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Comparative Evaluation Of Dentinal Tubule Occlusion Using Different Desensitizing Agents - An In-Vitro Study

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ABSTRACT
Background
Dentin hypersensitivity (DH) is a common issue characterised by a short, sharp pain. The most common method for treating dentin hypersensitivity is by reducing dentin permeability by occluding dentin tubules. Many substances are available to decrease hypersensitivity. The purpose of this study was to evaluate different desensitizing agents on dentinal tubule occlusion by scanning electron microscopy.
Methodology
Forty healthy human maxillary first premolar teeth extracted for orthodontic purposes were collected for this study. A dentin disc of two mm thickness was obtained using a diamond disc from the crown. The specimens were divided into four groups of ten discs each: Group 1: (negative control): No treatment material was applied Group 2: Specimens were treated with diode laser, Group 3: Specimens were treated with GC tooth mousse, (GC, Melbourne, Australia), Group 4: Specimens were treated with Nanohydroxyapatite (Dente 91 tooth paste). . All the specimens were examined under SEM.
Results
The results showed that the use of diode laser was able to achieve complete occlusion of dentinal tubules followed by nanohydroxyapatite and that of the use of GC tooth mousse while control group showed completely open tubules.
Conclusion
Under the limitations of the study, it can be concluded that the application of diode laser has the highest efficiency in reducing dentin hypersensitivity which is followed by nanohydroxyapatite and Gc Tooth mousse respectively.
Keywords
Dentine desensitizing agents, Dentine Hypersensitivity, diode laser, GC tooth mousse, scanning electron microscope

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I. INTRODUCTION

DH has been defined as “pain derived from exposed dentin in response to chemical, thermal tactile or osmotic stimuli which cannot be explained as arising from any other dental defect or disease”.[2] Although DH is a common disorder and one of the most unpleasant diseases, the offered treatments are both insufficient and ineffective. The patient may experience physical and psychological problems as a result of this. Additionally, it may have a detrimental impact on a person's quality of life, particularly in terms of food, maintaining good dental hygiene, and appearance [1,3,4].

The terms root hypersensitivity, cervical hypersensitivity, and dentinal hypersensitivity are also used to describe it. The condition is common in patients between the ages of 20 and 50. However, it is more common in patients between the ages of 30 and 40, and it is more common in women, which is presumably related to their diet and dental care. Additionally, canines and premolars are more likely than other teeth to develop DH. It has been reported that the DH affects the buccal surfaces of teeth more than other areas.[1]

Many theories, including the Direct Innervation Theory, Odontoblast Receptor Theory, and fluid movement/hydrodynamic theory, have been proposed in the literature to explain the cause of DH.[5,7] The theory of DH, put forth by Brannstorm in 1964, is the one that is most commonly accepted. According to this hypothesis, DH results from fluid movement within the dentinal tubules, which further excites the baroreceptors and results in neural discharge.[5,6]

The two main mechanisms to desensitize the dentin involve decreasing dentin permeability and the intradental nerve response to fluid changes. Several products are available on the market that reduce DH by decreasing permeability, including laser therapy, the use of various materials, including fluoride, hydroxyapatite, strontium chloride, zinc chloride, and potassium chloride, as well as dental adhesive, glass ionomer cement, oxalate, bioglass, Portland cement, and casein phosphopeptide—amorphous calcium phosphate.[5,8]

Lasers used for the treatment of DH can be divided into two categories:[5,9]

Low output power (low-level) lasers

• Helium-neon and gallium/aluminium/arsenide (diode lasers)
• Middle output power lasers
• Neodymium-doped yttrium aluminium garnet and carbon dioxide lasers.

On sensitive teeth, the laser operates via two mechanisms. One method is to melt the dentin and occlude the dentinal tubules. he second method, which can temporarily relieve DH, involves the desiccation of dentin after laser irradiation.[5,9] Diode laser has demonstrated a reduction in DH that is comparable to or superior to other conventional methods.[5]

Another effective treatment option is an at-home regimen, such as using GC tooth mousse. Neutral sodium fluoride (NaF), stannous fluoride, and strontium fluoride, which can precipitate minerals, are present in significant concentrations in remineralizing products like GC tooth mousse. These precipitates physically seal dentinal tubules with a plug that limits dentinal fluid flow and resists normal pulpal pressures and acid challenge [10]

Another substance with the potential to treat DHS is nanohydroxyapatite (nano-HAP). Studies have demonstrated that the topical application of nano-HAP in the form of a cream or toothpaste can remineralize early caries lesions. It is believed that nano-HAP may act as a calcium and phosphate reservoir, maintaining a level of supersaturation for these ions at the tooth surface and promoting crystal deposition and growth. and occlude dentin tubules, thus relieving DHS symptoms[11].

The aim of this *in vitro* study was to compare the effects of diode laser, GC tooth mousse, and Nanohydroxyapatite on DH by scanning electron microscopic (SEM) evaluation.

II. METHODOLOGY

Forty healthy human maxillary first premolar teeth extracted for orthodontic purposes were collected for this study. Teeth were cleaned thoroughly, disinfected in 5% sodium hypochlorite solution for 1 h and stored in distilled water. A dentin disc of two mm thickness was obtained using a diamond disc from the crown. Subsequently, the dentin discs were polished using a carbide abrasive paper. For smear layer removal, all the specimens were dipped in 17% ethylenediaminetetraacetic acid for 1 min.

An exposed surface was marked on each disc, and other parts of the disc were covered with protective tape. The specimens were divided into four groups of ten discs each:

• Group 1: (negative control): No treatment material was applied
• Group 2: Specimens were treated with diode laser
• Group 3: Specimens were treated with GC tooth mousse. (GC, Melbourne, Australia)
• Group 4: Specimens were treated with Nanohydroxyapatite (Dente 91 tooth paste)

The current study simulates actual clinical application of each drug. Pastes are typically suggested to be used twice daily, but laser exposure can only be performed in a clinical setting with a typical number of exposures and applications being three. Therefore, GC tooth mousse and Dente 91 tooth paste were applied twice a day for 3 min with 12 h interval for a week. Diode laser exposure was done on dentin disc for 3 consecutive days. The specimens were kept in distilled water after each treatment.

All the specimens were washed with distilled water, dried in a desiccator for 2 days, and sputter-coated with a thin gold layer. All the specimens were examined under SEM at a magnification of ×1500. SEM images were categorized as follows:

1. Occluded (100% of tubules occluded)
2. Mostly occluded (50% to < 100% of tubules occluded)
3. Partially occluded (25% to <50% of tubules occluded)
4.Mostly un occluded (<25% of tubules occluded)
5.Unoccluded (0%, no tubule occlusion)

The standardized SEM microphotographs were scored using above criteria by two blind observers.


Fig 1a - Dentin disc **Fig 1b – Irradiation with diode laser**

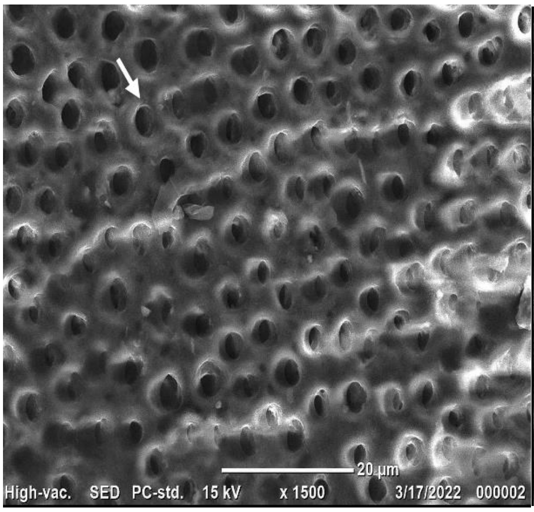
Fig 1c – Sirolaser blue (Dentsply sirona)

STATISTICAL ANALYSIS

The sample size has been estimated using the **GPower software v. 3.1.9.4 [(Franz Faul, Universität Kiel, Germany)**. Considering the effect size to be measured (f) at 40% **[Based on the results from previous literature by Rosemary Corneli,, et al, 2021]**, power of the study at 80% and the alpha error at 5%, **the sample size was 40.** Each study group had 10 samples [10 samples x 4 groups = 40 samples]. Kruskal Wallis test followed by Mann Whitney post hoc analysis was used to compare the mean scores describing the percentage of dentinal tubule occlusion between 4 groups.The level of significance [P-Value] was set at P<0.05.

III. RESULTS

The present study evaluated the occlusion of dentinal tubules by diode laser, GC Tooth mousse and Nanohydroxyapattite.The average score by the two blind observers were selected and considered in the study.
Group 1 (negative control) showed 90% samples with score 5 and 10% samples with score 4
Group 2 (Diode laser) showed 80% samples with score 1 and 20 % with score 2
Group3 (GC Tooth mousse) showed 30% samples with score 2, 40% with score 3 and 30% with score 4
Group 4 (Nanohydroxyapatite) showed 10% samples with score 1, 40 % with score 2, 30% with score 3 and 20% with score 4



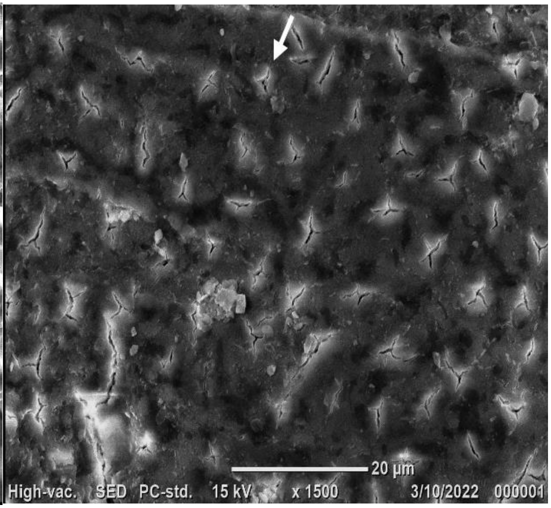
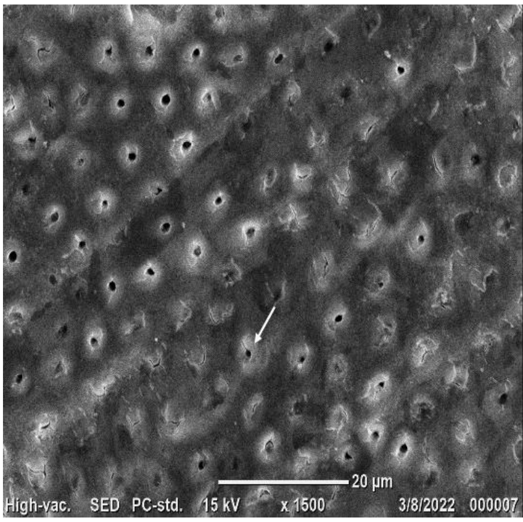


Fig2 Scanning electron microscopic image of control Group

Fig3 Scanning electron microscopic image of diode group



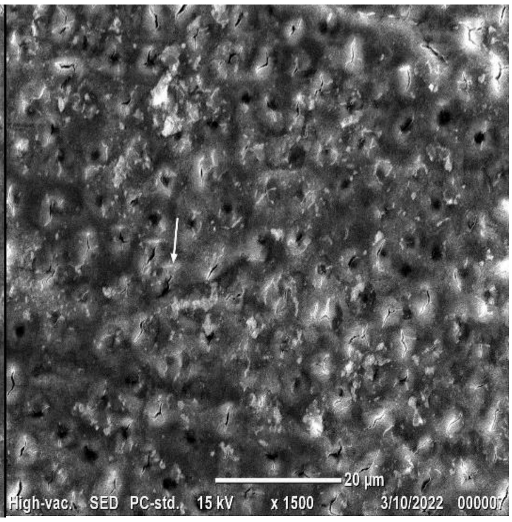


Fig4 Scanning electron microscopic image of Gc Tooth mousse

Fig5 Scanning electron microscopic image of Nanohydroxyapatite group

IV. DISCUSSION

The dentin is a porous, fluid-filled, mineralized tissue with dentinal tubules that aid in penetrability. Hypersensitivity is caused by loss of enamel and cementum from attrition, abrasion, abfraction and gingival recession as it exposes dentinal tubules to the oral environment.[12,13] It has been extremely challenging for many years to manage painful dental issues including dental hypersensitivity,[14] It is necessary to develop successful procedures that can occlude tubules quickly, permanently, and are resistant to environmental challenges in the oral cavity. Currently, occlusion of dentinal tubules is a very successful method for treating dentin hypersensitivity.

In this study, an effort has been made to evaluate the dentinal tubule occluding ability of diode laser, GC Tooth mousse and Nanohydroxyapattite.

From extracted sound maxillary premolars, 40 samples were taken and kept in saline. The premolars were chosen because they are the teeth that experience sensitivity the most frequently, followed by molars, canines, and incisors.12 The study excluded any teeth with wasting disease, caries, fractures, periapical infections, nonvital teeth, or any developmental malformations.

No agents were used on the samples in Group 1. The SEM pictures after etching revealed completely open tubules. This was considered the control group for comparison. The observers gave a score of 4 to all of the specimens in this group because they all had completely opened tubules.

According to Asnaashari and Moeini and Aranha and Eduardo, low power laser therapy has biomodulatory effects, minimises discomfort, and lowers inflammatory processes[15,16] There are two mechanisms by which diode laser acts on dentin hypersensitivity. First, there is a melting effect that results in the crystallization of the inorganic component of dentin and coagulation of the fluids in the dentinal tubules . Second, by lowering the pain threshold of the pulpal nerve.[5] Diode lasers are the most extensively researched among lasers and produced the best outcomes in a number of clinical protocols, even in high-grade DH cases. Based on the observers' scoring in our study, the laser group had scores of 1 and 2, which indicated that the tubules were almost entirely occluded, which can significantly lower DH.

It is widely accepted that external trigger stimuli cause the fluid in exposed dentinal tubules to move quickly, activating sensory nerve receptors in the pulp and causing the characteristic short, sharp pain of DHS.[11] According to Amaechi et al., it has been demonstrated that hydroxyapatite mineral plugging of exposed dentinal tubules reduces the permeability of the tubules, which inevitably prevents the disturbance of the fluid within the tubules and, as a result, lowers DHS. [17]

The tubule lumen of dentin treated with CPP-ACP revealed significant crystal-like deposits. However, in a few areas, the orifices of the dentinal tubules were covered by the layer of amorphous calcium phosphate that was present on the dentin.[18] According to Kowalczyk et al., when the peptide complex binds to plaque or the tooth surface, it is said to deliver bioavailable calcium and phosphate for remineralization, resulting in the occlusion of dentin tubules.[19]Both Gc Tooth Mousse and nanohydroxyapatite showed partial occlusion of tubules.

V. CONCLUSION

Under the limitations of the study, it can be concluded that application of diode laser has the highest efficiency in reducing dentin hypersensitivity which is followed by nanohydroxyapatite and Gc Tooth mousse respectively.

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