Research Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2021;11:2s:327-334.

Comparative Evaluation of Diode Laser and Various Dentin Desensitizers on Dentinal Tubule Occlusion: A Scanning Electron Microscopic Study

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ABSTRACT

Background: Various treatment modalities have been put forth in order to occlude the dentinal tubules in the treatment of dentinal hypersensitivity. The present study aims to evaluate and assess dentinal tubule occlusion using diode laser alone and in combination with NovaMin (Sensodyne Repair & Protect), Pro-Argin (Colgate Sensitive Pro-Relief), and Glutaraldehyde (Gluma desensitizer) using a Scanning Electron Microscope (SEM).

Materials and Methods: Forty-eight extracted teeth were collected, dentinal blocks were prepared and etched with 17% Ethylenediamine tetraacetic acid (EDTA). Extracted teeth were divided into four groups: Group 1- NovaMin application followed by laser irradiation, Group 2- Pro-Argin application followed by laser irradiation, Group 3- Gluma desensitizer application followed by laser irradiation, Group 4- Application of diode laser alone. Assessment of dentinal tubule occlusion was done using Scanning Electron Microscopic analysis.

Results: Dentinal blocks treated with Gluma + Laser demonstrated advanced tubule occlusion. A statistically significant difference was observed between the four groups with respect to the mean number of tubules at both 1000X and 2000X magnification except partially occluded and mostly occluded at 2000X magnification.

Conclusion: All four groups demonstrated dentinal tubule occlusion. However, Gluma along with Laser showed more occlusion followed by Laser alone, followed by Pro-Argin with Laser and NovaMin with laser groups.

Keywords: Dentifrices; Dentin; Dentin sensitivity; Lasers; Microscopy.

INTRODUCTION

Dentinal hypersensitivity (DH) is characterized by a short sharp pain arising from exposed dentin in response to stimuli typically thermal, tactile, evaporative, osmotic or chemical, and which cannot be ascribed as any other form of dental defect or disease.[1] It compromises the quality of life, and it is the primary cause that affects 8%-35% of the general population.[2] Women are more frequently affected than males, with the majority of sufferers aged between 20 to 40 years.[3]

Dentin is a primary supporting structure of the tooth that consists of an organic component containing collagen fibers in the collagen matrix and an inorganic component comprised of hydroxyapatite crystals. Approximately, there are 30,000 to 40,000 tubules per square millimeter, which can transmit pain to the pulp if dentin is exposed. Each tubule contains a Tomes fiber (cytoplasmic cell process) and an odontoblasic process that communicates with the pulp. Dentinal

Received: Jan. 18, 2021**:** **Accepted**: Feb. 12, 2021
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pISSN 2278-0076
eISSN 2321-9270

tubules consists of two types of nerve fibers, myelinated (A-fibers) and unmyelinated (C fibers), of which A fibers are responsible for the sensation of dentin hypersensitivity.[4] Three major mechanisms of dentinal hypersensitivity have been proposed so far: neural theory, odontoblastic transduction theory, and hydrodynamic theory. The currently accepted hypothesis being the hydrodynamic theory proposed by Brannstrom (1964), who suggested that exposed dentin with patent tubules allows the movement of tubule fluid, which leads to dentin sensitivity.[1]

The etiology of dentinal hypersensitivity can stem from various sources, such as abfraction, abrasion, erosion, traumatic oral hygiene, and periodontal disease. Other factors include various deleterious habits, poor oral hygiene, chewing tobacco, excessive occlusal force, premature occlusal contact, and gastroesophageal reflux.[4]

To avert the stimulation of hypersensitivity, various treatment modalities have been introduced, which includes at-home and in-office treatments. A wide scope of treatment modalities are available for the management of dentinal hypersensitivity, such as desensitizing toothpaste, fluoride iontophoresis, varnishes, LASERs, and remineralizing agents. However, desensitizing dentifrices are the most accepted and widely used measure.

Various desensitizing agents are used depending on the mechanism of action, such as dentin adhesive sealers (fluoride varnishes, dentin-bonding agents), agents plugging dentinal tubules (sodium fluoride, stannous fluoride, and bioactive glass), agents forming protein precipitates (silver nitrate), and nerve-desensitizing agents (potassium nitrate and strontium nitrate). Recently, it has been proposed that irradiation with low-output power lasers of affected teeth has significant anti-inflammatory actions. Diode laser generates continuous wave without overheating. The combined effects of various desensitizing agents with Laser have shown reduced discomfort of dentinal hypersensitivity.[5]

NovaMin is a bioactive glass advocated for the treatment of dentin hypersensitivity. It is a biocompatible material that forms hydroxyapatite crystals when exposed to water and saliva, thereby occluding the exposed dentinal tubules.[3]

Pro-Argin has been shown to occlude and seal the exposed tubules physically. The latest research suggests that at physiologic pH, arginine and calcium carbonate binds to the negatively charged dentin to form a calcium-rich layer in dentinal tubules, thereby blocking pain conduction.[6]

Gluma desensitizer in an aqueous solution composed of 5% glutaraldehyde and 35% hydroxyethyl methacrylate. It has been suggested that gluma reacts with the plasma proteins present in the dentinal fluid, thereby occluding the dentinal tubules.[3]

Thus the present study aimed to compare the effectiveness of desensitizing agents along with Laser in dentin tubule occlusion using a Scanning Electron Microscope.

MATERIALS AND METHODS

In the present study, a total of forty-eight human extracted molars were collected from adult patients of age ranging from 18-50 years. All the extracted teeth were collected from the Department of Oral and Maxillofacial Surgery, Sree Sai Dental College & Research Institute, Srikakulam, Andhra Pradesh. Extracted teeth were divided into four groups, each group consisting of 12 extracted teeth. These teeth were stored in saline until further treatments were performed. Inclusion Criteria are age range between 18 - 50 years, extracted human molars, and teeth devoid of restorations. Teeth with any pulpal involvement (caries), teeth with wasting diseases, teeth with developmental anomalies, and teeth with fractures were excluded from the study.

The selected teeth were randomly divided into the following four groups, with each group containing 12 samples (n=12).

Group 1- Novamin application (Sensodyne Repair & Protect) followed by laser irradiation.

Group 2- Pro- Argin (Colgate Sensitive Pro-Relief) application followed by laser irradiation.

Group 3- Gluma desensitizer (Kulzer Gluma desensitizer) application followed by laser irradiation

Group 4- Application of diode laser alone.

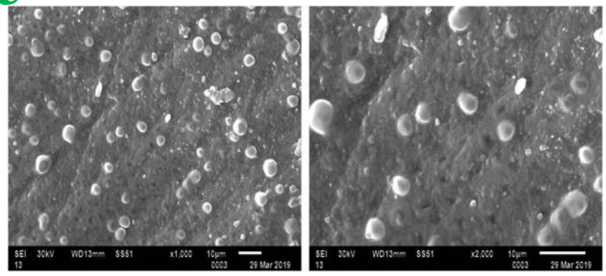

Fig 1: Photomicrographs of NovaMin + Laser group at a) 1000X and b) 2000X magnification.

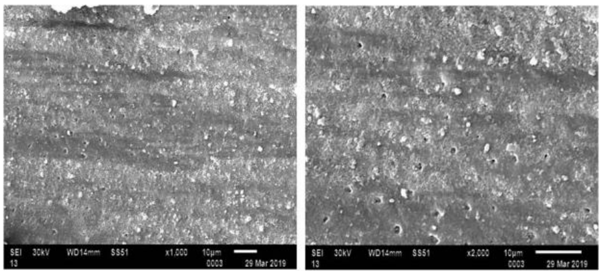

Fig 2: Photomicrographs of Pro-Argin + Laser group at a) 1000X and b) 2000X magnification.

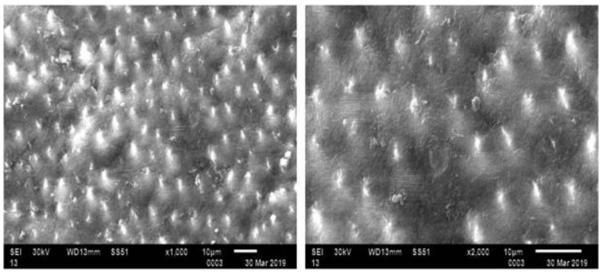

Fig 3: Photomicrographs of Gluma + Laser group at a) 1000X and b) 2000X magnification.

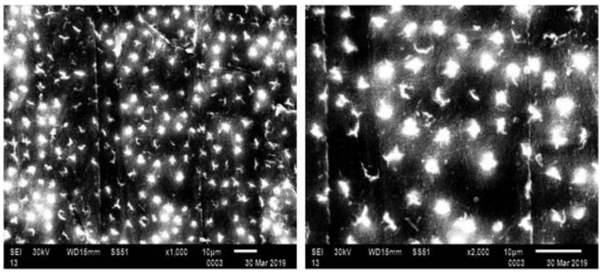

Fig 4: Photomicrographs of Laser group at a) 1000X and b) 2000X magnification

The teeth were thoroughly cleaned with normal saline prior to the treatment. A modified dentin disc model was used similar to that proposed by Gillam et al.[7] The teeth were carefully sectioned using a diamond disc mounted on a straight handpiece. The first cut was made perpendicular to the long axis of the tooth just above the cementoenamel junction, and the second cut was made parallel to the first to remove the coronal enamel and to expose the flat dentin surface to obtain 3 mm thick dentin discs. The remaining enamel around the blocks was removed, creating specimens measuring 5mm× 5mm× 3mm. Forty-eight such dentin discs were prepared, which were free of enamel. All the obtained discs were then polished with 400 grit silica paper for 30 seconds to create a standard smear layer. This smear layer was then removed by applying 17% EDTA gel onto the dentine discs for 5 minutes, followed by rinsing them with distilled water.

Laser Protocol:

Laser irradiation of dentin discs was done using a Diode laser (ZOLAR) at a wavelength of 810 nm beam with a power setting of 1 W. A Non-contact mode with a pulsed length was used, maintaining a 1.5 mm gap between the fiber optic tip and teeth, and was irradiated for 60 seconds. All laser safety precautionary measures were followed.

Experimental Procedure:

Group 1- The dentin discs were initially brushed with Novamin containing toothpaste for 6 minutes, followed by Laser irradiation for 60 sec. (Figure 1)

Group 2- Dentin discs were brushed with Pro-Argin formulated toothpaste for 6 minutes followed by Laser irradiation for 60 sec. (Figure 2)

Group 3- Gluma is applied and is left to dry for 60 sec. It is then rinsed thoroughly, and Laser irradiation is done for 60 sec. (Figure 3)

Group 4- Laser irradiation in a non-contact mode for 60 sec. (Figure 4)

Teeth were washed with distilled water and were subjected to SEM analysis the same day after dehydration.

SEM Analysis:

The samples were mounted on a SEM stub and were gold coated with the help of a sputter coating machine (JEOL, JFC-1600, Auto Fine Coater). This was done to ensure the conductivity of the sample surface. Without sputtering, the electron charges tend to bombard the sample surface, thereby resulting in blurred images.

Table 1: Comparison of four groups (1,2,3 and 4) with respect to mean number of tubules at each magnification (1000X and 2000X) in each variable.

Variables	Magnification	Group1 (Mean±SD)	Group 2 (Mean±SD)	Group 3 (Mean±SD)	Group 4 (Mean±SD)	p value
Occluded	1000X	8.50 ± 4.10	17.83 ± 11.26	45.08 ± 15.54	39.83 ± 27.82	0.0001*
	2000X	8.00 ± 4.11	14.08 ± 10.47	23.83 ± 7.32	19.25 ± 13.66	0.0015*
Mostly Occluded	1000X	5.42 ± 3.23	6.33 ± 2.15	11.08 ± 7.30	15.75 ± 7.42	0.0001*
	2000X	5.08 ± 3.58	6.17 ± 3.13	5.33 ± 3.11	5.25 ± 3.11	0.8485
Partially Occluded	1000X	9.08 ± 4.56	6.67 ± 2.61	11.50 ± 9.94	18.75 ± 9.35	0.0014*
	2000X	7.42 ± 3.68	7.00 ± 2.30	6.75 ± 5.85	6.58 ± 3.32	0.9604
Mostly Unoccluded	1000X	5.42 ± 3.53	4.83 ± 2.29	7.00 ± 6.27	17.58 ± 10.33	0.0001*
	2000X	3.83 ± 2.98	5.33 ± 2.35	3.67 ± 3.65	6.17 ± 5.44	0.3147
Unoccluded	1000X	42.58 ± 11.93	38.67 ± 8.87	22.42 ± 9.77	10.50 ± 4.68	0.0001*
	2000X	37.42 ± 13.81	30.92 ± 11.63	18.33 ± 10.77	7.00 ± 4.26	0.0001*
Total	1000X	71.00 ± 13.56	74.33 ± 15.06	97.08 ± 18.70	102.42 ± 35.78	0.0018*
	2000X	61.75 ± 19.37	63.50 ± 16.64	57.92 ± 14.02	44.25 ± 15.33	0.0268*

***p<0.05**

Table 2: Comparison of two magnifications (1000X and 2000X) with mean number of tubules in four groups (1,2,3,4) at each of property by independent t test.

Groups	Property	1000X Mean ± SD	2000X Mean ± SD	p-value
Group 1	Occluded	8.50 ± 4.10	8.00 ± 4.11	0.7683
	Mostly Occluded	5.42 ± 3.23	5.08 ± 3.58	0.8130
	Partially Occluded	9.08 ± 4.56	7.42 ± 3.68	0.3353
	Mostly Unoccluded	5.42 ± 3.53	3.83 ± 2.98	0.2476
	Unoccluded	42.58 ± 11.93	37.42 ± 13.81	0.3374
	Total	71.00 ± 13.56	61.75 ± 19.37	0.1891
Group 2	Occluded	17.83 ± 11.26	14.08 ± 10.47	0.4073
	Mostly Occluded	6.33 ± 2.15	6.17 ± 3.13	0.8804
	Partially Occluded	6.67 ± 2.61	7.00 ± 2.30	0.7427
	Mostly Unoccluded	4.83 ± 2.29	5.33 ± 2.35	0.6027
	Unoccluded	38.67 ± 8.87	30.92 ± 11.63	0.0800
	Total	74.33 ± 15.06	63.50 ± 16.64	0.1087
Group 3	Occluded	45.08 ± 15.54	23.83 ± 7.32	0.0003*
	Mostly Occluded	11.08 ± 7.30	5.33 ± 3.11	0.0200*
	Partially Occluded	11.50 ± 9.94	6.75 ± 5.85	0.1677
	Mostly Unoccluded	7.00 ± 6.27	3.67 ± 3.65	0.1256
	Unoccluded	22.42 ± 9.77	18.33 ± 10.77	0.3412
	Total	97.08 ± 18.70	57.92 ± 14.02	0.0001*
Group 4	Occluded	39.83 ± 27.82	19.25 ± 13.66	0.0313*
	Mostly Occluded	15.75 ± 7.42	5.25 ± 3.11	0.0002*
	Partially Occluded	18.75 ± 9.35	6.58 ± 3.32	0.0003*
	Mostly Unoccluded	17.58 ± 10.33	6.17 ± 5.44	0.0026*
	Unoccluded	10.50 ± 4.68	7.00 ± 4.26	0.0686
	Total	102.42 ± 35.78	44.25 ± 15.33	0.0001*

***p<0.05**

Table 3: Intergroup comparisons of four groups (1, 2, 3, 4) with respect to mean number of tubules at each magnification (1000X and 2000X) in each variable.

Property	Magnification	Grp 1 vs Grp 2 p value	Grp 1 vs Grp 3 p value	Grp 1 vs Grp 4 p value	Grp 2 vs Grp 3 p value	Grp 2 vs Grp 4 p value	Grp 3 vs Grp 4 p value
Occluded	1000X	p=0.5413	p=0.0002*	p=0.0004*	p=0.0018*	p=0.0145*	p=0.8740
	2000X	p=0.4136	p=0.0013*	p=0.0303*	p=0.0748	p=0.5543	p=0.6471
Mostly Occluded	1000X	p=0.9775	p=0.0743	p=0.0004*	p=0.1712	p=0.0010*	p=0.1834
	2000X	p=0.8451	p=0.9976	p=0.9993	p=0.9218	p=0.8992	p=0.9999
Partially Occluded	1000X	p=0.8497	p=0.8497	p=0.0119*	p=0.3788	p=0.0013*	p=0.0865
	2000X	p=0.9942	p=0.9768	p=0.9563	p=0.9988	p=0.9942	p=0.9997
Mostly Unoccluded	1000X	p=0.9961	p=0.9296	p=0.0003*	p=0.8401	p=0.0002*	p=0.0013*
	2000X	p=0.7669	p=0.9996	p=0.4406	p=0.7045	p=0.9490	p=0.3796
Unoccluded	1000X	p=0.7251	p=0.0002*	p=0.0002*	p=0.0006*	p=0.0002*	p=0.0141*
	2000X	p=0.4556	p=0.0006*	p=0.0002*	p=0.0307*	p=0.0002*	p=0.0607
Total	1000X	p=0.9837	p=0.0342*	p=0.0076*	p=0.0795	p=0.0198*	p=0.9381
	2000X	p=0.9938	p=0.9404	p=0.0584	p=0.8396	p=0.0313*	p=0.1915

***p<0.05**

The sputtered samples were then transferred to the SEM machine (JEOL, JSM-6610LV) and were mounted. Vaccumization of the chamber was done to remove the air molecules in the microscope. This ensured the prevention of collision of electrons to the gas molecules, thereby allowing the electrons to reach the sample surface directly.

Image processing was then performed under the scanning electron microscope, and photomicrographs were obtained from the central portion of the tooth. Photographs were taken at 30kV and were evaluated at 1000X and 2000X magnifications.

The images were then assessed by two trained examiners to score the level of tubule occlusion. Both the examiners analyzed the photomicrographs together in order to eliminate the inter-examiner variability. The tubule occlusion classification scoring system used was:[8,9]

(1) Occluded (100% of tubules occluded)

(2) Mostly occluded (50–<100% of tubules occluded)

(3) Partially occluded (25–<50% of tubules occluded)

(4) Mostly unoccluded (<25% of tubules occluded)

(5) Unoccluded (0%, no tubule occlusion)

The mean value of tubule occlusion evaluated by two examiners was considered for the analysis.

Statistical Analysis:

The data obtained for the study were statistically analyzed using Statistical Package for Social Sciences (SPSS) version 20 software (IBM SPSS Statistics for Windows version 20, Armonk, NY, USA). One way ANOVA was performed to compare four groups with respect to the mean number of tubules at each magnification (1000X and 2000X) in each criteria. Tukey's multiple post hoc test was performed to assess intergroup comparison with respect to the mean number of tubules at each magnification (1000X and 2000X). Comparison of two magnifications (1000X and 2000X) in 4 groups was evaluated using the Independent t-test.

RESULTS

A statistically significant difference was observed between four groups (1,2,3,4) with respect to the mean number of tubules at each magnification (1000X and 2000X) in each variable except mostly occluded, partially occluded, and mostly unoccluded with 2000X magnification. (Table 1)

In the present study, the number of occluded tubules was significantly higher in groups 3 and 4 at 1000X magnification. In group 1 and 2 no significant difference was seen at both magnifications. (Table 2) On intergroup comparison, a significant difference of occluded tubules was seen between group 1 & group 3, group 1 & group 4, group 2 & group 3, group 2 and group 4. ($p<0.05$) (Table 3)

The number of mostly occluded tubules were significantly higher in group 3 and 4 at 1000X magnification. (Table 2) On intergroup comparison of mostly occluded tubules, significant difference was seen between group 1 & group 4, group 2 & group 4. ($p<0.05$) (Table 3)

A significant difference of Partially occluded tubules between both magnifications was observed in Group 4. In group 1, 2 and 3 no significant difference was seen at both magnifications in this variable. (Table 2) Intergroup comparison of partially occluded tubules showed a statistical significance between group 1 & group 4, group 2 and group 4. ($p<0.05$) (Table 3)

The number of mostly unoccluded tubules in group 4 showed a significant difference comparing the two magnifications. (Table 2) Intergroup comparison of mostly unoccluded tubules showed a significant difference between group 1 & group 4, group 2 & group 4, group 3 & group 4. ($p<0.05$) (Table 3)

No significant difference was seen in magnification between the groups in relation to the unoccluded tubules. (Table 2) On intergroup comparison of unoccluded tubules, significant difference was seen between group 1 & group 3, group 1 & group4, group 2 & group 3, group 2 & group 4, group 3 and group 4. ($p<0.05$) (Table 3)

DISCUSSION

Various in-vitro and in-vivo methods have been adopted to determine the efficacy of desensitizing agents. The present study was therefore designed to evaluate the effectiveness of diode laser when used along with various desensitizers. A modified dentin disc model similar to that proposed by Gillam et al.was used in this study.[7] The dentinal tubule occlusion was evaluated using SEM at 1000X and 2000X magnification.[6]

Dentin disc model is a feasible and non-invasive approach to evaluate the efficacy of various desensitizers, and SEM photomicrographs were able to demonstrate the physical modifications of dentinal tubules.[5]

In the present study, a combination of laser irradiation with desensitizing agent enhanced the treatment effectiveness. Among the four groups, Group 3 – Gluma along with laser irradiation showed the highest number of completely occluded tubules. Laser power used in this study was a Diode laser (810 nm) of 1 watt for 60 seconds in non-contact mode 1.5mm away from the teeth, which is safer to the pulp and seals the dentinal tubules. A laser power of 0.8, 1, 1.6 and 2 W seals the dentinal tubules without causing any damage. However, Laser should be carefully applied due to its adverse thermal effects on the pulp and adjacent structures. An increase in the energy density of Laser may result in increased pulpal space pressure and temperature.[5]

In a study conducted by Guntakal Vikram Reddy et al., they concluded that SEM analysis for the Diode laser group showed dentinal tubule occlusion of almost 96.57%, which indicated the efficacy of diode laser was more compared to dentifrices alone groups.[5] A study done by Yilmaz et al., showed that the application of Er, Cr: YSGG is effective in the management of dentinal hypersensitivity.[10]

In the present study, a combination of gluma with laser irradiation (Group 3) and Laser alone (Group 4) groups showed enhanced tubular occlusion compared to Pro-Argin with Laser (Group 2) and Novamin plus Laser (Group 1) groups.

Contrary to the present study Moritz et al.,[11] Lan et al.,[12] and Schwartz et al.,[13] reported that Laser in combination with chemical agents (dentifrices) showed increased effectiveness by >20% when compared to laser alone group. A study by Litkowski[14] substantiates the findings in support of

NovaMin, which demonstrates *in vivo* relief from the application of NovaMin after two weeks, and on SEM analysis, it was confirmed that it caused complete occlusion, which aided in relief from hypersensitivity. An *in-vivo* study reported that Gluma desensitizer was not effective in relieving dentinal hypersensitivity after four weeks.[15] This difference in the results may be because of the variation in the mode of application of the desensitizing agents. NovaMin and Pro-Argin were applied using a toothbrush, whereas Gluma desensitizer was applied using an applicator that might have changed the outcomes of the present study.

A study conducted by Fatma *et al.* concluded that Er:YAG laser and Pro-Argin Desensitizing Paste groups showed significantly more tubule occlusion than the Gluma Desensitizer group.[16]

Although the study data are not directly comparable, a study done by Schupbach *et al.* reported that, topical application of Gluma 3 Primer leads to a peripheral, intrinsic barrier in the dentinal tubules. The removal of the smear layer is a prerequisite for this phenomenon. Glutaraldehyde seems to be the compound in Gluma 3 Primer, which is responsible for the occlusion of the tubules as an effect of GA on the serum proteins in the dentinal fluid. The peripheral occlusions of the dentinal tubules counteract the hydrodynamic mechanism of dentinal hypersensitivity and may explain the effect of Gluma desensitizer.[17]

A major drawback of the study is the lack of negative control. However, the authors consider it unethical to have a negative control group. Other limitations of this study include, smaller sample size and also the assessment of hydraulic conductance of dentine was not estimated. The future perspectives should involve an in-vivo comparison of clinical efficacy and long term effects of commercially available desensitizing agents with long term follow-up.

CONCLUSION

All three desensitizers along with Laser and Laser alone showed varying degrees of tubular occlusion in the form of complete and partial occlusion. However, Gluma along with Laser showed higher tubular occlusion, thereby proving effective in providing relief from dentinal sensitivity.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

REFERENCES

1. CL Chen, A Parolia, A Pau, IC Celerino de Moraes Porto. Comparative evaluation of the effectiveness of desensitizing agents in dentine tubule occlusion using scanning electron microscopy. Australian Dental Journal 2015; 60: 65–72.

2. AR Pradeep, Anuj Sharma. Comparison of Clinical Efficacy of a Dentifrice Containing Calcium Sodium Phosphosilicate to a Dentifrice Containing Potassium Nitrate and to a Placebo on Dentinal Hypersensitivity: A Randomized Clinical Trial. J Periodontol 2010;81:1167-1173.

3. Surabhi Joshi, Ashwini Shivananje Gowda, Chintan Joshi. Comparative evaluation of NovaMin desensitizer and Gluma desensitizer on dentinal tubule occlusion: a scanning electron microscopic study. J Periodontal Implant Sci 2013;43:269-275.

4. Manhas KJ, Malhotra G, Shukla P, Dahiya V, Kataria P. Comparative evalution of dentinal tubule occlusion ability of three commercially available desensitizing dentifrices: An in vitro scanning electron microscope study. Int J Oral Care Res 2018;6(1):5-11.

5. Reddy GV, Akula S, Malgikar S, Babu PR, Reddy GJ, Josephin JJ. Comparative scanning electron microscope analysis of diode laser and desensitizing toothpastes for evaluation of effi cacy of dentinal tubular occlusion. J Indian Soc Periodontol 2017;21:102-6.

6. Shah S, Shivakumar AT, Khot O, Patil C, Hosmani N. Efficacy of NovaMin- and Pro-Argin-Containing Desensitizing Dentifrices on Occlusion of Dentinal Tubules. Dent Hypotheses 2017;8:104-9.

7. Gillam DG, Tang JY, Mordan NJ, Newman HN. The effects of a novel bioglass dentifrice on dentine sensitivity: A SEM investigation. J Oral Rehab 2002;29:305-13.

8. West NX, Macdonald EL, Jones SB, Claydon NC, Hughes N, Jeffery P. Randomized in situ clinical study comparing the ability of two new desensitizing toothpaste technologies to occlude patent dentin tubules. J Clin Dent 2011;22:82–89.

9. Davies M, Paice EM, Jones SB, Leary S, Curtis AR, West NX. Efficacy of desensitizing dentifrices to occlude dentinal tubules. Eur J Oral Sci 2011;119:497–503.

10. Yilmaz HG, Cengiz E, Kurtulmus-Yilmaz S, Leblebicioglu B. Effectiveness of Er,Cr:YSGG Laser on dentine hypersensiti-vity: a controlled clinical trial. J Clin Periodontol 2011;38(4):341-346.

11. Moritz A, Schoop U, Goharkhay K, Aoid M, Reichenbach P, Lothaller MA, *et al.* Long-term effects of CO2 laser irradiation on treatment of hypersensitive dental necks: Results of an *in vivo* study. J Clin Laser Med Surg 1998;16:211-5.

12. Lan WH, Liu HC, Lin CP. The combined occluding effect of sodium fl uoride varnish and Nd:YAG laser irradiation on human dentinal tubules. J Endod 1999;25:424-6.

13. Schwarz F, Aoki A, Becker J, Sculean A. Laser application in non-surgical periodontal therapy: A systematic review. J Clin Periodontol 2008;35 8 Suppl: 29-44.

14. Litkowski L. Pilot clinical and *in vitro* studies evaluating NovaMin in desensitizing dentifrices. Dent Res 1998;77:199.

15. de Assis Cde A, Antoniazzi RP, Zanatta FB, Rosing CK. Efficacy of Gluma Desensitizer on dentin hypersensitivity in periodontally treated patients. Braz Oral Res 2006;20:252-6.

16. Fatma Sag Gungor, Said Karabekiroglu, Nimet Unlu. Effects of Three Desensitizing Agents and Erbium-Doped Yttrium Aluminum Garnet Laser on Dentinal Tubule Occlusion: An In-Vitro Study. International Journal of Medical Science and Innovative Research 2017;2(6):117-128.

17. Schupbach P, Lutz F, Finger WJ. Closing of dentinal tubules by Gluma desensitizer. Eur J Oral Sci 1997; 105: 414-421.