone did not reduce pain scores after 180 days. (Table 1)

Scores achieved by DHEQ-15 were significantly lower after treatment when compared with before treatment for all the three groups although there were no difference between the three groups both before and after treatment. (Table 2)

Table 3. Medians (Q1 and Q3) of the answers categorized by aspects of the Quality of Life measured by DHEQ-15 before and after treatment (n=57).

Treatment	DHEQ-15	Restriction	Coping	Social	Emotion	Identity	
Before	66(61,69)	[a]16(15,19)	[a]16(14,17)	[b]10(9,13)	[a]16(14,17)	[c]6(6,9)	p < 0,01
After	40(36,42)	[x]11(9,13)	[y]8(7,10)	[yz]7(5,8)	[yz]7(6,8)	[z]6(5,7)	p < 0,01
	p < 0,01	p < 0,01	p < 0,01	p < 0,01	p < 0,01	p < 0,01	

same letters in the same row means there is no statistical difference between groups

Categorizing DHEQ-15 questions into five aspects of dentine hypersensitivity experience, it can be observed that before treatment patients had suffered more with aspects of Restriction, Coping and Emotion equally. Social aspects showed an intermediate level of nuisance and the Identity aspect was the least bothering of them. (Table 3)

All aspects were significantly reduced after treatment, but changed the importance between them to overall dentine hypersensitivity experience. After treatment, Restriction still remained as the most significant aspect of discomfort. Coping showed the second higher median, but was statistically similar to Social

and Emotion aspects. Identity remained with the lowest median of them all, although after treatment it was also similar to Social and Emotion aspects.

Discussion

There are many treatment approaches to control DH, being the physical obstruction of various kinds of stimuli to dentin the most common of them. (Lopes et al, 2015; Yilmaz et al, 2011; Torres et al, 2014) Fluoride varnishes has been used to DH treatment for over 20 years (Gaffar, 1999) and have been reported to provide instant relief as it may cause dentinal tubule occlusion in the form of calcium fluoride crystals. However, the resultant layer may not resist the frequent acid and mechanical challenges in oral daily routine resulting in the need of frequent reapplication in order to maintain efficacy. (Rizzante et al, 2016) (Hansen, 1992)

Several studies have evaluated irradiation of the tooth surface with Lasers of many kinds such as of CO2 (Carbon Dioxide), Nd: YAG (Neodymium - Ytrium-Aluminum-Garnet), Er: YAG (Erbium - Ytrium-Aluminum-Garnet), Er, Cr: YSGG (Erbium - Garnet-Yttrium-Scandium-Gallium sensitized with chromium), GaALAS (Gallium Arsenide and Aluminum) and others of diode to control DH (Kimura et al, 2000). Lasers of high energy density may promote dentinal tubules occlusion by melting and re-crystallization of dentine on the surface level (Yilmaz et al, 2011) as well as function as a low energy density Laser after most of the energy dissipates during the passage through the dentin and act through biostimulation of odontoblasts to produce secondary dentin or even act directly on the dental pulp through its analgesic and anti-inflammatory properties. (Sgreccia et al, 2020)

The combined properties of both treatments have been also tested (Jain et al, 2020) with positive results, especially in the long term and after acid challenges. Theoretically, the heat caused by the Laser energy could possibly make the varnish more fluid and contribute to further dentinal tubule penetration as well as the potential melting of the dentine could also prevent the varnish to be easily removed by acid challenges.

This study agrees with these theories and studies as the varnish alone treatment was the only one to show similar results of pain perception before and after 180 days of treatment. The treatments with Laser alone and Laser combined with fluoride varnish reduced pain perception even after 180 days after treatment. A systematic review conducted by Marto et. al (2019) showed that many studies have shown similar results.

Aiming to evaluate the impact of pain reduction on quality of life, this study also interviewed the patients with a questionnaire before and 180 days after treatments. Oral health-related quality of life (OHRQoL) is an important component of quality of life, being composed by physical, cognitive, emotional and social aspects. (Dijkers, 2003) Pain itself is not a sole factor that can determine an adverse impact on a patients QoL. It is necessary to consider the impairment, disability and handicap that affect all possible functional and psychosocial outcomes that an oral disorder may be related. (Locker and Quiñonez, 2011)

The Oral Health Impact Profile (OHIP) (Slade and Spencer, 1994) is a 49 items questionnaire that approaches several aspects of OHRQoL such as functional limitation, physical pain and disability, psychological discomfort and disability, social disability and handicap. It is widely used to assess OHRQoL

(Soares et al, 2021), however, OHIP have a broad set of generic questions that tend not to detect the specific and nuanced problems of particular oral diseases and a more specific evaluation of a specific oral condition, as DH, may not be reliable. (Bekes et al, 2009)

To ensure a more objective analysis, Boiko et al (2010) developed a Dentine Hypersensitivity Experience Questionnaire (DHEQ) with 48 questions that could capture subjective impacts of dentine hypersensitivity, a global oral health rating and a scale to record effects on life overall showing good psychometric properties in both a general population and clinical sample.

Machuca et al. (2013) however, identified that a questionnaire with 48 questions could take a long time to administer and complete, making their clinical application more burdensome for clinicians, researchers and participants and may result in reduced response rates and more missing data. This way they proposed a reduction of the Dentine Hypersensitivity Experience Questionnaire to 15 questions (DHEQ-15) that could be answered in 7 gradually options that would give an overview to the many aspects of QoL associated with DH such as functional restrictions; coping; social; emotions and identity.

Although Locker (Locker and Allen, 2007) states that exactly what is being measured by indexes of OHRQoL is somewhat unclear, the evidence that oral discomforts, such as DH, influence on the way people feel, react and make decisions should not be neglected (Soares et al, 2021) and may be considered an important factor of general QoL.

In this study, all three treatments had a positive impact on QoL over time showing that oral health care is important not only for solving the objective oral

problem, but it also had influence in others aspects promoting well-being. Other studies had the same outcome (Bekes et al, 2009), which reinforce the idea that oral health and quality of life are closely interconnected.

The three treatments observed had similar DHEQ-15 scores between them, both before and after treatment, showing that even the treatment using fluoride varnish alone that had no difference in pain values before and after treatment, had positive influence on QoL. This could be due to the fact that the treatment with fluoride varnish alone may induce immediate pain relief, but loses its effectiveness through time and acid challenges of a daily routine. (Raichur et al, 2013; Femiano et al, 2013; Francisconi-Dos-Rios et al, 2021) With that in mind, is possible that for a period of time, the treatment had effectively improved QoL of the patients and they considered that when answering the questionnaire even if the pain at that moment was at the same levels as before treatment.

When dividing the DHEQ-15 in five aspects of OHRQoL, it could be observed that the aspect that DH mostly interfere is the functional restriction. Even after the treatment it remained as the most bothering aspect to the patients whilst the minor nuisance was the identity aspect. It shows that DH really prevent people of eating specific kinds of food and maybe even with the treatment diminishing the pain sensation, people could continue to avoid certain products because of the fear of experiencing pain. On the other hand, DH did not seem to be a significant problem of people thinking that these discomforts are relevant to their feelings of aging or getting sick. It could confirm the results found by Gillam et. al (1999) that observed that people usually do not consider DH to be a severe oral health problem. It could be inferred that even having significant issues with DH, most people do not think that these nuisances affect their QoL when

considering all the aspects that can be involved. This finding confirms the complexity of evaluating general QoL and that every aspect should be investigated and have its importance considered. (Slade, 2012)

Conclusion

The three treatments had positive impact on the DHEQ-15 method of evaluating quality of life.

None of the treatments showed better impact on the evaluation of QoL when compared between them.

Pain relief from DH, even for a short period of time, may be capable of improving quality of life indexes.

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3 Discussion

3 DISCUSSION

Aiming at correctly exposing the data obtained with the studies, we divided the discussion into important items, as follows: sample selection, results compared to the literature, study limitations, and clinical relevance.

3.1 SAMPLE SELECTION

In this study, we show two papers related to the evaluation of a response toward different DH treatments. The first paper reported the pain response of individuals measured by a Visual Analogic Scale (VAS) found before and after three different treatments at four moments. Thus, the sample of the first paper was composed by 57 adults divided into three groups regarding the selected treatment: Group 1 – 19 patients treated with Fluoride Varnish; Group 2 – 19 patients treated with diode Laser irradiation; Group 3 – 19 patients treated with diode Laser irradiation associated with Fluoride Varnish. The second paper reported QoL response of the same individuals measured by the DHEQ-15 Questionnaire. Although the second paper has the same sample and group distribution as the first one, the QoL evaluation were not performed at every control query, only before treatment and after 180 days of the selected treatment because of the own nature of the DHEQ-15 that does not provide information of the sole moment of answering but the feelings experienced through the last weeks. (MACHUCA et al., 2013)

Based on a systematic review performed by Zhu et al. (2015), papers that evaluated DH after evaporative stimulus through VAS showed an expected standard deviation of 1,01. That way, the first article achieved a minimum

detectable difference in means of 1,04 with three groups with 19 subjects each and a test power of 80% with alpha of 0,05.

The second article analysis of DHEQ-15 answers expect a standard deviation of 5,0 (DOUGLAS-DE-OLIVEIRA et al., 2018). That way it was possible to achieve a minimum detectable difference in means of 2,0 with the same three groups of 19 subjects each with a test power of 84% with alpha of 0,05.

The inclusion and exclusion criteria of the sample was to ensure that only patients with DH in exposed roots without the presence of any other potential pain-causing pathological agent, such as caries and occlusion traumas, were selected because this is one of DH definitions (HOLLAND et al., 1997) and could provide bias. These inclusion and exclusion criteria are widely documented through several studies about DH. (LOPES et al., 2017; POURSHAHIDI et al., 2019; ORHAN et al., 2011)

3.2 RESULTS COMPARED TO THE LITERATURE

In this study, both papers shared the sample, thus the methodology of the selected treatments are the same, differing only on the variable evaluated. The three selected treatments are among the most common of the DH solutions nowadays (MARTO et al., 2019). Fluoride varnishes has been used to DH treatment for over 20 years (GAFFAR, 1999) and have been reported to provide instant relief as it may cause dentinal tubule occlusion in the form of calcium fluoride crystals. However, the resultant layer may not resist the frequent acid challenges in oral daily routine resulting in the need of frequent reapplication in order to maintain efficacy. (RIZZANTE et al., 2016; CUMMINS, 2010)

Several studies have evaluated irradiation of the tooth surface with Lasers of many kinds such as of CO2 (Carbon Dioxide), Nd: YAG (Neodymium - Ytrium-Aluminum-Garnet), Er: YAG (Erbium - Ytrium-Aluminum-Garnet), Er, Cr: YSGG (Erbium - Garnet-Yttrium-Scandium-Gallium sensitized with chromium), GaALAS (Gallium Arsenide and Aluminum) and others of diode to control DH (KIMURA et al., 2000; VERMA et al., 2012; GOJKOV-VUKELIC et al., 2016; LOPES et al., 2017).

Lasers of high energy density may promote dentinal tubules occlusion by melting and re-crystallization of dentine on the surface level (Yilmaz et al., 2011). Theodoro et al. (2003), however, suggests that dentin melting or fusion may not occur as the temperatures achieved through Laser irradiation are not high enough to reach melting point. Nevertheless, this study showed that even the diode Laser irradiation alone effectively reduced pain through all control times. Sgreccia et al. (2020), states that a high energy density Laser may function as a low energy density Laser after most of the energy dissipates during the passage through the dentin and act through biostimulation of odontoblasts to produce secondary dentine or even act directly on the dental pulp through its analgesic and anti-inflammatory properties, being a possibly cause for the good results.

Considering that is reported safe an increase within 5ºC in the pulp (SELZER and BENDER, 1990), there was a concern with the safety of irradiation since there may be an increase in temperature inside the pulp chamber during the irradiation procedure. Theodoro et al. (2003) verified that diode Laser irradiation with power outputs of 1.0 and 1.4W caused a temperature increase of 1.6ºC and 3.3ºC respectively in the pulp chamber. Ishikiriama et al., (2015) also evaluated the thermal variations caused by the diode Laser irradiation with power

outputs of 0.5; 0.7 and 1W, associated or not with fluoride varnish, and no increase in intra-chamber temperature above 4ºC was found, consisting, therefore, in safe parameters for clinical irradiation without harm to patients (ZACH ET AL. 1965).

The combined properties of both treatments have been also tested (JAIN et al., 2020) with positive results, especially in the long term and after acid challenges. Theoretically, the heat caused by the Laser energy could possibly make the varnish more fluid and contribute to further dentinal tubule penetration as well as the potential melting of the dentine could also prevent the varnish to be easily removed by acid challenges.

Rizzante et al., (2016) published a paper with the same Laser irradiation parameters as this study, varying the power outputs of 0.5, 0.7 and 1W, evaluating dentin permeability. The 1W group presented the best results, and was the reference for the pilot tests in this study. However, some patients related discomfort during irradiation and the power output was changed to 0,8W and irradiation movement speed was adjusted to maintain the same energy density. No discomfort was observed and the clinical result was positive, showing that it was an efficient and safe protocol.

The first paper in this study agreed with these results as the Laser alone and its combination with Fluoride Varnish provided long lasting effect when compared with the Fluoride Varnish alone.

Regarding QoL, it is almost a consensus that the OHRQoL is an important aspect of an individual wellbeing. (LARSSON, 2010; BRENNAN and SPENCER, 2004; HOLLISTER and WEINTRAUB, 1993), but the literature has

few studies that investigate specifically the relation of DH and QoL (DOUGLAS-DE-OLIVEIRA et al., 2017), most of them agrees with the second article of this study. Jalali and Lindh, (2010) found that the fluoride varnish treatment for DH improved QoL up to 6 months after application. And Lima et al., (2017) found that the low-intensity Laser treatment for DH also improved QoL.

When dividing the DHEQ-15 in five aspects of OHRQoL (functional restriction, coping, social, emotion, and identity), it could be observed that the aspect that DH mostly interfere is the functional restriction. Even after the treatment it remained as the most bothering aspect to the patients whilst the minor nuisance was the identity aspect. It shows that DH really prevent people of eating specific kinds of food and maybe even with the treatment diminishing the pain sensation, people could continue to avoid certain products because of the fear of experiencing pain. On the other hand, DH did not seem to be a significant problem of people thinking that these discomforts are relevant to their feelings of aging or getting sick.

The non-standardization of the several studies that evaluate either pain or QoL related to DH difficult a direct comparison of the papers of this study with the existing literature, but the general conclusion that the irradiation with high power Laser, associated or not with Fluoride Varnish provide an effective and long lasting pain relief that result in improved QoL. (BAL et al., 2015; OSMARI et al., 2018; GILLAM et al., 1999; BEKES et al., 2009)

3.3 STUDY LIMITATIONS

The first limitation observed is in the methodology itself. The movement of Laser irradiation, even with extensive training and calibration, is impossible to be absolutely standardized. Despite of the extreme effort of the operator to maintain the same steady pattern of movement, it is impossible to guarantee that every individual at the Laser groups received the same energy density during treatment. Even if it was possible in controlled academic environment, extrapolating theses exact parameters to clinical practice and create a protocol is also a challenge, as it would be necessary to photograph and calculate the exposed root to apply the parameters defined by this study as safe and efficient.

The subjectiveness of the variables analyzed in both articles is also a limitation. Although pain is easily perceived, it may be more or less intense in the same individual as well as the capacity to transfer to a piece of paper depending on several uncontrollable factors. QoL, even measured with questions, may be influenced by the same factors. Chaffee et al. (2017) evaluated that the lower socioeconomic status and higher caries experience may cause patients to perceive less QoL impact for the same level of disease experience that patients facing less disadvantages.

Miron et al. (2020) suggests a more objective way to evaluate DH using Laser-Doppler flowmetry that could be an alternative method in future studies.

3.4 CLINICAL RELEVANCE

By evaluating the pain response evolution through time and impact in QoL after specific DH treatments is possible to obtain valuable information on the

predictability of these treatments, providing a reliable and safe tool to the clinical practice and patients well-being, which is mandatory for the individual. The results of the present study suggest that the irradiation with high power diode Laser, associated or not with Fluoride Varnish, presented good performance in the treatment of DH, improving the clinical practices used in the present and future oral discomfort of these individuals.

4 Conclusions

4 CONCLUSIONS

Conclusion Article #1: This study suggests that irradiation with diode Laser within the proposed parameters is a safe, efficient, and long-lasting treatment protocol to control DH.

Conclusion Article #2: The treatment of DH, at different degrees of pain reduction has positive impact of an individual quality of Life

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Appendix

APPENDIX

Appendix A

DECLARATION OF EXCLUSIVE USE OF THE ARTICLE IN THESIS

We hereby declare that we are aware of the article **Effect of diode Laser irradiation on exposed roots, associated or not with fluoride varnish, to control dentin hypersensitivity: Randomized controlled clinical trial.** will be included in the Thesis of the student Bruno Nicoliello Moreira was not used and may not be used in other works of Graduate Programs at the Bauru School of Dentistry, University of São Paulo.

Bauru, November 03, 2021.

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