Comparative evaluation of the efficacy of light amplification by the stimulated emission of radiation, desensitizing agents, and their combined effect on dentinal hypersensitivity in cuspids and bicuspids – In Vivo Study

Shazia Siddiqui, Mohsin Khan, Ramesh Chandra, Supratim Tripathi, Jyoti Jain, Urvashi Ojha Tiwari

Department of Conservative Dentistry and Endodontics, TMU, Moradabad, Department of Oral and Maxillofacial Surgery, TMU, Moradabad, Department of Conservative and Endodontics, Career Institute of Dental Sciences and Hospital, Lucknow, Department of Conservative Dentistry and Endodontics, Career Postgraduate Institute of Dental Sciences and Hospital, Lucknow, Associate Professor, RML, Lucknow, Department of Conservative Dentistry and Endodontics, Dental College Azamgarh, Azamgarh, Uttar Pradesh, India

Abstract

Context: Dentinal Hypersensitivity is the most common dental problem, in order to find a suitable treatment plan this study was conducted incorporating LASER and desensitizing agents on the patients complaining of dentinal hypersensitivity in cuspids and bicuspids. Most of the desensitizing agents provided incomplete relief hence the combination of LASER and Desensitizing agents proved to be successful.

Aim: The aim of this study is to evaluate and compare the efficacy of individual desensitizing agents and c (LASER) and also to know their potential in reducing dentinal hypersensitivity when both desensitizing agents and LASER are combined together and applied on cuspids and bicuspids.

Setting and Design: Sixty patients with sensitivity only in cuspids and bicuspids and not having caries, restoration, or undergoing any desensitizing therapy were selected. Patients were divided into 5 groups with 12 patients in each group.

Materials and Methods: Air blast stimulus was given for 10 s from 1 cm distance on the affected group. Verbal analog score was recorded. Treatment was carried on according to the groups mentioned: Group I – nanohydroxyapatite was applied for 15 min; Group II – biosilicate was applied for 15 min; Group III – LASER application was done twice for 60 s in noncontact mode; Group IV – Nanohydroxyapatite plus LASER application; and Group V – biosilicate plus LASER application. Desensitizing agent was applied with the applicator tip and was left for 15 min. It was then rinsed and again the stimulus was given, and the score was recorded. The same treatment procedure was repeated on 1st, 7th, and 14th day and the score was recorded and analyzed using ANOVA.

Results: The maximum reduction in sensitivity score was observed in patients where nanohydroxyapatite and LASER application was done.

Conclusion: All the investigated treatments have promising desensitizing potential, but maximum was found in Group IV > Group V > Group III > Group I > Group II.

Keywords: Biosilicate, hypersensitivity, light amplification by the stimulated emission of radiation, nanohydroxyapatite, verbal analog scale

Access this article online

How to cite this article: Siddiqui S, Khan M, Chandra R, Tripathi S, Jain J, Tiwari UO. Comparative evaluation of the efficacy of light amplification by the stimulated emission of radiation, desensitizing agents, and their combined effect on dentinal hypersensitivity in cuspids and bicuspids – In Vivo Study. J Conserv Dent 2022;25:363-8.
INTRODUCTION

Dentin hypersensitivity (DHS) represents a pain of short and sharp nature but of rapid onset, this arises from exposed dentin in response to osmotic, thermal, chemical, or mechanical stimuli which cannot be attributed to any other form of dental disease or defect. [1] DHS has prevalence of 45%–57%, and higher incidence has been documented in 20–40 years age group. The teeth most commonly affected are canines and premolars. [2]

The proximity of dentin to pulp accounts for its higher sensitivity naturally. This inherent sensitivity usually is not a problem until the tissues that cover dentin, such as enamel, cementum, and gingival tissue, are lost.

The etiology of DHS is multifactorial. Various theories have been put forth to explain the mechanism of dentinal hypersensitivity. The hydrodynamic theory given by Brännström in 1964 is the most accepted theory. [1] It states that an immediate pain response occurs when any stimuli cause rapid displacement of dentinal fluid within the tubules resulting in excitation of intradental nerves. Based on this theory, successful treatment of DHS depends on preventing or reducing fluid flow within the tubules. Thus, using different means to seal the open orifices of the dentinal tubule is the chief requirement.

Some studies have reported that light amplification by the stimulated emission of radiation (LASER) is effective in the treatment of DHS. Matsumoto et al. were the first to use Nd: YAG LASER in 1985 for the treatment of DHS. After which many LASER such as CO₂, Er: YAG, HeNe, Er, and Cr: YSGG have been used for desensitization. However, very few studies are available with 980-nm diode laser for dentin desensitization.

Biosilicate, a ceramic material made up of amorphous sodium calcium phosphosilicate, is highly reactive in water, and as the particle size is fine hence can occlude dentinal tubules. [3]

Hydroxyapatite has a crystal structure similar to human teeth. Many researchers have explored the effects of hydroxyapatite in dentin hypersensitivity, remineralization of early enamel lesions, and whitening. [4]

Several agents and therapies have been tried for the treatment of hypersensitivity, but none of them have proven completely effective. Hence, the aim of this study is to compare the efficacy of LASER, desensitizing agents, and their combined effect on dentinal hypersensitivity.

MATERIALS AND METHODS

The research protocol for the present study was initially submitted to the Ethical Committee, after the approval, informed consent was obtained from the patients before participation.

Inclusion criteria

Patients with a sensitivity score of 2 or more to the air blast stimulus as recorded on verbal analog scale, cuspsids, and bicuspids were included in the study.

Exclusion criteria

Carious teeth, restored teeth, and patients undergoing desensitizing therapy were excluded from the study.

DHS is classified as mild, moderate, or severe based on the intensity of pain, [4] which is the measured response from the patients on the application of external stimulus such as air blast stimulus and recorded on the verbal analog scale as told by the patient.

Five groups with 12 patients in each were formed. Air blast stimulus was given for 10 s from a distance of 1 cm on the mentioned tooth, and the sensitivity score was recorded [Figure 1]. Isolation was done with the cotton rolls and then with the help of an applicator tip, desensitizing agent was applied.

Following treatment was given in each group:

- Group I: Aclaim, containing nanohydroxyapatite, was applied on the surface of the tooth and left for 15 min and then patient was asked to rinse
- Group II: Vantej, containing biosilicate, was applied on the surface of the tooth and left for 15 min and then patient was asked to rinse
- Group III: LASER application was done with 0.5 W,

![Figure 1: Verbal analog scale (0: No sensitivity; 1–3: Mild sensitivity; 4–6: Moderate sensitivity; and 7–10: Severe sensitivity)](image-url)

![Figure 2: Treatment procedure. (a) Air blast stimulus. (b) Desensitizing agent applied. (c) Desensitizing agent left. (d) LASER application for 15 min. LASER: Light amplification by stimulated emission of radiation)](image-url)
continuous noncontact mode, applied 2–3 mm away from tooth surface for 60 s, each site received two applications

- Group IV: Aclaim (nanohydroxyapatite) for 15 min. Then LASER application was done with 0.5 W, continuous noncontact mode, applied 2–3 mm away from tooth surface for 60 s, each site received two applications of 1 min and then the patient was asked to rinse as shown in Figure 2.
- Group V: Vantej (biosilicate) for 15 min and then LASER application was done with the same parameters as mentioned above and then the patient was asked to rinse as shown in Figure 2.

After the above treatment again, the air blast stimulus was given on the surface of the tooth for 10 s from a distance of 1 cm, and the sensitivity score was recorded in all the patients as recorded from patients in Table no 2. Procedure was repeated at 1st, 7th, and 14th day. The scores were recorded from each of the 12 patients of a group, and the same was done for all the groups as given in Table 1, and their mean, standard deviation (SD), and \( P \) value were calculated. Statistical analysis was done using SPSS (Statistical Package for the Social Sciences) Version 15.0 Statistical Analysis Software. Analysis of the result was done using descriptive statistics, and comparisons were made between treatment groups with respect to adaptation parameters. Discrete (categorical) data were summarized as in proportions and percentages (%). Proportions were compared using Chi-square test. The values were denoted in number (%) and mean ± SD. The ANOVA test was used to compare the within- and between-group variances among the study groups. ANOVA provided “\( F \)” ratio, where higher inter-group difference presented with a higher \( F \) value.

**RESULTS**

On comparing the tooth sensitivity among various groups, it was found that the before treatment, the tooth sensitivity score was almost equal in all the study groups as ANOVA test showed no significant difference among the groups (\( P = 0.979 \)).

Immediately after just applying the treatment, the tooth sensitivity score was maximally reduced to 2.92 ± 1.24 in Group IV which was followed by Group V where it was reduced to 4.92 ± 1.98. The minimum reduction was seen in Group II with a mean of 5.75 ± 1.60. ANOVA test showed a significant difference among the groups (\( P = 0.001 \)). Hence, according to sensitivity reduction, the quality of various groups can be arranged into Group IV > Group V > Group III > Group I > Group II.

One week after applying the treatment, the tooth sensitivity score was maximally reduced to 1.58 ± 1.00 in Group IV which was followed by the Group V where it was reduced to 3.25 ± 1.42. The minimum reduction was seen in Group II with a mean of 4.50 ± 1.45. Significant difference was there among the groups (\( P < 0.001 \)). Hence, according to sensitivity reduction, the quality of various groups can be arranged into Group IV > Group V > Group III > Group I > Group II.

Fourteen days after applying the treatment, the tooth sensitivity score was maximally reduced to 0.67 ± 0.78 in Group IV followed by Group V where it was reduced to 1.58 ± 1.31. The minimum reduction was seen in Group II with a mean of 3.25 ± 1.06. Significant difference was seen among the groups (\( P < 0.001 \)). Hence, according to sensitivity reduction, the quality of various groups can be arranged into Group IV > Group V > Group III > Group I > Group II.

\[
F = \frac{\text{Mean of Sum of Between Group Differences}}{\text{Mean of Sum of within Group Differences}}; \quad \text{“}P\text{” is level of significance}
\]

**DISCUSSION**

DHS is a problematic condition for dentists to effectively manage. It also affects the quality of life of those suffering with it.\[^{[9]}\]

Over the years, number of treatment regimens has been recommended. Specific importance has been given on dentifrices containing various active ingredients, which act either by blocking the hydrodynamic mechanism or the neural response.\[^{[6]}\]

Comparison was made in this study between two dentifrices containing nanohydroxyapatite, biosilicates with diode LASER, and their combination with LASER. All the materials used in the study were able to reduce dentinal

**Table 1: Composition and method of application of various materials used**

| Material | Composition | Mode of application |
|----------|-------------|---------------------|
| Aclaim   | Nanohydroxyapatite - Active ingredient | Pea-sized desensitizing agent was taken on the applicator tip and applied on the surface of the tooth, covering the surface and was left for 15 min |
| Vantej   | Biosilicate (calcium sodium phosphosilicate) - Active ingredient | Pea-sized desensitizing agent was taken on the applicator tip and applied on the surface of the tooth, covering the surface and was left for 15 min |
| LASER    |             | LASER application was done with 0.5 W, continuous noncontact mode, applied 2–3 mm away from tooth surface for 60 s, each site received two applications |

LASER: Light amplification by stimulated emission of radiation
Table 2: Verbal Analogue Scale score recorded from the patients

| Group | Sample number | Pretreatment score | Immediate treatment score | Treatment score after 1 week |
|-------|---------------|--------------------|----------------------------|----------------------------|
| 1     | 1             | 10                 | 6                          | 3                          |
|       | 2             | 8                  | 4                          | 3                          |
|       | 3             | 5                  | 6                          | 4                          |
|       | 4             | 7                  | 5                          | 2                          |
|       | 5             | 9                  | 6                          | 5                          |
|       | 6             | 10                 | 4                          | 2                          |
|       | 7             | 6                  | 3                          | 2                          |
|       | 8             | 8                  | 5                          | 3                          |
|       | 9             | 4                  | 9                          | 4                          |
|       | 10            | 9                  | 7                          | 4                          |
|       | 11            | 5                  | 7                          | 5                          |
|       | 12            | 6                  | 3                          | 1                          |
| Mean±SD | 7.25±2.05     | 5.42±1.78          | 3.17±1.27                  |

| 2     | 1             | 9                  | 7                          | 4                          |
|       | 2             | 8                  | 6                          | 3                          |
|       | 3             | 5                  | 4                          | 3                          |
|       | 4             | 8                  | 6                          | 4                          |
|       | 5             | 10                 | 8                          | 4                          |
|       | 6             | 6                  | 5                          | 3                          |
|       | 7             | 5                  | 5                          | 2                          |
|       | 8             | 9                  | 7                          | 4                          |
|       | 9             | 4                  | 3                          | 1                          |
|       | 10            | 8                  | 6                          | 3                          |
|       | 11            | 6                  | 4                          | 3                          |
|       | 12            | 10                 | 5                          | 5                          |
| Mean±SD | 7.33±2.06     | 5.75±1.60          | 3.25±1.06                  |

| 3     | 1             | 8                  | 6                          | 2                          |
|       | 2             | 6                  | 5                          | 1                          |
|       | 3             | 10                 | 3                          | 2                          |
|       | 4             | 8                  | 6                          | 5                          |
|       | 5             | 9                  | 7                          | 3                          |
|       | 6             | 5                  | 8                          | 2                          |
|       | 7             | 5                  | 5                          | 1                          |
|       | 8             | 6                  | 5                          | 2                          |
|       | 9             | 10                 | 3                          | 2                          |
|       | 10            | 8                  | 6                          | 3                          |
|       | 11            | 9                  | 4                          | 2                          |
|       | 12            | 5                  | 3                          | 0                          |
| Mean±SD | 7.42±1.93     | 5.08±1.62          | 2.08±1.24                  |

| 4     | 1             | 10                 | 4                          | 0                          |
|       | 2             | 9                  | 4                          | 1                          |
|       | 3             | 6                  | 3                          | 0                          |
|       | 4             | 7                  | 3                          | 1                          |
|       | 5             | 5                  | 2                          | 0                          |
|       | 6             | 10                 | 0                          | 0                          |
|       | 7             | 8                  | 4                          | 2                          |
|       | 8             | 4                  | 2                          | 0                          |
|       | 9             | 9                  | 3                          | 1                          |
|       | 10            | 6                  | 4                          | 2                          |
|       | 11            | 5                  | 2                          | 0                          |
|       | 12            | 7                  | 4                          | 1                          |
| Mean±SD | 7.17±2.04     | 2.92±1.24          | 0.67±0.78                  |

| 5     | 1             | 5                  | 4                          | 1                          |
|       | 2             | 4                  | 3                          | 0                          |
|       | 3             | 6                  | 5                          | 0                          |
|       | 4             | 10                 | 9                          | 2                          |
|       | 5             | 8                  | 6                          | 3                          |
|       | 6             | 9                  | 6                          | 4                          |
|       | 7             | 5                  | 3                          | 3                          |
|       | 8             | 8                  | 6                          | 2                          |
|       | 9             | 6                  | 4                          | 1                          |
|       | 10            | 10                 | 7                          | 2                          |
|       | 11            | 7                  | 4                          | 0                          |
|       | 12            | 5                  | 2                          | 1                          |
| Mean±SD | 6.07±2.07     | 3.02±1.24          | 1.12±0.78                  |

Table 2: Contd...

| Group | Sample number | Pretreatment score | Immediate treatment score | Treatment score after 1 week |
|-------|---------------|--------------------|----------------------------|----------------------------|
|       | 12            | 5                  | 2                          | 1                          |

| Mean±SD | 6.92±2.07     | 4.92±1.98          | 1.58±1.31                  |
| F       | 0.11          | 5.35              | 9.00                      |
| P       | 0.979         | 0.001             | <0.001                    |

SD: Standard deviation

Shetty et al. found that 25% hydroxyapatite in a liquid slurry and 100% in a dry sol version gave significant desensitization. Whereas higher concentration causes enhanced better penetration of particles into the tubules. Maximum patients obtained relief with just one or two applications of hydroxyapatite in the study. Shetty et al. also concluded that hydroxyapatite is an effective desensitizing agent, which provides quick and sustained relief from symptoms when compared with other agents, although hypersensitivity symptoms were reduced in all the treatment groups.[7]

Small nanohydroxyapatite crystals mimic the size of natural dentinal hydroxyapatite (20 nm).[7] This study suggests that nanohydroxyapatite can be an effective ingredient in toothpaste for reducing dentinal hypersensitivity. Joshi et al. in their study found that biosilicate application was more effective in providing relief from dentinal hypersensitivity when compared with hydroxyethyl methacrylate and glutaraldehyde (Gluma Desensitizer).[8]

According to Pradeep et al., the biosilicate group presented effectiveness at reducing dentinal hypersensitivity because calcium sodium phosphosilicate (NovaMin) is bioactive glass and belongs to class of highly biocompatible materials that were formerly developed as bone-regenerative materials. There is an exchange of hydrogen cations (H+ or H3O+) from saliva with sodium ions (Na+) of calcium sodium phosphosilicate particles immediately. This ionic interchange allows calcium (Ca2+) and phosphate (PO4 3−) ions to be released from the particle structure. It results in transient increase in pH which stimulates the precipitation of calcium and phosphate from NovaMin and from saliva to form a calcium phosphate (Ca-P) layer on the tooth surfaces. Crystallization of this layer results into hydroxyapatite, that is chemically and structurally similar to biological apatite.[9]

LASER plays a noticeable role in treating hypersensitive dentin and providing consistent and repeated results.
It can be the result of the melting effect of diode LASER on surface dentin. Portion of LASER energy absorbed by mineral structures of dentin cause sufficient increase in temperature to result in thermochemical ablation and melting of the dentin tissue.

Diode LASER (Doctor Smile) provided good results in the treating dentinal hypersensitivity; this finding is also supported by the results of research by Umberto et al.

Parameter of the power used in this study was 1W, which is in support with the study by Liu et al. Their study demonstrated that it is a suitable parameter for the 980-nm diode LASER.

The use of He–Ne and GaAlAs LASER has presented a decrease in sensitivity to thermal and tactile stimuli. Similarly, in the present study, diode LASER therapy resulted in a considerable decrease in sensitivity after the first application and this is supported by Matsumoto et al. It was also observed that teeth, which presented exacerbated sharp pain during air blasting and continuous discomfort after the removal of these stimulations before desensitizing treatments, were accomplished, provided an accentuated decrease of painful sensation immediately after the first application of diode LASER and even 1 week after initial irradiation. The higher efficacy may be because of depressed neural transmission within the pulp, rather than changes in exposed dentin surface, as observed with other treatment modalities. Moreover, LASER therapy may initiate the normal physiological cellular functions that is the production of sclerotic dentin will be increased, which will promote the obliteration of dentinal tubules internally.

Another mode of the effect of LASER on dentin is the absorption of thermal energy, leading to LASER-induced blockage or narrowing of dentinal tubules. Direct nerve analgesia was suggested as a possible mechanism by Whitters et al. However, Funato et al. suggested thermal effects on microcirculation. In their study, some vascular changes were observed shortly after the LASER application was done, which included vascular coagulation, degeneration, vascular shrinkage, and stasis.

Biostimulation using thermal energy and light sources of low-level LASER can be another approach. It works on the regulation of the cell physiological functions, analgesia effect, bioregulation of the cell response, and presents anti-inflammatory effects. This study showed that LASER was effective as the pain level decreased over time. The analgesic effect of therapeutic LASER affects the release of alpha- and β-endorphins that bind to receptors from the nociceptive system causing analgesia due to the block transmission of the input substances.

Few cases of dentinal hypersensitivity may resolve with desensitizing dentifrices, few with office methods such as LASER and further some cases may require the combination of home and office method treatment modalities. In the present study, desensitizing agents plus the application of LASER proved to be more efficient in reducing dentinal hypersensitivity. Umberto et al. found diode laser to be more effective in reducing dentinal hypersensitivity when used in combination with desensitizing agents.

Better performance of combined treatment can be likely because of the higher adhesion to the dentinal tubules in the presence of LASER energy; LASER-induced superficial melting provides longer tubule occlusion by desensitizing agent promoting the reduction of dentinal hypersensitivity-related pain. There is a synergism between LASER and desensitizing agents.

According to Arulmozhi et al., desensitizing agents in conjunction with LASER was claimed to penetrate the tubules for up to 10 mm, which is a reason for reduced hypersensitivity, same study presents that activating the desensitizing agents with LASER and analyzing through SEM reveals diminished tubule diameter than when desensitizing agents are used alone.

Although the initial price of the LASER machine is high in comparison to desensitizing agents which are cheap and easy to apply, with the possibility of multiple applications, but LASER is cost-effective in the long-term.

In the present study, all the groups provided relieve in dentinal hypersensitivity, but the group containing nanohydroxyapatite plus LASER and the group containing biosilicate plus LASER provided much better relief to the patients as compared to the other groups in which LASER or desensitizing agents such as nanohydroxyapatite or biosilicates were used alone.

**CONCLUSION**

Within the limitations of the present study, we conclude the following:

Promising desensitizing potential was shown by all of the investigated treatments though the mechanism of action varied. The patients who got treated for dentinal hypersensitivity using nanohydroxyapatite plus LASER presented with maximum relief from hypersensitivity within a period of 14 days. The quality of various desensitizing agents according to ranks in relieving dentinal hypersensitivity was found to be:

Group IV > Group V > Group III > Group I > Group II.

**Financial support and sponsorship**

Nil.
Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Davari A, Ataei E, Assarzadeh H. Dentin hypersensitivity: Etiology, diagnosis and treatment; a literature review. J Dent (Shiraz) 2013;14:136‑45.
2. Miglani S, Aggarwal V, Ahuja B. Dentin hypersensitivity: Recent trends in management. J Conserv Dent 2010;13:218‑24.
3. Skallevold HE, Rokaya D, Khurshidand Z, Zafar MS. Bioactive glass applications in dentistry. Int J Mol Sci 2019;20:5960.
4. Yuan P, Shen X, Liu J, Hou Y, Zhu M, Huang J, et al. Effects of dentifrice containing hydroxyapatite on dentinal tubule occlusion and aqueous hexavalent chromium cations sorption: A preliminary study. PLoS One 2012;7:e45283.
5. Gillam D. Diagnosis and management of dentine sensitivity. Dent Nurs 2013;9(6):320‑7.
6. Maji P, Murthy KR. Clinical efficacy of four interventions in the reduction of dentinal hypersensitivity: A 2-month study. Indian J Dent Res 2016;27:477‑82.
7. Low SB, Allen ER Kontogiorgos ED. Reduction in dental hypersensitivity with nano-hydroxyapatite, potassium nitrate, sodium monofluorophosphate and antioxidants. Open Dent J 2015;9:92‑7.
8. Joshi S, Gowda AS, Joshi C. Comparative evaluation of NovaMin desensitizer and Gluma desensitizer on dentinal tubule occlusion: A scanning electron microscopic study. J Periodontal Implant Sci 2013;43:269‑75.
9. Burwell AK, Litkowski LT, Greenspan DC. Calcium sodium phosphosilicate (NovaMin®): Remineralization potential. Adv Dent Res 2009;21:35‑9.
10. Jain PR, Naik GD, Uppor SA, Kamath DG. Diode laser and fluoride varnish in the management of dentin hypersensitivity. J Interdiscip Dent 2015;5:71‑4.
11. Matsumoto K, Funai H, Wakabayashi H, Oyoama T. Study on the treatment of hypersensitive dentine by GaAlAs laser diode. Jpn J Conserv Dent 1985;28:766.
12. Hashim NT, Gasmalla BG, Sabahelkheir AH, Awooda AM. Effect of the clinical application of the diode laser (810 nm) in the treatment of dentine hypersensitivity. BMC Res Notes 2014;7:31.
13. Ozlem K, Esad GM, Ayse A, Aslihan U. Efficiency of lasers and a desensitizer agent on dentin hypersensitivity treatment: A clinical study. Niger J Clin Pract 2018;21:225‑30.
14. Umberto R, Claudia R, Gaspare P, Gianluca T, Alessandro del V. Treatment of dentine hypersensitivity by diode laser: A clinical study. Int J Dent 2012;2012:858950.