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EVALUATION OF EFFICACY OF SHIELD FORCE PLUS AND GLUMA DESENSITIZER ON DENTINAL TUBULE OCCLUSION: A SCANNING ELECTRON MICROSCOPIC STUDY

Bharath Chandra NR[1], Kunal Kumar Ghosh[2], Narayan N Valavalkar[3], Shobha Prakash[4]
1-4.Department(s) and institution(s): Department of periodontics, College of Dental Sciences, Davangere, Karnataka

ABSTRACT:

Aim: To evaluate the efficacy of GLUMA and SHIELD FORCE PLUS in terms of occlusion of patent dentinal tubules through scanning electron microscope analysis in vitro.

Materials and methods: 2mm dentinal discs were procured from the middle third of the crown, parallel to the CEJ of 20 extracted third molars which were previously impacted and unexposed to the oral environment. Each disc was divided into 2 sections and Gluma and Shield force plus was applied to them respectively. Thereafter the dentinal discs were subjected to scanning electron microscopy at a magnification of 3500X to check for the status of the dentinal tubules.

Results: Shield force plus showed more completely occluded tubules while Gluma desensitizer showed more partially occluded tubules. The differences among both the groups were statistically significant ($P \leq 0.0001$)

Conclusion: Both materials were effective in occluding dentinal tubules but shield force plus appeared more promising in occluding tubules than gluma desensitiser.

Keywords: Dentin sensitivity, Gluma desensitizer, Scanning electron microscopy, Polyacrylic acid.

INTRODUCTION:

One of the most frequently presenting symptoms in dental practice is the oral pain condition of dentine hypersensitivity, which may be of only minor inconvenience to some patients, yet very disturbing and an issue affecting quality of life to others. Dentin hypersensitivity is defined as a transient pain arising from exposed dentin, typically in response to chemical, thermal, tactile, or osmotic stimuli, which cannot be explained by any other dental defect or pathology.[1] The condition generally involves the facial surfaces of teeth near the cervical aspect and is very common in premolars and canines. [2] Typically, this condition develops in patients with gingival recession, periodontal diseases, and after periodontal surgery or loss of cementum following non-surgical periodontal therapy.[3] In addition, tooth defects, dentine exposure as a result of a developmental anomaly, and improper brushing habits can predispose patients to cervical dentin exposure and pain.[4,5]

The most widely accepted theory for dentin hypersensitivity is the

*Corresponding Author Address: Dr. Bharath Chandra N R Email: bharath.chandra.319@gmail.com

hydrodynamic theory proposed by Brannstrom, [6] who suggested that pain may result from the movement of the dentin fluid in the tubules provoked by external stimuli, such as temperature, physical or osmotic changes which, in turn, trigger nerve fibers within the pulp. Products for the management of dentin hypersensitivity typically aim to control the hydrodynamic mechanisms of pain. Approaches to control the condition fall into two broad categories: agents or products that reduce fluid flow within the dentin tubules by occluding the tubules themselves, thereby blocking the stimuli, and those that interrupt the neural response to stimuli.

During the years a variety of topically applied professional dental products have been made available to block the tubular liquid shifts, acting mostly by polymer sealing, precipitation of fine-grained salts, or precipitation of dentin fluid proteins. The first commercial product of this latter category was GLUMA Desensitizer (Heraeus Kulzer GmbH, Hanau, Germany), a spin-off product of the GLUMA bonding system, introduced to the dental market almost 15 years ago.[7]

GLUMA is a dentin-bonding agent containing glutaraldehyde. Glutaraldehyde coagulates the serum albumin present in the dentinal fluid resulting in blockage of tubules. This reaction of glutaraldehyde with serum albumin is said to induce polymerization of hydroxyl ethyl methacrylate (HEMA) which is a hydrophilic monomer component of dentine bonding agents with the ability to infiltrate into acid etched and moist dental hard tissues.[8] (figure 1).

SHIELD FORCE PLUS (TOKUYAMA BOND FORCE), a one component Self-etching Light-cured dental adhesive based on SR technology, is another product characterized by an SR monomer component that penetrates into the tooth substrate, multi-point interactions with apatite calcium, and three-dimensional cross-linking reactions. It forms a thin, even, hard coating on the tooth surface for superior bonding strength to the tooth substance. Given these characteristics, it was considered a superior sealant for tooth surface. In November 2009, the TOKUYAMA SHIELD FORCE, protective sealant for treatment of hypersensitive dentin was introduced in Japan.[9] (figure 2).

The major objective of this study was to evaluate and compare the effect of GLUMA desensitizer, and TOKUYAMA SHIELD FORCE PLUS on dentinal tubule occlusion after their initial application as desensitizing agents in the treatment of dentinal hypersensitivity.

MATERIALS AND METHODS:

20 impacted healthy third molars extracted for surgical reasons were collected after informed consent from patients aged 25 to 30 years, from the Department of Oral and Maxillofacial Surgery, College of Dental sciences, Davangere. **inclusion criteria:** 1.Third

molar tooth indicated for extraction due to impaction. 2. Teeth with intact crown and root surfaces. 3. Tooth surface unaltered by extraction procedure. **exclusion criteria:** 1.Teeth which had any periapical lesion or affected by dental caries.[10] 2.Teeth with developmental anomalies such as concrescence, fusion, dentinogenesis imperfecta, enamel hypoplasia etc. 3. Teeth from patients with dental fluorosis.[11]

The extracted teeth were immediately washed in running tap water and were stored in bottles containing 5% Phosphate buffered saline solution [12] for not more than one month until required for the experiment.

Dentin discs of 2mm thickness [10] were prepared from the coronal portion of the tooth just above the level of cemento - enamel junction using a hard tissue microtome. The dentin discs were then cut into two halves so that one half from the same tooth could be allotted to each of the two groups**.** This ensured that the specimens for both the groups were obtained from the same tooth. These specimens were ultrasonicated (BIOSONIC UC 100, WHALEDENT CORP, USA) in distilled water for two minutes to remove residual smear layer and then etched by immersing the specimens in a tray containing 6% citric acid for 2 minutes to simulate dentin hypersensitivity condition.[13,14] The resulted specimens were subjected to the experiment and were stored in artificial saliva [15] during the experimental period**.**

A total of 40 dentin specimens from 20 teeth were taken and divided into two groups to evaluate the effect of acid etched dentin specimens treated with GLUMA and Shield Force Plus. Care was taken that each group receives one specimen from the same tooth.

In the gluma group, gluma desensitizer was applied onto the dentin discs using small cotton pellets as per the manufacturer's instructions and left for 30–40 seconds per application**.** 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.

In the shield force plus group, apply the agent with the applicator and leave for 10 seconds then dry by dry air for 10 seconds and then light cure for 10 seconds as per manufacturer’s instructions.

The specimens were placed in 2.5% glutaraldehyde in 0.1 M phosphate buffer (pH 7.4) for a minimum of 24 hours. Following washing and dehydration through a graded alcohol series, they were mounted on SEM stubs. Mounted specimens were air-dried for 48 hours and sputter coated with 30 to 40nm of gold using gold sputtering machine (JEOL JFC 1100E, Japan). Finally specimens were examined using a scanning electron microscope (JEOL-JSM-840A) operating at an accelerating voltage of 20kV. The specimens were checked for the tubule patency and occlusion. The area in the

center of each specimen was scanned so as to obtain tubules in a circular cross section. [22] Representative photomicrographs were obtained at 3500x magnification (FIGURE 3,4,5). These photomicrographs were analysed by three blind, trained examiners to assess the percentage (%) of tubular occlusion. The percentage of occluded tubules was calculated by using the following equation %OCT= number of occluded tubules x 100/Total number of tubules. This percentage represents the occlusion exhibited by the different treatments used and also showed the occlusion relative to the maximum number of open tubules obtained after citric acid.[16]

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 were counted. The ratio of completely occluded tubules to the total tubules and the ratio of partially occluded tubules to the total tubules were calculated. The results of the study are interpreted in Table 1, Graph 1. Inter group comparision was done using unpaired t test. In the two groups there was a highly significant difference (p=0.0001) in favour of the Shield Force Plus (Tokuyama Bond Force) which showed the complete occlusion of dentinal tubules (>75% occlusion). All of the statistical analyses were performed by using IBM SPSS ver. 21 (IBM Co., Armonk, NY, USA).

DISCUSSION:

Dentine hypersensitivity is characterized by short, sharp pain arising from exposed dentine in response to stimuli, typically thermal, evaporative, tactile, osmotic or chemical and which cannot be ascribed to any other dental defect or pathology.[1] This definition was adopted in the international workshop on dentin hypersensitivity.[17] The definition clearly has two aspects. The first is a clinical descriptor of the condition. The second, perhaps more importantly identifies dentine hypersensitivity as a distinct clinical entity and invites the clinician to consider a differential diagnosis, since other conditions may have identical symptoms but require different management strategies.[1]

Discomfort from dentine hypersensitivity is a common finding in adult populations, with the available prevalence data ranging from 8–57%. [18,19,20,21] The prevalence in Indian population was found to be 26%. The prevalence of cervical dentine sensitivity, another term used to describe dentine hypersensitivity, was found to be much higher in periodontal patients, ranging between 72.5–98%. In general, a slightly higher incidence of dentine hypersensitivity is reported in females than in males. [19,20]

Most sufferers from dentine hypersensitivity range in age from 20 to

40 years but the peak occurrence is found at the end of third decade. Regarding the intra-oral distribution, dentine hypersensitivity is most commonly reported from the buccal cervical zones of permanent teeth. Sites of predilection in descending order are canines and first premolars, incisors and second premolars and molars.[18]

SEM studies of hypersensitive dentin surfaces reveal that they have more patent tubules per unit area than nonsensitive dentin. Furthermore, tubules in superficial parts of hypersensitive dentin are on average twice as wide as tubules in nonsensitive dentin. Absi et al.[22] and Yoshiyama et al.[23] reported that in naturally desensitized dentin, most of the tubules were occluded. On the basis of transmission electron microscopic studies, Yoshiyama et al.[23] reported that tubular occlusions could be due to extension of the intratubular dentin layer or deposition of substances in the tubules. Some of the occlusions in their study were crystals of inorganic salts, but some may be organic in origin. However, the nature of the occluding layer is important. Some surfaces where the tubules were observed to be occluded with a "dense pellicle" were found to be very sensitive. Pashley and Carvalho [24] noted that tubules apparently occluded with a smear plug are permeable to both solvent and solute. Thus, the surface appearance alone may not correlate with sensitivity or permeability [25].

The width of the tubule is very important, as the rate of fluid flow is dependent on the fourth power of the radius. If the tubule diameter doubles, a 16-fold increase in fluid flow results. Sensitive teeth have many more (8×) and wider (2×) tubules at the buccal cervical area compared with nonsensitive teeth. A higher velocity of fluid flow also occurs in tubules of smaller diameter, possibly provoking pain sensations. Dentin will only be sensitive if the tubules are patent from the pulp to the oral environment, and this patency will change with production and removal of the smear, hence resulting in an episode condition. [26] Most studies on tubule occlusion have focused on coronal dentin, where important variables such as the dentin surface area, thickness, and surface characteristics can be controlled. The validity of data collected *in vitro*, however, is open to criticism. The hydraulic conductance of radicular dentin has been observed to be much lower than that of coronal dentin; there is a good correlation between tubule density and diameter and the measured hydraulic conductance. [27]

Since dentinal hypersensitivity can recur over time even in the same individual one must be able to decisively diagnose and recognize the predisposing factors to formulate a treatment plan for effectively managing dentinal hypersensitivity. The goal of the present study was to find out the most efficacious agent amongst Gluma and Shield Force Plus.

Gluma desensitizer is an aqueous solution containing 5% glutaraldehyde and 35% hydroxyethyl methacrylate. Because glutaraldehyde is a biological fixative, it has been suggested that the dentinal tubules are occluded as an effect of reaction with plasma proteins from dentinal fluid. Hydroxyethyl methacrylate is a hydrophilic monomer compound of dentin bonding agents with the ability to infiltrate into acid-etched and moist dental hard tissue [28].

Tokuyama Shield Force Plus contains a phosphoric acid monomer, necessary for decalcifying the tooth substance and forming the matrix of the SR monomer; various monomers used to build the coating; an alcoholic solvent; water; and camphor Quinone as the photo polymerization catalyst. The mechanism of hypersensitive dentin treatment of TOKUYAMA SHIELD FORCE PLUS is believed to be based on the double-block effect. When TOKUYAMA SHIELD FORCE PLUS is applied to the affected area, the adhesive monomer (3D-SR monomer) and calcium in the tooth substance react, and the reaction product accumulate in the dentinal tubules and on the coated surface. When the solvent component and water are removed with a stream of air, a thin film will be formed on the surface affected by hypersensitivity. At this stage, the dentinal tubules are sealed, and the treatment effect (pain relief) appears. Exposure to light cures the reaction product in the dentinal tubules and the thin film on the coated surface, forming a strong coating. As described, hypersensitivity is suppressed when the dentinal tubules are sealed by the double-block effect: that is, blocking by the reaction product of the adhesive monomer and the calcium of the tooth substance and blocking by the formation of a durable coating on the dentin surface by curing [9] (as per manufacturer details).

In the present study Shield Force Plus showed complete occlusion of dentinal tubules where as gluma desensitizer showed less number of completely occluded tubules (**Graph 1**).

To conclude Severity of dentinal hypersensitivity can be episodic. Hence establishing a concrete diagnosis becomes imperative in the attempts to identify and isolate an effective therapeutic agent for the elimination of Dentinal Hypersensitivity. In the present study Shield Force Plus was found to produce more completely occluded dentinal tubules than GLUMA. However further long term studies are needed to for the usage of these agents.

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TABLES:

TABLE 1 - INTER GROUP COMPARISION OF GLUMA AND SHIELD FORCE PLUS

PRODUCT	NUMBER OF DENTINAL TUBULES	T1	T2	T3
SHIELD FORCE	26.25±1.20	26.00±1.25	0.00±0.00	0.00±0.00
GLUMA	26.60±1.23	7.70±0.86	5.15±0.67	3.60±1.23
P VALUE	0.370(NS)	0.0001(HS)	0.0001(HS)	0.0001(HS)

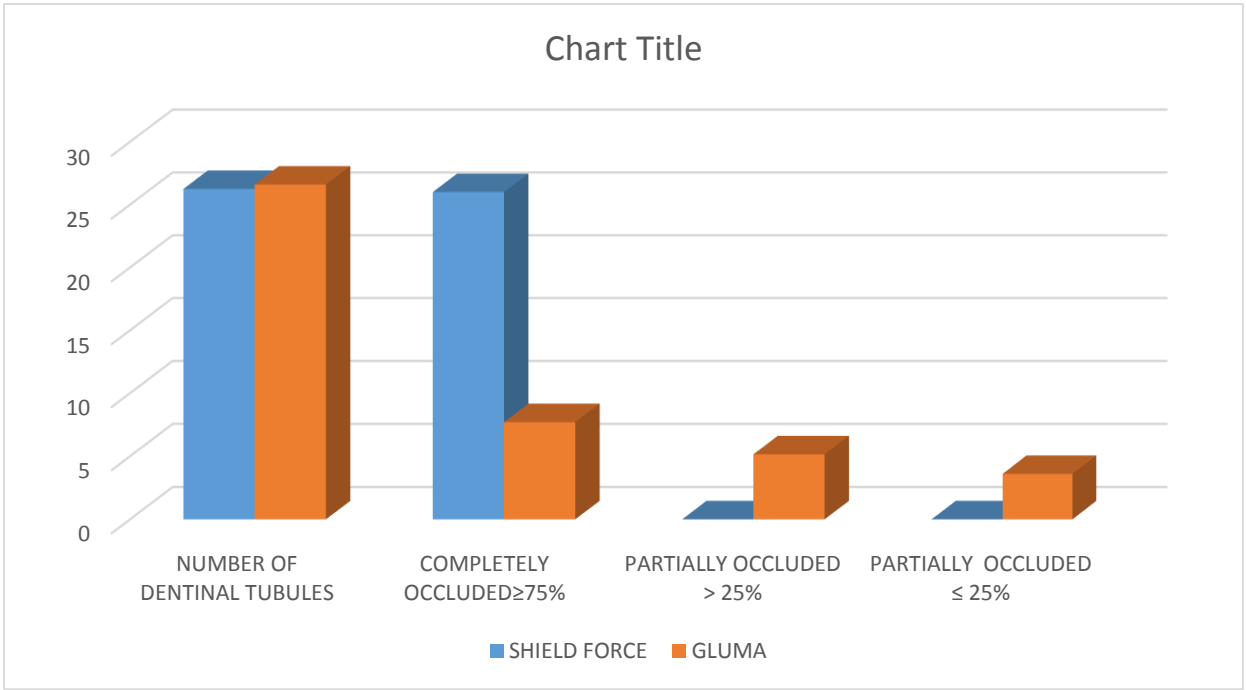
T1: Nearly complete dentinal tubule occlusion of >75% of dentinal tubule orifice.

T2: Partial dentinal tubule occlusion of > 25 % upto 75% of dentinal tubule orifice.

T3: Partial dentinal tubule occlusion ≤ 25% of dentinal tubule orifice.

HS: Highly Significant

GRAPH 1 - INTER GROUP COMPARISION OF GLUMA AND SHIELD FORCE PLUS



FIGURES:

FIGURE 1: GLUMA

FIGURE 2: SHIELD FORCE PLUS

SEM

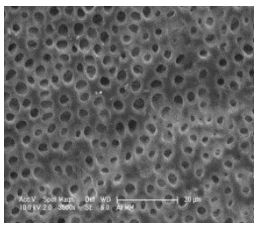


FIGURE 3: OPEN DENTINAL TUBULES

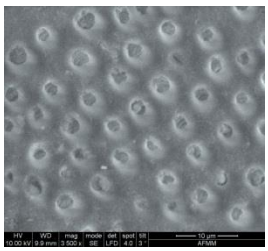


FIGURE 4:GLUMA

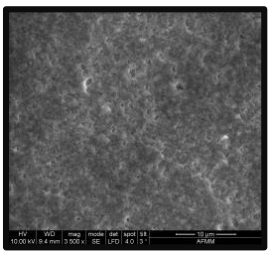


FIGURE 5:SHIELD FORCE PLUS