Ozone and laser effects on dentin hypersensitivity treatment: a clinical study

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Abstract

Objectives Evaluate and compare the clinical efficacy of diode laser and gas ozone in the treatment of dentin hypersensitivity (DHS) of non-carious-cervical lesion.

Materials and methods 88 teeth from 44 patients with moderate DHS were randomised into two groups according to a split-mouth design. In the diode laser group, the operator at first aplicated the fluoride and potassium nitrate gel and then irradiated the superficial dentine exposed with 808 wavelength, incremental power from 0,2 to 0,6 W, with 20 seconds of interval. In the gas ozone group, the operator applied, using a silicon cup, a high dose of ozone (32 g/m³) for 30 seconds. The subjects underwent a first evaluation of the dentin sensitivity level (T0), directly after treatment (T1), after 3 months (T2), and after 6 months (T3), with a cold air blast challenge and tactile stimuli. The pain severity was quantified according to the Visual Analogue Scale (VAS). Statistical analysis was performed using Wilcoxon and Bonferroni correction for multiple comparisons (p=0.05).

Results A significant decrease of DHS were observed in both groups immediately, after 3 and 6 months of the therapy. After 6 months from the therapy, the sensitivity values in the teeth treated with gas ozone remain statistically lower than those treated with diode lasers (p=0.00026).

Conclusion Laser diode and gas ozone are both efficient as dentin sensitivity treatment. Ozone maintains an invariable effectiveness after 6 months.

Clinical relevance Laser diode and gas ozone can be recommended to reduce dentinal hypersensitivities.

Trial registration: ClinicalTrials.gov Identifier: NCT05853523

Introduction

Dentin Hypersensitivity (DHS) is characterized by short and acute pain arising from dentin in response to osmotic, tactile, evaporative, thermal, and chemical stimulus which cannot be associated to another dental pathology [1]. The prevalence of DHS can reach 50% and 90% of patients with periodontal disease. Most patients are between 20–30 years old and there are no differences between men and women. The buccal surface of premolar teeth is at the first place in the prevalence of sensible area [2].

Several physio pathological theories have been presented for this condition. The “nerve theory” hypothesis is based on the direct stimulation of dental nerves. The "hydrodynamic theory" attributes dentinal sensitivity to nerve stimulation by fluid movement within dentinal tubules: cold stimulation causes an outward fluid flow while a hot stimulation induces an inward fluid flow in dentinal tubules. The "odontoblastic theory" is consistent with the capability of the odontoblasts to sense diverse stimuli [3–4]. The "hydrodynamic" theory seems to be the most important, but these three theories are not mutually exclusive and cannot be considered separately [4].
Gingival recession, enamel loss, limited alveolar bone, erosion, abrasion, and periodontal surgeries are the main reason to DHS. To prevent DHS, oral hygiene education and brushing technique instruction, elimination of predisposing factors, diet, and behavior correction should be improved. However, dental caries, cracked teeth, dental or occlusal trauma, periodontal and endodontic problems must be excluded [3, 5].

Strategies for management of DHS include non-invasive treatments for pain relief and restorative treatments of hard and soft tissue defects. The most frequently used non-invasive treatment is the application of desensitizing agents. They mean to suppress nerve impulses by either mechanical or chemical blockage of the dentin tubules or by stopping the nociceptive transduction/transmission [3]. In 1935 Grossman listed the requirements for an ideal desensitizer. He indicated that the material or technique must: not irritate the pulp excessively; be painless; be easily applied, be permanently effective; act quickly; and not produce discoloration. Sadly, no single agent has yet met all of these criteria [4]. A lot of treatments were proposed for DHS but till these days, it is still an increasing problem. Gas ozone and diode laser were both suggested as a new treatment [6–8].

Ozone ($\text{O}_3$) is distinguished by elevate instability and reactivity, because of the third oxygen atom weakly bonded to the other two atoms [9]. Ozone is incapable of keeping its chemical stability for a longer time because of its powerful oxidizing agent, so it has been proposed for a long time in general dentistry for its antimicrobial, virucidal, disinfectant and biocompatible properties. It also has anti-inflammatory, analgesic, immunostimulant properties and it promotes tissue regeneration. Ozone is presented in different form as gaseous, water or oil [10–11]. Lately, with new devices, it possible to apply gas directly on the surfaces of the teeth by taking it from a special $\text{O}_2$ that can transform it into a high and controlled concentration of 32 g/m³, a higher efficacy and power than previous devices presented in literature [6, 8, 12]. Azarpazhooh et al. [13] and Lena et al. [6] suggested the use of gas ozone to treat DHS.

Laser diode treatment has been long proposed for managing DHS. It has been presented with different wavelength and parameters to treat this clinical condition. In addition, treatment with diode laser low-intensity were used to create photobiomodulatory effects that reduce pain and inflammation or higher-intensity to block mechanical tubules by dissolving dentin through the thermal effect made by laser irradiation [14–15]. Laser treatment can be used by either direct application, involving irradiation over the area affected, or indirect irradiation, preceded by the application of chemical agents such as sodium fluoride or stannous fluoride ($\text{SnF}_2$) [16].

Although the literature presents studies supporting the effectiveness on dentin hypersensitivities for laser diode and gas ozone there is no clinical trials comparing these two procedures. The aim of this clinical trial is to evaluate and compare the clinical efficacy of diode laser and gas ozone in the treatment of dentin hypersensitivity (DHS) of non-carious-cervical lesion.

**Materials and Methods**
This spit-mouth randomized clinical trial, with a duration of 6 month, involved 44 patients of both sex, who referred to the Faculty of Dentistry, University of Study of L'Aquila, Italy.

The University's local ethics Committee (prot. 28944/2021) approved the study, and it was conducted in accordance with the principles of the Declaration of Helsinki (World Medical Association Declaration of Helsinki, 2008). The subjects involved were voluntary, and informed consent was obtained from all of them.

Participants were examined and involved or excluded based on the following criteria.

**Inclusion criteria:**

- 18-70 years old.
- Stimulated dentin hypersensitivity greater than 6 on visual analogue scale (VAS)
- DHS affected two teeth, not contiguous, of different mouth semiarch.

**Exclusion criteria:**

- Periodontal surgery in the last 3 month
- Use of desensitizing paste in the last 3 month
- Pregnant or breastfeeding state
- Teeth with caries, reconstructions, pulpits congenital anomalies, fracture, and occlusal interferences.

**Dentin hypersensitivity assessment.**

Two stimuli were adopted to assess the degree of dentin hypersensitivities: evaporative test and tactile test. For the evaporative test, the teeth were trigged by a single operator, experienced, and trained, with a jet of air at a pressure of 45-60 psi at a distance of 2 mm from the buccal surface for 5 s. For the tactile test, the pain was triggered using a probe gently touched the dentin exposed in mesiodistal direction. The patient quantified the pain with the visual analogue scale (VAS) giving a value in the range from 1 (minimum pain) to 10 (maximum pain). The highest value of the pain stimulated by the two methods was registered.

The sensitivity level was quantified in the enrolling stage (T0), directly after treatment (T1), after 3 months (T2), and after 6 months (T3).

**Randomization and Blinding method**

The teeth, of different quadrants, were randomized, using computer-generated numbers, to receive gas ozone or diode laser treatment. All patients involved received both treatments, according to split mouth study design.
The operator, who was responsible for recording VAS scores, and the statistician were unaware of the type of therapies were applied. The dentist who applied the desensitizing treatments did not know pain VAS value of each tooth.

**Desensitized treatment protocols:**

A single operator treated the teeth from the buccal aspect to the cervical surface in one session using the followings procedures.

Gas ozone group (GOG): the application of ozone was performed with the HealOzone System X4 (Healozone Technology, Genova, Italy). The dentist adapted the silicon cup stricken on the cervical surface of the teeth. The pumping system created the vacuum and the machine applied high dosage of ozone, equal to 32 g/m$^3$, for 30 second (Figure 1).

Diode laser group (DLG): the dentist applied desensitized gel (JW-Desensitizing Gel, Heydent Gmbh, Germany), fluoride and potassium nitrate gel, directly on the cervical zone of the teeth. Subsequently the irradiation was performed with Wiser III (Doctor Smile, Lambda Spa, Brendola, Italy) in the desensitizing assisted mode (preprogramed protocol) (Figure 2).

The protocol provides consecutively steps (not in contact) with 20 second of interval, 808 wavelength, and power incrementation, from 0,2 till 0,6 W radiating the entire desensitize surface second using the “black tip” (400 micron). The procedure continued maintaining the tip of the laser on contact with the dentin surface making movement of lawn mowing (brushing technique) for 20 second. Then the surface was rinsed, and the irradiation applied again without the gel.

**Statistical analysis**

Means and standard deviations of each group were calculated at each experimental period. Statistical analysis was performed using Wilcoxon and Bonferroni correction for multiple comparisons (p=0.05).

**Results**

44 participants were included in this study: 22 woman and 22 men. Diode laser desensitized treatment were applied to 44 teeth and gas ozone desensitized treatment were applied to another 44 teeth. A total of 100% of the evaluated teeth were premolar.

By using the VAS system, the patients’ pain severity was evaluated and registered before the treatment (T0), directly after the treatment (T1), after 3 months (T2) and after 6 months (T3). All the patients enrolled completed the study procedure.

In both GOG and DLG the dentin hypersensitivity (P<0,05) reduced immediately, after 3 months and 6 months from T0 as shown in Figure 3.
Data were presented with their respective standard deviation. The hypersensitivity of 2 of the teeth treated with ozone were completely resolved after 6 months and one in diode laser group. The mean percentage of pain reduction in Laser Group was 57.57% in Ozone Group was 68%.

There was no significant difference in pain reduction between the two groups immediately (P > 0.05). After 6 months from the therapy, the sensitivity values in the teeth treated with gas ozone remain statistically lower than those treated with diode lasers (p=0.00026) (Figure 4).

**Discussion**

In this study, the effects of ozone gas and diode laser on dentin hypersensitivity were evaluated till 6 months. The results showed that both ozone gas and diode laser affect in decreasing dentin hypersensitivity immediately and over a 6-month period; gas ozone treatment was more effective to maintain the desensitizing effect than diode laser at 6 months from the treatment.

Tooth hypersensitivity is a chronic disease, and it can affect the quality of life of over 80% of patients affected [5]. The related suffering makes patients unable to maintain good oral hygiene, accelerating plaque accumulation and eventually periodontal problems in future, the treatments proposed in this study seem to be, with the limitation of the results, satisfactory modalities to treat DH in long period [2,17].

Diode lasers have been commonly used till now since them were first applied for DH in 1985 [18-19]. Laser-assisted treatment of dentinal hypersensitivity appears to be effective as suggested to clinical trials and the recent review [15,16-19,20]. Researchers agree with the mechanism of action: the diode laser treatments involve either physically melting of exposed dentin blocking the dentinal tubules, and the photobiomodulatory effect. Medium and high intensity laser involve the physically melting of exposed dentin, sealing or alters tubular content by coagulation, protein precipitation, or the creation of insoluble calcium complexes blocking the dentinal tubules and the use of desensitising molecules within laser promotes the precipitation of inorganic crystals in them. A low intensity laser can induce an analgesic effect by changing C-fiber depolarization, thus increasing the amplitude of cell membranes’ action potential, which can relieve pain [15,16,19].The modern generation of Diode laser, presented in this study research, make be possible use at the same time different parameters from low to medium intensity combinate the effects on DH. In this study the desensitization program, as the manufactory proposed, used a low power wavelength at different frequency.

The use of ozone has been proposed for a long time in general dentistry for its antimicrobial, virucidal, disinfectant and biocompatible properties, it also has anti-inflammatory, analgesic, immunostimulant properties and it promotes tissue regeneration [21,22]. The ozone mode of action of DH is still debated. The beneficial effects have commonly been associated to its powerful oxidizing potential results of its inability to maintain chemical structure for a long time. When the ozone meets unsaturated organic molecules, like proteins, carbohydrates, and phospholipidic compounds present on dentin surface it induces a chemical reaction that increase the diameter of dentinal tubules facilitate the entrance of minerals into the dentinal tubules, that come from saliva, calcium covered surfaces or desensitizing
agents [6,10]. Other possible explanations for the ozone-based reduced sensitivity have been attributed to
the documented analgesic properties consequent of the induced increasing activity of antioxidant
enzymes [23].

In literature the devices and the protocols suggested are heterogenic and no reviews about this topic are
still presented, probably cause of lack of clinical trial about this topic.

In recent years, the introduction of new devices has made it possible to apply a high dosage
concentration of 32 g/m$^3$ of gas directly on the tooth surfaces, taking it from a special canister of
O2 [7,24]. The use of a silicon cup makes possible to isolate the area to treat ad control the dosage of
ozone applied [8,13].

The possibility of a placebo effect must be taken into consideration, especially as patients reports were
positive immediately after treatment, investigators have described patients obtaining relief from DH
without any treatment due to the placebo effect [1,5,25]. It is a consequent of doctor-patient relationship
and of the interaction of complex mixture physiologic and psychological factors. This relationship
convinces patients that the treatment is valuable and can provide relief of symptoms. This effect is
commonly found in clinical DH trials, from 20% – 60% [13].

Moreover, has been shown that although the dentin might at first be sensitive, sensitivity usually subsides
within a few weeks without any therapeutic intervention as resulting in self-healing of tooth
hypersensitivity. Secondary dentin can be formed over the pulpal ends of the exposed tubules or the
gradual occlusion of the tubules by mineral deposits. However, the duration of this study was likely too
short for self-healing to have a significant effect on the results [26].

In chronic diseases, should be taken into consideration that patients might feel better one day and worse
the next cause of fluctuation of symptoms [26]. However, all the patients who took part in this study had
been suffering from tooth hypersensitivity for a considerable period of time. They had received various
treatments without effect and were thus actively seeking treatment. Therefore, symptom fluctuation is
less likely to be relevant.

About the effective cost-effectiveness of the use of diode laser and gas ozone are increasing in the
modern minimally invasive dentistry, not only to treat DH, but also for a plethora of uses, from
conservative to oral surgery [26,27].

About the difference result of gas ozone treatment and diode laser treatment is difficult to compare
studies due to lack of uniformity between ozone and laser application protocols for dentin
hypersensitivity treatment. The difference could be claimed that the effect of ozone on the obstruction of
dentinal tubules is more durable than the crystallization of the saline part of the gel induced from laser
and it might be the reason for differences between the results after 6 months. At the same time, the
diameter of the laser fibre is small, measuring 0.4 mm, and same tubules may be missed, instead the use
of silicon cup act to all the surfaces.
However, it is not obvious what the results would be if the application is performed in multiple sessions or with longer follow-ups, and future clinical trial are suggested.

It is necessary to conduct further studies for defining a standard protocol for the treatment and research purposes in the future, with larger sample sizes and longer follow-ups periods with the application of different devices settings and different exposure protocols.

**Conclusion**

Based on the findings from this clinical study, Gas Ozone therapy and Diode laser therapy both effectively reduce dentin sensitivity immediately after application and for a period of six months having a positive impact on the DH. at the end of the treatment gas ozone treatment was more effective.

**References**


Figures

Figure 1

Application of ozone with silicon cup stricken on the cervical surface of the tooth.
Figure 2

Laser irradiation on dental cervical surface.

Figure 3
Bar plot of total of VAS (visual analogue scale) values stratified by timing, according to group GOG and LDG. T0, before the treatment; T1 immediately after the treatment; T2 after 3 months; T3 after 6 months. Comparison of longitudinal changes in laser group and ozone group: significative values.

![Bar plot of total of VAS values stratified by timing, according to group GOG and LDG. T0, before the treatment; T1 immediately after the treatment; T2 after 3 months; T3 after 6 months. Comparison of longitudinal changes in laser group and ozone group: significative values.](image)

**Figure 4**

Bar plot of total of VAS values stratified by timing, according to group GOG and LDG. T0, before the treatment; T1 immediately after the treatment; T2 after 3 months; T3 after 6 months. Comparison of longitudinal change between groups: significative values.