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Comparative Evaluation of Diode Laser and Glutaraldehyde Based Bonding Agent in Occlusion of Open Dentinal Tubules - A Sem Study

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Abstract: ***Dentinal hypersensitivity (DH) is defined as short, sharp pain arising from exposed dentine typically in response to chemical, thermal or osmotic stimuli. The present study compares and evaluates the dentin tubule occlusion achieved with 980-nm Diode laser and Gluma desensitizer by means of SEM. Materials and Methods: Thirty dentin disc of extracted sound maxillary and mandibular single rooted teeth were taken. These disc immersed in artificial saliva. Each specimen was etched with Gluma etch 35 gel for 1 min to expose the dentinal tubules and then the specimens were rinsed with distilled water. Specimens were allotted to the three groups of ten each: Group A- Control group, Group B- Diode laser group, Group C- Gluma group. The disc were later analyzed under SEM. The proportions of completely occluded, partially occluded, and open tubules within each group were calculated. The ratios of completely and partially occluded tubules to the total tubules for all the groups was determined, and the data was statistically analyzed. Results: All the two desensitizing agents were effective in the closure of dentinal tubules despite their different chemical compositions and application procedures. On inter-group comparison between Diode laser and Gluma, it was found that Diode laser desensitizer had shown better results in the closure of the dentinal tubules followed by Gluma desensitizer. Conclusion: Although dentinal tubules occlusion was effective by both diode laser (980 nm) and Gluma, Diode laser produced a more complete occlusion of dentinal tubules.***

Keywords: Dentin Hypersensitivity, Diode Laser, Gluma, Dentinal tubule occlusion, Scanning electron microscope

1. Introduction

Dentinal hypersensitivity is a very common clinical symptom, which consist of sharp pain arising from exposed dentin in response to various types of stimuli and thus can cause considerable concern for patients. Abrasion, attrition, erosion, abfraction, wedge shaped defects, odontagma and periodontal atrophy can all result in dentinal hypersensitivity.[1]

Dentinal hypersensitivity (DH) is defined as short, sharp pain arising from exposed dentine typically in response to chemical, thermal or osmotic stimuli that cannot be explained as arising from any other forms of dental defect or pathology. The occurrence rate of dentinal hypersensitivity usually ranges from 4% to 74%.[2] Although the age of patients suffering from dentinal hypersensitivity varies from 20-70 years, the peak incidence usually occurs in individuals between 20-40 years of age.

Currently the hydrodynamic theory has been widely accepted, and this theory was first described by **Brannstrom et al, 1962**. It states that external stimuli cause movement of fluid inside dentinal tubules inwardly or outwardly, promoting deformation of nerve ending at the pulp/dentin interface, which is transmitted as a painful sensation.[2] Under normal conditions, the dentin is covered by enamel or cementum and is not sensitive to direct stimulation. DH occurs only with the exposure of the peripheral terminations of the dentinal tubules.[1] Therefore blocking the exposed dentinal tubules is critical to the treatment of DH.

The most commonly used agents in the treatment of DH are classified as anti-inflammatory agents, protein precipitants, tubule-occluding agents, tubule sealants and lasers.

Gluma is a dentine-bonding agent containing glutaraldehyde. Glutaraldehyde coagulates the serum albumin present in dentinal fluid resulting in blockage of tubules. This reaction of glutaraldehyde with serum albumin is said to induce polymerization of HEMA which is a hydrophilic monomer component of dentine bonding agents with the ability to infiltrate into acid etched and moist dental hard tissue.[3] A combination product of an aqueous solution of 5% glutaraldehyde and 35% hydroxyethylmethacrylate has been reported to be an effective desensitizing agent. Glutaraldehyde intrinsically blocks dentinal tubules.

Laser systems have been used widely in the endodontic field, including ND:YAG, Er: YAG, CO_2 and Diode lasers.

Recently, an innovative 980-nm Diode wavelength laser was introduced, which was first reported on 2004.[4] **Liu et al** investigated the ultra structural changes of dentin irradiated with 980 nm Diode laser under different parameters and the morphological alterations of odontoblasts and pulp tissue to determine the safety parameters of 980nm diode laser in the treatment of dentin hypersensitivity. It was found that irradiation with 980-nm Diode laser could be effective for routine clinical treatment of DH, and 2.0W/CW (166 J/cm²) was a suitable energy parameter due to its rapid sealing of the exposed dentin tubules and its safety to the odontoblasts and pulp tissue. Diode lasers are high-energy lasers, with low purchase and maintenance cost, as well as greater versatility because of its compact size.

The present study was planned to evaluate and compare the effect of 980-nm Diode laser and Gluma desensitizer on dentinal tubule occlusion under scanning electron microscope after their initial application as desensitizing agents on dentin in the treatment of dentinal hypersensitivity.

2. Materials and Methods

In this study, 30 extracted single rooted teeth were included, all of which had been extracted for periodontal reasons and indicated for extraction. These samples were stored in 10 % formalin as it inhibit microbial growth. The root surfaces of all the teeth were scaled with an ultrasonic scaler and thoroughly planed with #5-6 Gracey curette (GDC). With the help of disc bur, the enamel was removed to expose the dentinal tubules, so that the samples simulate the hypersensitive teeth, 30 dentinal discs were prepared. These disc were immersed in artificial saliva. Each specimen was etched with Gluma etch 35 gel for 1 min to expose the dentinal tubules and then the specimens were rinsed with distilled water. The specimens were randomly divided by Lottery method into 3 groups:

Group A: The control group were immersed in artificial saliva.

Group B: Each area were irradiated twice for 5 seconds in the laser group. The Diode laser was delivered through a 320-micronmeter optic fiber and the laser tip was held perpendicular to the irradiated surface at a distance of 1 mm.

Group C: Each area were treated with Gluma desensitizer. A small amount of gluma desensitizer was applied on the dentin disc using applicator as per the manufacturer's instructions and left for 30-40 seconds. The surface was then dried by applying a stream of compressed air until the fluid film had disappeared and the surface was no longer shiny, and then rinsed thoroughly with water.

DIODE LASER

Diode lasers are semiconductor devices that use the p-n junction of a semiconductor diode to create light that is coherent and generally of a single wavelength. The available wavelength for dental use range from about 800 nm for an active medium containing aluminium to 980-nm for the active medium composed of indium. Due to the small size, low power consumption and cost-effective production of these devices, Diode lasers have become the most common types of lasers in the world, used in a large variety of components and fields, including electronics, communications, medical practices.

The following parameters are:
1) Power- 0.1-2W
2) Irradiation time- 5seconds/point
3) Irradiated area- 3 mm x 4 mm
4) Pulse parameter- continuous mode
5) Number of laser treatment- Irradiated twice
6) Wavelength – 980 nm

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Each area was irradiated with Diode laser with 320 micronmeter fiber optic handpiece at a wavelength of 980 nm, operated at power range of 0.1-2W, in a non contact mode and the laser tip was held perpendicular to the irradiated surface at a distance of 1mm.

GLUMA DESENSITIZER (Herauz Kulzer):

Gluma desensitizer is a desensitizing agent used for the purpose of dentinal tubule occlusion. It is composed of 5% glutaraldehyde and 35% HEMA **(hydroxyl ethyl methacrylate)** in water. It is used to help control both hypersensitive dentin and reduce the incidence of post operative sensitivity in restorative dentistry procedures. Each sample was air dried in a dessicator and sputter coated with gold. The surface of specimens were visualized under SEM at a magnification of x5000 and the photographs of the area were obtained. The total number of tubules, number of open tubules, number of completely occluded tubules and number of partially occluded tubules were counted in each photographs of all the specimens.

After observing the SEM images at a magnification of 5000X, the images were assessed independently to score the level of tubule occlusion (on a categorical scale of 1– 5), in accordance with the tubule occlusion classification scoring system:[5]
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 score of tubule occlusion was taken and used for statistical analysis.

3. Results

The total number of tubules was counted from the various images captured by the SEM. Out of the total tubules; those

that were completely occluded, partially occluded, and open tubules were counted. The ratio of completely occluded tubules to the total tubules as well as the ratio of partially occluded tubules to the total tubules was calculated and each group were plotted. The data obtained was statistically analysed using the SPSS (Statistical Package for the Social Sciences, SPSS Inc, v.16, IBM, USA). Comparison of tubule occlusion scores among the three study groups was done using Kruskal-Wallis test followed by Mann-Whitney test for pair-wise comparisons of the study groups.

Table 1: Descriptive statistics of Dentinal tubule occlusion

	N	Mean ± SD	Mean Rank	P value
Control	10	4.60±0.52	24.5	<0.001*
Diode Laser	10	1.40±0.52	5.5	
Gluma	10	3.50±0.52	16.5	

Table 2: Intergroup comparison of Dentinal tubule occlusion in Diode laser and Gluma test group

	Group	N	Mean Rank	Sum of Ranks	P value
(Tubule Occlusion Score)	Diode Laser	10	5.5	55	<0.001
	Gluma	10	15.5	155	
	Total	20			

4. Discussion

SEM studies of hypersensitive dentin surfaces showed that they have tubules that are more patent per unit area as compared to normal non-sensitive dentin. Furthermore, tubules in superficial parts of hypersensitive dentin are on average twice as wide as tubules in non-sensitive dentin.[3] **Absi et al[6] and Yoshiyama et al[7]** reported that in naturally desensitized dentin, most of the tubules were occluded. On the basis of transmission electron microscopic studies, **Yoshiyama et al[7]** stated that tubular occlusions could be due to extension of the intratubular dentin layer or deposition of substances in the tubules. Saliva naturally occludes patent dentinal tubules by transporting calcium and phosphate ions into the tubules to induce tubule plugging and by forming a surface protective layer of salivary glycoprotein with calcium and phosphate. However, this process of natural tubule occlusion is very slow and the tubule plugging is easily removed by dietary acid and physical insult, thus rendering it neither effective nor reliable in providing lasting relief of DH.[7]

The present study was carried out with the objective to evaluate and compare the effect of 980 nm Diode laser and Gluma desensitizer.

Thirty samples of extracted sound maxillary and mandibular single rooted teeth were taken for the study as dentinal hypersensitivity is most commonly seen in premolars and canine. These samples were stored in 10 % formalin as it inhibits microbial growth.

The teeth with caries, fractures, having periapical infection or non-vital teeth, developmental malformation, and wasting disease were excluded from the study because it could have affected the outcome of the study. The root surfaces of all the teeth were scaled with an ultrasonic scaler and thoroughly planed with #5-6 Gracey curette (GDC). With the help of disc bur, the enamel was removed to expose the dentinal tubules, so that the samples simulate the hypersensitive teeth, 30 dentinal discs were prepared. These discs are immersed in the artificial saliva. Each specimen was etched with Gluma etch 35 gel for 1 min to expose the dentinal tubules and then the specimens were rinsed with distilled water. These blocks were ultrasonicated in distilled water for 12 min to remove the residual smear layer and then these samples were immersed in the artificial saliva for 7 days. Following the chemical treatment, all samples were dried, in accordance with different studies by **Ghafournia M et al (2019) [8], Gupta AK et al (2014)[3] and Liu Y et al (2013).[4]**

The samples were randomly divided by lottery method to improve the quality of study into three groups: **group A**- Control, **group B**- Diode laser and **group C**- Gluma.

The samples were dried and mounted on metal stubs, and inserted in an SC7640 sputter coating machine, the samples were sputter coated with 25 nm of gold for 10 min. All the specimens were examined in a POLARON-SEM at a magnification of 5000X and photomicrographs were evaluated to assess the opening of dentinal tubules in the controls and occlusion of dentinal tubules in their contralateral parts coated with the desensitizing agents. The evaluation of SEM images was done, in accordance with the tubule occlusion classification scoring system as reported by **West et al. [9]**

The tubular occlusion classification-scoring system was scored accordingly. All the tubules completely occluded were given score 1, the samples with most of the tubules occluded were given score 2, the samples with partially occluded tubules were given score 3, the samples with the tubules mostly unoccluded were given score 4, the samples with all tubules unoccluded were given score 5. The same index was used by **CL Chen et al.[10]** The mean score of tubule occlusion was taken and used for statistical analysis. The statistical analysis was done using SPSS (Statistical Package for the Social Sciences, SPSS Inc, v.16, IBM, USA).

Table 1 shows the descriptive statistics for tubule occlusion scores in the three study groups. The control group had the highest mean score, followed by Gluma and Diode Laser with the lowest mean score. A mean of 4.6±0.52 was seen in the Control group as compared to the mean of 1.4±0.52 was seen in Diode laser and a mean of 3.50±0.52 was seen in Gluma. This intergroup comparison revealed the significant difference in tubule occlusion. These results were in accordance to study done by **Gupta AK et al (2014),[3] Samuel SR et al (2014)[11] and Mushtaq S et al (2020).[12]**

Table 2 depicts the intergroup comparison of level of tubule occlusion in the Diode laser group and Gluma test group. On intergroup comparison analysis showed that significantly different amount of tubules got occluded after the application of Diode laser and Gluma with a mean of 5.50 was seen in Diode laser group as compared to a mean of 15.50 was seen in Gluma ($P<0.001$). This indicates that more tubules got occluded after the application of Diode laser as compared to that of Gluma desensitizer. This is due to superficial dentinal melting leading to the occlusion or narrowing of dentinal

tubules. Similar results were reported by **Namour A et al (2014)[13] and Liu Y et al (2013).[4]**

Diode laser 980 nm is in the near infrared position of the electromagnetic spectrum part of the energy is absorbed by the dentinal components provoking melting of the dentin structure. These transformations are more intense when higher irradiation parameters are used. The absorption coefficients of diode lasers are low in dentin. This low absorption in dentine results in the propagation of the laser beam to the pulpal tissue which will generate heat and may cause undesirable side effects such as hyperemia or irreversible pulpitis. **Liu Yet al[4]** demonstrated that 2 W/CW (166 J/cm²) was a suitable parameter for a 980-nm diode laser to seal dentinal tubules without excess melting of the dentin.

Gluma desensitizer penetrates upto 200 micronmeter into the exposed dentinal tubuli where it forms multiple layers of protein septa thereby preventing intratubular movement following osmotic changes and preventing hypersensitivity.

The result of the present study confirmed by SEM analysis of dentin samples, demonstrated that Diode laser and Gluma were able to occlude dentinal tubules but Diode laser resulted in more number of dentinal tubule occlusion as compared to Gluma desensitizer. This finding may clinically translate to a better desensitising effect of diode laser as compared to Gluma desensitizer.

5. Conclusion

In the present study Diode laser was found to produce more completely occluded tubules while Gluma desensitizer caused more partial occlusion on application. On inter-group comparison between Diode laser and Gluma, it was found that Diode laser desensitizer had shown better results in the closure of the dentinal tubules followed by Gluma desensitizer.

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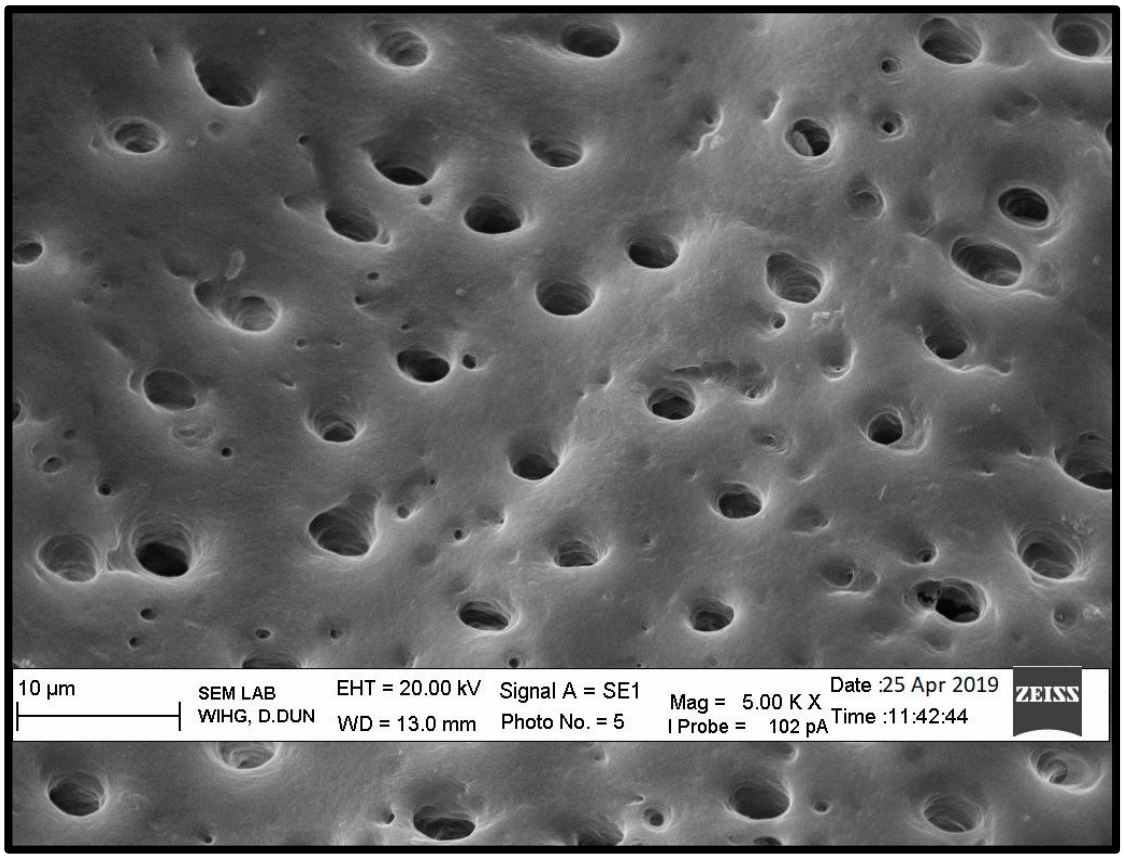
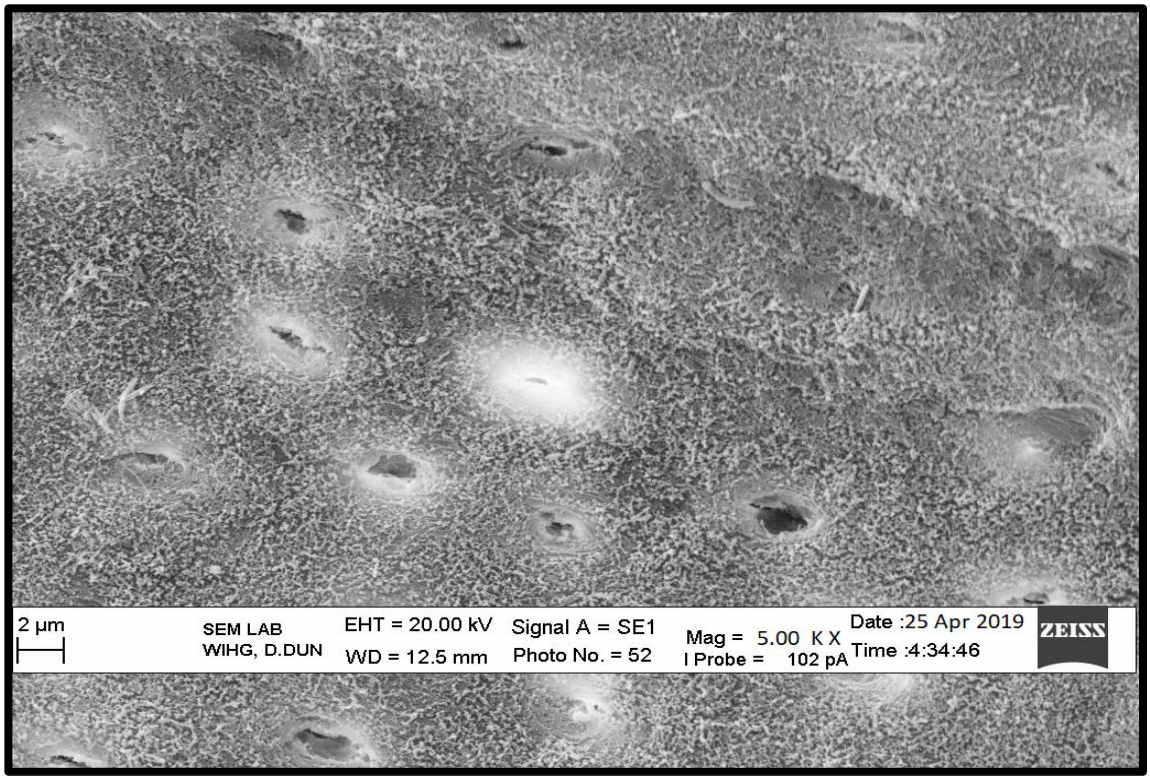
Figure Legend:

Control Group



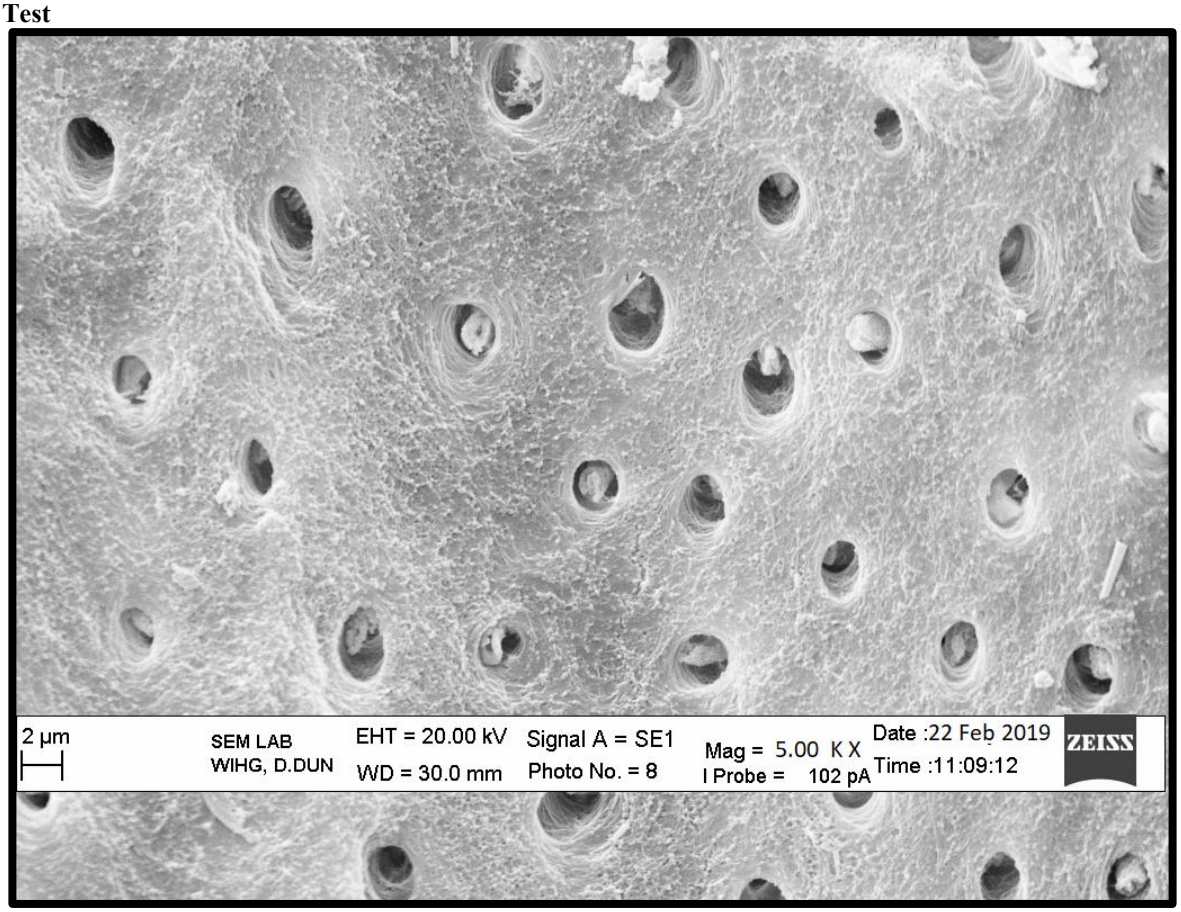
Photomicrograph of Dentin Sample with all the Dentinal Tubules Mostly Unoccluded; Score (4)

Diode Laser Test Group



Photomicrograph of Dentin Sample with all the Dentinal Tubules Mostly Occluded; Score(2)

Gluma Test



Photomicrograph of Dentin Sample with the Dentinal Tubules Mostly Unoccluded; Score (3)