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Original Article

Efficiency of Lasers and a Desensitizer Agent on Dentin Hypersensitivity Treatment: A Clinical Study

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Abstract

Aim: The aim of this clinical study was to determine and compare the efficiency of the glutaraldehyde-containing agent (GCA), Nd:YAG, Er,Cr:YSGG lasers, and the combination of them on the dentin hypersensitivity (DH) treatment. **Subjects and Methods:** This study was performed with the participation of 17 healthy adult patients having 100 teeth with DH; the patients were randomly divided into five groups according to the treatment protocol: (1) application of GCA on sensitive teeth, (2) Nd:YAG laser (1 W/cm^2, 10 Hz) irradiation on sensitive teeth, (3) application of GCA on sensitive teeth and then Nd:YAG laser irradiation, (4) Er,Cr:YSGG laser (0.25 W/cm^2, 20 Hz) irradiation on sensitive teeth, (5) application of GCA on sensitive teeth and then Er,Cr:YSGG laser irradiation. Sensitivity levels were assessed by the Yeaple probe on the buccal surfaces of the teeth at a force setting of 10 g. Measurements were performed for 30 min, after 7, 90, and 180 days of the therapy to assess the effects of desensitization. The evaluations were analyzed using the one-way analysis of variance and repeated measurement test ($P < 0.05$). **Results:** After sessions, DH was significantly reduced in all groups at each measurement point. The Er,Cr:YSGG laser with or without GCA application were the most effective ones in DH treatment ($P < 0.05$). Comparison of the treatment regimens demonstrated that the scores achieved with the Yeaple probe were not significantly higher for the Nd:YAG laser groups than the GCA alone group. **Conclusions:** This clinical study shows that the Er,Cr:YSGG laser have promising potential for the treatment of DH.

Keywords: *Dentin hypersensitivity, Er,Cr:YSGG laser, Nd:YAG laser, Yeaple probe*

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Introduction

Dentin hypersensitivity (DH) is as an acute, non-spontaneous, short-duration pain resulting from exposure of the dentin to chemical, mechanical, osmotic, or thermal stimuli unlikely to be ascribed to any other form of dental pathology[1,2] DH develops when dentinal tubules are exposed to oral cavity. The exposure of dentin and its resulting sensitivity is likely to be caused by one or two mechanisms: either with the removal of enamel or the denudation of the root surface with the loss of the overlying cementum.[3-5] The commonly accepted theory to explain the pain related to DH is the hydrodynamic theory.[6] In the perspective of this theory, when dentinal tubules are exposed, the pressure differences in the surrounding tissue affect the flowing direction of the dentinal fluid inward or outward. This flowing may stimulate mechanoreceptors in intratubular nerves or in the superficial pulp that is recognized by the patient in the form of a rapid and sharp pain.[7]

There are several methods used for the treatment of DH. These methods include instructions for proper brushing, dietary advice, occlusal adjustment, use of desensitizing products, irradiation of low-power or high-

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power lasers, the use of adhesive systems, and adhesive restorations.[3, 5, 8]

In the last decade, dental laser applications have become a popular option for the treatment of DH. Various theories are asserted to describe the impact of laser irradiation on dentin, which include sealing of dentinal tubules by melting and re-solidification of dentin, vaporization of the dentinal fluid, analgesic effect associated with inhibition of nerve transmission, or obliterating the dentinal tubules with tertiary dentin formation.[5,7,9]

Nd:YAG laser affects DH as a modality by laser-based obliteration or narrowing of dentinal tubules in the form of nerve analgesia. The brief exposure to the Nd:YAG laser may be applied, to fuse dentin, and the dentin fused in this manner becomes solid with a glazed, non-porous surface.[10] Whitters *et al*.[11] have also suggested a possible mechanism of direct nerve analgesia. The authors conducted a clinical trial using an electric pulp tester to measure the extent and duration of anyanalgesic effect induced by pulsed Nd:YAG laser treatment. A statistically significant increase in pain thresholds was observed in the mean responses measured 5 min after laser treatment.

Er,Cr:YSGG laser is also practiced for the treatment of DH. The high absorption of the Er,Cr:YSGG laser emission (wavelength 2,78 μm) can be highly absorbed in water. Thus dentinal fluid vaporizes from the exposed tubules leaving the insoluble salts behind. Hence, it could be asserted that this deposition is the source of sealing of the dentinal tubules and the reduction of DH.[12] Yilmaz *et al*. [13] reported that Er,Cr:YSGG laser could be used as a routine clinical treatment for DH, due to their findings of rapid and 3-months clinical effectiveness without adverse reactions.

A product containing the combination of an aqueous solution of 35% hydroxyethyl methacrylate and 5% glutaraldehyde (Gluma desensitizer, Heraeus Kulzer GmbH) is considered to be an efficient desensitizing agent. Dentinal tubules are inherently blocked by the glutaraldehyde, and this counteracts the hydrodynamic mechanism that gives rise to DH.[14] Clinically, Lopes and Aranha[15] found that the Gluma desensitizer showed a statistically significant reduction in sensitivity between initial and 6 months after application.

The quantitative evaluation of DH is difficult because of its subjective painful nature. There are several methods described for the evaluation of DH in the literature. The most commonly used method is visual analog scale (VAS) among all described methods that results in subjective measurements.[16,17] On the other hand, Yeaple pressure-sensitive probe has been used in several investigations that results in more objective measurements in comparison to VAS because of its sound controlled standardized probing pressure.[18-20]

The aim of this clinical study was to assess the efficacy of Gluma desensitizer (GCA), Nd:YAG, and/or Er,Cr:YSGG laser applications on DH treatment for a period of 180 days. The null hypothesis of this study was that there were no significant differences among the different treatment modalities in the reduction of DH.

Materials and Methods

Patient selection

The design of this study was approved by the Ethics Comittee of Bezmialem Vakif University with a reference number 258/2013. In total, 17 (6 males and 11 females) out of 48 patients between the ages of 18 and 56 years with 100 hypersensitive teeth in total volunteered for this study as shown in Table 1. The inclusion criteria were as follows: (1) good general health with no known allergies to commercial dental products, (2) no use of desensitizing toothpaste within the prior three months, and (3) no decay or restorations of tested teeth.

The exclusion criteria were as follows: (1) patients with chronic disease with daily pain episodes; those who were under anticonvulsive, analgesic, antihistaminic, tranquilizing, anti-inflammatory, or sedative medication in the last 72 h, (2) use of any desensitizing toothpaste or mouthwash in the last 3 months, (3) prior periodontal surgery within the last 6 months, (4) nonvital teeth or vital teeth with cracks, restorations, carious lesions, or with active periodontal disease. Patients were informed about the purpose and the design of the study, and they signed the informed consent form and related consent forms were approved by the Ethics Comittee of Bezmialem Vakif University.

At the beginning and end of the trial, the vitality of all teeth was controlled by an electronic vitality tester (Dıgıtest, D626D, New York, USA). Aside from the applied treatments, the patients did not receive any other synchronous anti-sensitivity treatment during this study. Shortly prior to treatment, all teeth of the patients were polished and flossed by the examiner.

Dentin hypersensitivity assessment

A pre-calibrated Yeaple Probe (Model 200A Yeaple Electronic Force Sensing Probe, XinX Research, Inc., Portsmouth, NH, USA) was used to measure DH. The high Yeaple Probe scores indicated less tooth sensitivity. The same examiner held the #16 explorer tip perpendicular to the dentin surface of the tested tooth and moved it in horizontal direction by sweeping motion. The examiner began testing by applying 10 g of force and increased it where a pain response was elicited. The examiner re-challenged the teeth by applying the

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same amount of force and only those teeth responding positively to both challenges were used as test teeth, and the force recorded was noted as threshold. When the pain response was negative the force was increased by 2 g and the same process was repeated. This procedure continued until the patient response was positive. All assessments were made by the same clinician, in the same clinical environment.

Treatment modalities

After the measurement of initial DH level with the Yeaple probe, the teeth were randomly grouped as follows.

Group 1: A cotton pellet was used to apply GCA (Gluma desensitizer (GCA), Heraeus Kulzer GmbH, Hanau, Germany) with a gentle but firm rubbing motion. After 30–60 s, the dentin was dried completely until the fluid was vanished and the surface lost its gloss.

Group 2: The Nd:YAG laser (Fotona; At fields, Ljubljana, Slovenia) irradiation was performed in 1 mm distance, perpendicular to the surface with the repetition rate of 10 Hz, power of 1 W/cm^2, and 100 mJ of pulse energy (35.8 J/cm^2). A 300 µm quartz fiber was used with scanning movements in mesiodistal directions for 20 s for each tooth for three times. There was an interval (10 s) between the irradiations that was essential for thermal relaxation of the tissue.

Group 3: GCA application was followed by Nd:YAG laser irradiation as described previously.

Group 4: The Er,Cr:YSGG laser (Waterlase, Biolase Technology, Irvine, CA) was used perpendicular to the dentin surface with scanning movements from 1 mm distance with 0% water and 0% air for 30 s. The Er,Cr:YSGG laser irradiation was performed with the repetition rate of 20 Hz and power of 0.25 W (44.3J/cm^2). A Z6 sapphire tip (600 µm diameter, 6 mm length) was used during irradiation.

Group 5: GCA application was followed by Er,Cr:YSGG laser irradiation as described previously.

During the study, a standardized toothbrush and a toothpaste without any anti-hypersensitivity agent were used by the patients. The study was completed by all participants, leading to 100% compliance. Laser irradiations were carried out in compliance with the international standards and safety protocols. A single investigator conducted the laser therapy, whereas another investigator completed the pain assessment.

Study design

The treatments were performed at four stages. With intent to demonstrate the extent, capacity, and the duration of desensitization after irradiation, the measurements were carried out before each treatment session and 7 days after the treatments for 30 min. The desensitization effect of treatment was assessed at 90 and 180 days post-treatment as additional measurements.

Statistical analysis

For all groups, mean values obtained from the clinical parameters were calculated. The normal distribution of all scores was assessed using the Shapiro–Wilk test. To evaluate the changes of Yeaple probe scores all the time points among the groups, repeated analysis of variance (ANOVA) test were used for measurements. Post-hoc comparisons were performed using the Bonferroni method when significance was detected. One-way ANOVA and Tukey HSD tests were used for comparison among the groups at each time points. The values of $P < 0.05$ were accepted as statistically significant.

Results

The 6-month study period was completed by all 17 patients. Complications such as adverse pulp effects

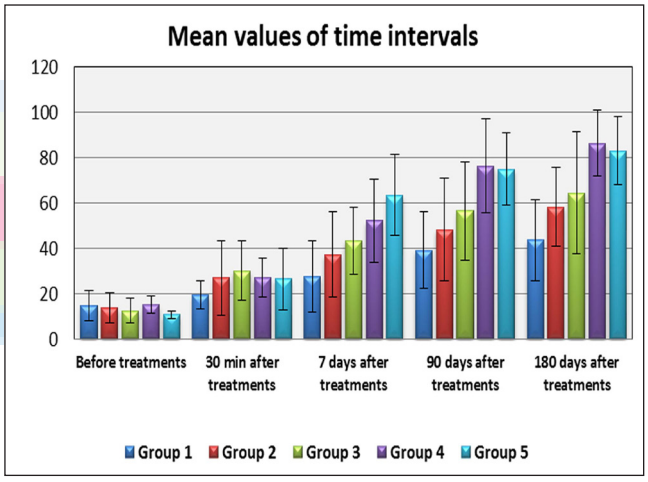

Figure 1: DH scores measured at different time intervals.

Table 1: Distribution of age, gender, tooth type and treatments in patient populations

Variables		n
Age	18-25	3
	26-36	7
	36-56	7
Gender	Female	11
	Male	6
Tooth type	Anterior	45
	Premolar	38
	Molar	17
Treatments	GCA application	20
	Nd:YAG irradiated	20
	Er,Cr:YSGG irradiated	20
	GCA application+ Nd:YAG	20
	GCA application+ Er,Cr:YSGG	20

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Table 2: The mean and standard deviation values of the DH treatments

	Group 1	Group 2	Group 3	Group 4	Group 5	p
Before treatments	15±6.6	13.9±6.7	12.6±5.5	15.1±3.8	10.9±1.6	0.067
30 min after treatments	19.5±6.3	27±16.3	30.2±13	27.1±8.4	26.5±13.7	0.086
7 days after treatments	27.45±15.6bc	37.2±18.8b	43.4±14.8bd	52.2±18.4ad	63.5±17.9a	0.001*
90 days after treatments	39.2±16.9b	48.3±22.4b	56.5±21.4b	76.3±20.6a	74.9±15.9a	0.001*
180 days after treatments	43.65±18bc	58.3±17.4b	64.5±26.7bd	86.4±14.6a	82.9±14.9a	0.001*

Values with different letters (a-d) are significantly different

or allergic reactions were not detected. The one-way ANOVA test revealed that there were statistically significant differences among treatment modalities after 7, 90, and 180 days ($P < 0.05$); however, there were no significant differences among the groups before treatment and after 30 min ($P > 0.05$) [Table 2].

Combined application of Er,Cr:YSGG laser and GCA presented the highest Yeaple probe values where GCA group presented the lowest values in all time intervals. There were no statistically significant differences between the GCA group and GCA combined with Nd:YAG laser group ($P > 0.05$). Er,Cr:YSGG laser groups resulted in higher DH values than Nd:YAG laser groups ($P < 0.05$). There were no significant differences between the Er,Cr:YSGG laser and GCA+ Er,Cr:YSGG laser groups ($P > 0.05$).

The mean measured DH values before and after treatments at different time points are shown in Figure 1. There were statistically significant differences among the groups at each time point except GCA group ($P < 0.05$). In GCA group, there were no significant differences before treatment and 30 min after treatment however, there was significant improvement observed after 7, 90, and 180 days ($P < 0.05$). Significant reduction in the level of DH from the first day to 180 days was observed in all treatment groups ($P < 0.05$).

Discussion

The overall relief in DH as a result of all treatment modalities was the major outcome of the present clinical study. The DH resistance was lower in the GCA group than the other four treatment groups. The laser-induced reductions in discomfort were still seen at 180 days' post-treatment. Therefore, the null hypothesis of the study that there were no significant differences among the different treatment modalities in reduction of the DH was rejected.

Thermal and tactile stimuli are the most typical stimuli for the evaluation of the DH. Either a sharp explorer is used by many of the investigators as a tactile stimulus, or a blast of cold air is used as a thermal stimulus. These two are the earliest and commonly used methods.[21] In the current study, the patient's feedback to a tactile stimulus was evaluated by using the Yeaple pressure-sensitive probe. It prevents the application of excessive force to dentin, standardizes probing force, and allows the comparison of data available at various centers. To achieve more sensitive measurement results, the force by the Yeaple probe was increased by 2g.

The existent predisposing factors and etiological approach are not taken into consideration in the treatment phase of DH. Instead, performed treatment results are based on it.[4] In general, because of the uncompared innumerable variables, the treatment protocols cannot be standardized under different agents. In addition, owing to the subjective nature, the intensity of the pain is hard to quantify and also the etiological factor is rarely considered on treatments.[21] Moreover, factors such as duration of studies, regression for the impact of the control product, the placebo effect, studied population, and differences in methodologies prevent the comparison of the outcomes and verification of the standard treatment protocol.[22] In the current study, the Yeaple electronic probe was used, because it is re-usable and gives reliable results.[20]

The application of desensitizing agents to those dentinal tubules exposed to the oral environment constitutes the basis of traditional DH treatment.[23-25] Desensitizing agents try to constrain painful stimuli either by means of covering the dentinal tubules with coating mechanisms or by means of adjusting tubule contents via protein precipitation, coagulation, or the creation of insoluble calcium complexes.[23] Owing to the fact that the application of tubule sealing agents brings some drawbacks, such as the need for repetitive applications, extended duration of treatment, and patient compliance, the usage of alternative treatment modalities has become necessary.[26] The formulation of GCA consists of fluoride, hydroxyethyl methacrylate (HEMA), glutaraldehyde, and benzalkonium chloride. The glutaraldehyde reacts with the albumin in dentinal fluid that leads to the precipitation of this protein. In the literature, it is claimed that HEMA polymerization takes place, which leads to the formation of deep tags so that the dentinal tubules are completely

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or partially obliterated and the DH is consequently reduced.[27] However, in the current study, reduction in DH values was lower in GCA applied group than in the Er,Cr: YSGG laser groups but was similar with Nd:YAG laser groups. Talesara *et al.*[28] have also concluded that Nd:YAG laser at 1 W, 10 Hz, and 60 s was effective in the treatment of DH for a period of 9 months which is in accordance with the current study that evaluated for a period of 6 months.

Recently, as a result of the improvement in the laser technology, the lasers have emerged as a new treatment alternative for DH. With the invention of earliest ruby laser, lasers have become a new treatment tool and various types of them have been developed and tested.[29] These lasers control sensitivity either by occluding dentinal tubules or reducing the pulpal nerve's pain threshold.[30] Dilsiz *et al.*[16] examined the efficacy of Er:YAG, Nd:YAG and low-level diode lasers in terms of decreasing DH. The outcomes of the Nd:YAG laser treatment were more successful than the Er:YAG and diode lasers in 3 months. Lopes *et al.* [15] treated hypersensitive teeth only with GCA desensitizer, Nd:YAG laser, and Nd:YAG laser with the GCA desensitizer in their clinical study and concluded that Nd:YAG laser with GCA is effective, and the positive results were unaltered even 6 months after the initial treatment. However, in the results of current study, GCA combined with Nd:YAG laser treatment was not more effective than the Nd:YAG laser treatment.

The laser parameters having an effect on the amount of energy applied to a given surface include power level (W), exposure time (seconds), energy density (J/cm^2), distance from the surface, and the angle between the target tissue and the tip. When the Nd:YAG laser power level is more than 1.5 W/cm^2, it is likely that the dentin cracks and fissures and the dentin's protein structure alter, causing damage to the pulp.[31-33] In the current study, Nd:YAG laser irradiation was used at 1 W/cm^2.

The efficacy of the Er,Cr:YSGG laser on DH depends on the impact on the neural receptor TRPVl that is known to be triggered by heat. It has been reported that local anesthesia may be facilitated by Ee,Cr:YSGG laser in a short term.[34,35]. Gholami *et al.*[35] demonstrated that the Er,Cr:YSGG laser managed to melt peritubular dentin, occlude dentinal tubules partially or in whole, and thus achieve the reduction of patient's hypersensitivity symptoms. In a clinical research, Aranha *et al.* [36] evaluated the efficacy of Er,Cr:YSGG and Er:YAG lasers on the reduction of hypersensitivity on 28 patients and reported significantly lower VAS scores of Er,Cr:YSGG laser at the power level of 0.25 W/cm^2 in 1 month. Yılmaz and Bayındır[37] concluded that Er,Cr:YSGG laser at the power level of 0.5 and 0.25 W/cm^2 seems to be suitable for the routine clinical treatment of DH. In the current study, the efficiency of Er,Cr:YSGG laser was found to be the most prominent in reducing DH with or without GCA application .

The vitality testing performed before and after laser treatment yielded analogous results, illustrating that the laser therapy had no adverse effect on the pulp. In this long-term clinical study, both Nd:YAG and Er,Cr:YSGG lasers and GCA resulted in a decrease in DH with no adverse effects on tooth vitality. In this condition, factors such as the clinical equipment, economy, patient cooperation, time efficiency of application and clinician's proficiency with the technique may affect the treatment measures be used.[5,23] Randomized and controlled clinical studies are necessary for finding the most suitable treatment modality.

Conclusion

Within the limitations of the clinical study, the following conclusions were drawn.

1) A significant reduction in the level of sensitivity after all treatments at all-time intervals was achieved.
2) The Er,Cr:YSGG laser with or without GCA application is the most effective modality in the treatment of DH.
3) The GCA and Nd:YAG laser seem have similar effects in the treatment of DH.

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Conflicts of interest

There are no conflicts of interest.

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