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ORIGINAL RESEARCH

The Effect of Three Dentinal Sealers on Retention of Crowns cemented with Resin-modified Glass Ionomer Cement: An *in vitro* Study

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ABSTRACT

Background: Dentinal sealers (desensitizing agents) are used to protect the pulp from possible injurious effects after tooth preparation and also prevent the penetration of dentinal tubules by bacteria and their products which are currently thought to cause most of the pulpal inflammation under the crowns.

Aim: The purpose of this study is to determine the efficacy of effect of three different desensitizing agents on retention of crowns cemented with resin-modified glass ionomer cement.

Materials and methods: Forty freshly extracted maxillary first premolars were notched for retention and the teeth specimens were mounted in autopolymerising resin. The axial height of all the specimens was 4 mm with a 20° angle of convergence. Impressions of the prepared teeth were made, later waxed invested and casted. Thirty teeth were coated with three different desensitizing agents were used in this study: Cavity varnish (Namuvar, Deepti Dental Products), Glutaraldehyde (Gluma-Heraeus Kulzer), Resin (AdheSE, Ivoclar Vivadent). Ten teeth were not coated with desensitizing agents to act as control group. Independent T test used to compare the mean values between groups.

Results: Tensile strength for average surface area of the groups I, II, III and IV are 0.3759, 0.2375, 0.2411, 0.2348 respectively. The t-test shows 'p'-value is statistically not significant ($p < 0.05$) for groups II and III, where as in group IV 'p'-value is statistically significant ($p < 0.01$).

Conclusion: The use of AdheSE/resin-based dentinal sealer showed increase in bond strength of the crowns luted with resin-modified glass ionomer cement when compared with control group. This study advocates the use of resin-based sealer or a glutaraldehyde-based sealer before cementation of the crowns. The cavity varnish, however, reduces the bond strength and is not acceptable.

Keywords: Bond strength, Desensitizing agents, Retention, Surface treatment.

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INTRODUCTION

To ensure a good retention in fixed restoration, it is imperative to adhere to the fundamental principles of tooth preparation. When the teeth are prepared for complete crowns, approximately 1.2 to 1.5 mm of tooth structure is removed to ensure appropriate crown contours and adequate structural durability. In this process, one to two million dentinal tubules are exposed on an average during a posterior tooth preparation.

Brainstorm's hydrodynamic theory speculated that any stimulus to the dentin can be transmitted back to nerve receptors. He also postulated that this occurred as a result of fluid movement in the dentinal tubules with stimulation of odontoblasts which elicited a response by nerve fibers and resulted in pain. After tooth preparation, bacteria can penetrate into the dentinal tubules, which correlated with pulpal disease.[1]

Provisional restorations often demonstrate microleakage that allows the ingress of bacteria and prepared teeth are often contaminated with saliva during various stages in fabrication of fixed partial denture. Glass ionomer cement when used as a luting agent for the final restoration, often cause sensitivity, especially if the remaining dentinal thickness was less than 1 mm. This sensitivity may be caused from the prolonged low pH of cement during setting and from hydrostatic pressure that enabled the cement to enter the dentinal tubules. This can result in abscess and pulpal hemorrhage or hyperemia.[2]

It has been suggested that the desensitizing agent can be applied on the prepared tooth surfaces to avoid complications during the interim stage while the restoration is fabricated and also before cementation. Desensitizing agent causes tubular occlusion, reduces the flow of fluids and diminishes hypersensitivity. The cavity varnish also prevented the formation of smear plugs (calcium and phosphorus-containing layers of dentin).[3,4]

Glass ionomer cement is used as a luting agent widely in prosthodontics and it binds chemically to the tooth structure. The carboxyl groups of the polyacids react with the calcium in the dentin. This possible chemical bond may be affected with the coat of desensitizing agents/varnish resulting in altered retentive qualities of the restroration. The desensitizing aspect of the coat of the varnish or the unfilled resin has been documented. The ill effects of these coats if any, on the retentive qualities of the restoration requires investigation.[1]

Dentinal sealers (desensitizing agents) are used to protect the pulp from possible injurious effects after tooth preparation. They are intended to provide a barrier against acidic components of the cement. The dentinal sealers prevent the penetration of dentinal tubules by the bacteria and their products which are currently thought to cause most of the pulpal inflammation seen under the crowns.

The purpose of this study is to determine the efficacy of effect of three desensitizing agents on retention of crowns cemented with resin-modified glass ionomer cement.

MATERIALS AND METHODS

Three different desensitizing agents were used in this study: Cavity varnish (Namuvar, Deepti Dental Products), Glutaraldehyde (Gluma, Heraeus Kulzer), Resin (AdheSE, Ivoclar vivadent) and were named as group II III, IV respectively. Group I as control group (no surface treatment). Total sample size was (n = 40).

STATISTICAL ANALYSIS

- Level of significance @ 5% (0.05)
- Power @ 90%
- Independent t-test**:** To compare the mean values between groups.

PREPARATION AND MOUNTING OF TEST SAMPLES

Forty freshly extracted maxillary first premolars were stored in 5% sodium chloride solution/normal saline. The teeth were carries free and did not contain any restorations for standardization. The roots were notched for retention and the teeth specimens were mounted in autopolymerising resin (polymethyl methaclylate, DPI Dental Products) of 1 cm ring. The cementoenamel junction of the tooth was at the level of the ring. The tooth sample was mounted on the surveyor (Marathon Surveyor, 103 BEGO) to which straight hand piece was attached and teeth were prepared (Fig. 1).

PREPARATION OF TEETH

The axial height of all the specimens was prepared 4 mm from the cementoenamel junction. The axial surface was prepared by rotating the base of the instrument against the diamond point. By using a new diamond point for each tooth the axial surface was reduced to a depth of 1 mm and the axial length of 4 mm. Taper of the diamond point (sintered diamond, DES Germany) is 10. Hence, the final tooth preparation resulted in 20 angle of convergence.

IMPRESSIONS AND PREPARATION OF MODELS

Impressions of the prepared teeth were made using condensation silicone putty (Zetaplus, Zhermack) and light body impression material (Oranwash, Zhermack) using putty reline technique with metal stock tray (Fig. 2). The cast of the impression were poured using type IV Gypsum (Kalabhai) and coated with die hardner (Stone-Die or plaster

Fig. 1: Preparation of tooth sample

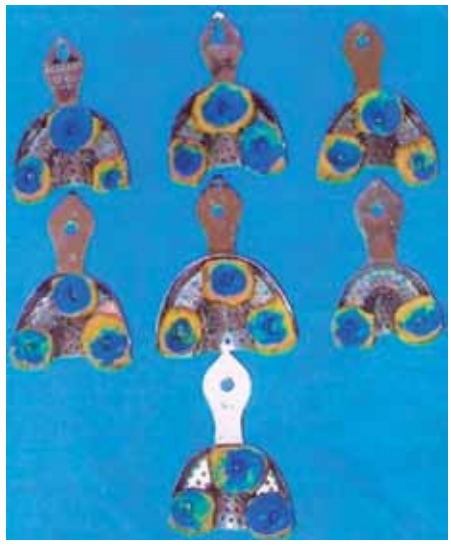

Fig. 2: Making an impression using putty reline technique

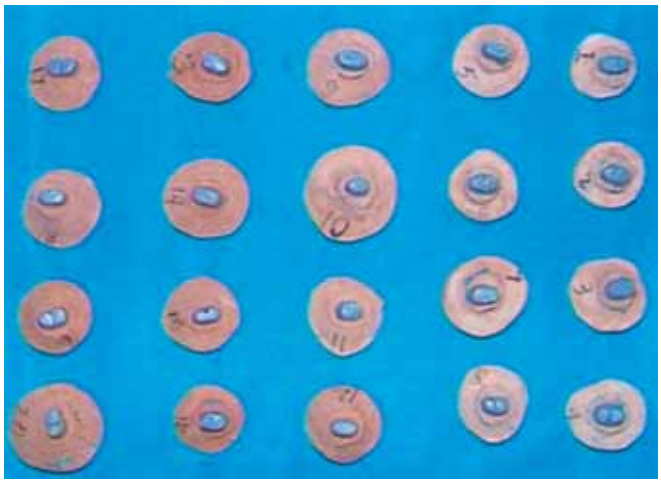

Fig. 3: Die stone models

Fig. 4: Crown on die stone model

hardner resin, Heartman Dental Lab) (Fig. 3). Three coats of die spacer (Color Spacer, Heartman Dental Lab) was applied to each master die in a controlled fashion with time for the previous layer to dry. Die lubricant (true release die lubricant, George Taub Products) was painted on the master die and existing lubricant was removed with a gentle stream of air.

WAXING, INVESTING AND CASTING

The inlay wax (GC Corporation, Tokyo) copings were standardized to 0.5 mm thickness using a wax guage. The wax loop was attached parallel to the long axis of the prepared tooth. The wax patterns were sprued and invested with phosphate bonded investment material (Bellasum and BegoSol, BEGO). Manufacturer's directions were followed for mixing, setting time and burn out process. The test crown were casted with Nickel chromium alloy (Bellabond, BEGO) using induction casting machine (Fornax, BEGO) and minor adjustments necessary to seat the casting were completed using a small round bur (No. 1) mounted on laboratory micro-motor hand piece (Ray Foster Dental Equipment). The internal surface of each crown were abraded with 50 ums aluminum oxide particles with an air abrasive unit (Korostar, BEGO). The fit of the completed castings was again verified by visual inspection on the preparations before cementation (Fig. 4).

MEASUREMENT OF SURFACE AREA OF PREPARED TEETH SAMPLES

Before cementation the axial surface of each prepared tooth was determined. The perimeter of each tooth at occlusal level was marked with the pencil on to a calibe-rated sheet and calculated. The perimeter of each tooth at the cervical level was calculated using dental floss. The surface areas of the axial surface and the occlusal surface were calculated by the following formula:

S = 1/2 Bh wherei

S = total surface of the tooth,

B = total perimeter of cervical Area + perimeter of occlusal area.

H = slant height (4 mm)

As the surface area varies from each tooth sample, a mean surface area of the 40 teeth sample was calculated.

APPLICATION OF DENTINAL SEALERS (DESENSITIZING AGENTS)

The cavity varnish (Namuvar, Deepti Dental Products) was coated twice over ten prepared tooth surface .Only one coating of Gluteraldehyde (Gluma, Heraeus Kulzer) was applied to ten prepared teeth. The Resin (AdheSE, Ivoclar Vivadent) was also coated once over ten prepared teeth and light cured. The remaining ten teeth were not coated with desensitizing agents to act as control group.

CEMENTATION

The resin modified glass ionomer cement (FujiCEM, GC Corporation, Tokyo, Japan) was mixed as per the manufacture's instruction and the crown was luted to the prepared teeth using finger pressure. Excess cement was cleaned from the margins of the casting and all the samples were placed in the water at room temperature for 24 hours (Fig. 5).

TESTING THE BOND STRENGTH

Now with the universal testing machine (Hounsfield) at a crosshead speed of 0.5 mm per minute, the crowns were subjected to a axial displacement force until failure of the bond between the crown and the cemented tooth sample (Fig. 6). Force of dislodgment and nature of debonding were recorded. The forces of dislodgment were measured

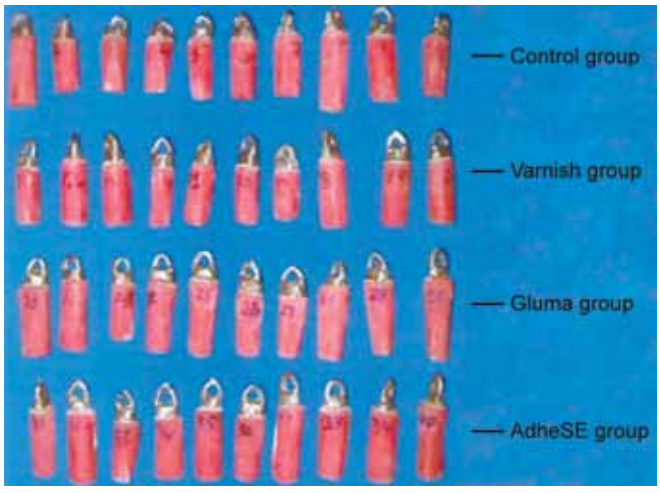

Fig. 5: Crowns luted with resin modified glass ionomer cement

Fig. 6: Testing a sample in Hounsfield universal testing machine

in Newtons. For a given surface area if the dislodgment force is X Newtons, then the dislodgment force for average surface area is calculated mathematically.

Example: For X1 mm^2 area if tensile strength recorded is 200 N. Then for X2 mm^2 (average surface area), the tensile strength would be X2 × 200/X1.

RESULTS

All data were analyzed by using the Statistical Program of Social Science version 18.0 (SPSS Inc, Chicago, USA).

The values obtained by measuring the tensile stress/bond strength of 40 maxillary Ist premolars cemented with resin-modified glass ionomer cements after being treated with cavity varnish, Gluma and AdheSE and a control group are shown in (Table 1). The dislodgment forces were measured in Newton's and converted to Megapascals (MPa) for the average surface areas.

Tensile strength for average surface area of the control group and varnish group are compared and the standard errors for the control group is 0.3759 and for varnish group it is 0.2375. The t-test shows us that the p-value is statistically not significant ($p < 0.05$).

The tensile strength for average surface area of the control group and the Gluma group are compared and the standard error shows 0.3759 for control group and 0.2411 for Gluma group. The t-test value shows us that the p-value is statistically not significant ($p > 0.05$).

Tensile strength for average surface area of the control group and group sample coated with AdheSE sealer. The standard error for AdheSE is 0.2348 and the t-test shows that the p-value is statistically significant ($p < 0.01$).

DISCUSSION

The amount of tooth reduction as well as the area of tooth surface prepared can lead to various degrees of dentin permeability and subsequent pulpal irritation. Prolonged low pH values of various luting cements including glass ionomer cement causes hypersensitivity. Several dentinal sealers have been advocated for sealing dentin before cementation of cast restoration to decrease post cementation sensitivity. The dentinal sealers prevent the penetration of the dentinal tubules by bacteria and their products which are currently thought to cause most of the pulpal inflammation seen under the crowns. Dentinal sealers,

Table 1: Average tensile strength for average surface area for all the groups

					95% confidence interval for mean				
Groups	*N*	*Mean*	*SD*	*Std. error*	*Lower bound*	*Upper bound*	*Minimum*	*Maximum*	*p > 0.05/ p > 0.01*
Group I (control)	10	2.6270	1.1887	0.3759	1.7767	3.4773	1.37	5.40	
Group II (varnish)	10	1.9680	0.7512	0.2375	1.4307	2.5053	1.30	3.52	>0.05
Group III (Gluma)	10	3.3040	0.7624	0.2411	2.7586	3.8494	2.30	4.87	>0.05
Group IV (AdheSE)	10	4.0420	0.7426	0.2348	3.5107	4.5733	3.12	5.36	>0.01
Total	40	2.9853	1.1525	0.1822	2.6167	3.3538	1.30	5.40	

however, alter the bond strength between the crown and the tooth to which the crown is cemented. The bond strength either increases or decreases.[1,3] The purpose of this study is to determine the efficacy of effect of three desensitizing agents on retention of crowns cemented with resin-modified glass ionomer cement.

The methodology used for tooth preparation was by using a straight handpiece with sintered diamond mounted on surveyor for the sake of standardizing the angle of convergence to 20. In previous studies by Edward SJ, an air rotar was used which was mounted on the surveyor at an established angle for tooth preparation.[5]

A 20° angle of convergence which was obtained using the sintered diamond point of 10 angulation was chosen for this study, so that the contribution of the resin modified glass ionomer cement is better assessed. The density of dentinal tubules is 20.000/mm^2 at the periphery and 29.500/mm^2 mid distance to the pulp with tubules diameters of 0.9 and 1.2 mm respectively. This equates to 1.3 to 3.3 mm^2 of open dentinal tubules per square centimeter of dentin. In this study the mean axial surface area of prepared dentin was 84.07 $mm.^2$ Previous study have used a constricted angle of convergence of 4.8°, which alone provided significant casting retention as reported by Kaufman et al.[6] In another study by Yim NH et al, the angle of convergence was 26° which resulted in more axial reduction of teeth than normal due to it, less intertubular dentin for bonding may have been available than that encountered in the present study which used 20 taper/angle of convergence and 4 mm axial height.[7]

The cavity varnishes are popular because they are convenient to use and they can be applied rapidly. They dry almost immediately. The dental cavity varnish was chosen for this study, because studies by Pashley et al showed that varnish reduces dentin permeability by 20 to 50% as measured by radioactive isotope technique.[8] The cavity varnishes contain dissolved solids which undoubtedly enhance its ability to decrease dentin permeability fluid movement in the direction of dentin to pulp tends to force varnishes down against the dentin which improves their sealing properties during the time the force (mastication) is applied.

The Gluma (glutaraldehyde-based sealer/desensitizer) was used in this study because studies by Edward SJ et al and by Glen JH et al showed that Gluma desensitizer had no effect on crown retention for glass ionomer.[5,9,10] The Gluma (glutaraldehyde—5%, hydroxyethyl methacrylate—35% and water—60%) binds chemically to the acid polymers of resin-modified glass ionomer cement. The resin-modified glass ionomer cement contains polyacrylic, itaconic and polymaleic acids along with calcium fluoroalumina silica glass.[11-13] The Gluma desensitizer occludes the dentinal tubules as the glutaraldehyde component products precipitate and thereby providing the sealing of dentinal tubules and desensitization. Although, there may be a loss of ionic bonding to dentin when sealing with Gluma desensitizing agent, the resin-modified glass ionomer cement may have chemical affinity to Gluma desensitizing agent which contains hydroxyethyl methacrylate monomers—35%.[14,15]

The resin-based dentinal sealer (AdheSE) was selected for this study because studies by Glen H Johnson showed that one step adhesive improved the retention of glass ionomer cement by 55%.[9] The reason being that the hydroxyethyl methacrylate monomers bind chemically with the acid polymers of the glass ionomer cement against the sealer, this interface may be a kin to polymerized resin modified glass ionomer cement. The AdheSE primer contains dimethacrylate, phosphoric acid acrylate, initiors, stabilizers in aqueous solution. The AdheSE bond contains HEMA, dimethacrylate, silicon dioxide, initiators and stabilizers.[16,17]

The main reason for using resin modified glass ionomer cement is because of low micro leakage and has antibacterial effect as reported by Herrara M et al due to slow release of fluoride.[18] The glass ionomer cement is known to adhere chemically to tooth structure Fuji CEM is the first resin modified glass ionomer cement available in paste from and dispensed in the form of cartridges and dispensing gun. The studies by Rosential SF showed that the tensile strength of resin-modified glass ionomer cement was superior to zinc phosphate cement and polycarboxylate cement.[19]

For debonding the cemented crowns luted on the teeth samples a universal testing machine was used. In previous study, Glen JH had used Instron universal testing machine.[9,10] In this study, Hounsfield universal testing machine with a computer to show the values of dislodging forces in Newtons was used.

The bond strength values of the crowns luted with resin modified glass ionomer cement after application of the cavity varnish were not statistically significant (control group—2.6 MPa and varnish group—1.96 MPa). The previous studies by Kai Chiu and Chan et al showed that the copalite and vernal varnish decreased dentinal bonding strength for zinc phosphate cement and polycarboxylate cement because the varnishes formed a layer which prevents the bonding between the cement and the tooth surface.[3]

The effect of desensitizer on crown retention for resin modified glass ionomer cement was evaluated, and there was not much statistically significant values between the control group and Gluma desensitizer group (control—2.26 MPa and the Gluma group—3.3 MPa), indicating that the Gluma desensitizing agent did not decrease the retention of crowns but increased the

retention of the crowns. Another study by Glen JH et al proved that Gluma desentizer demonstrated no loss in retention of crowns cemented with glass ionomer cement.[9]

An increase in the bond strength between the crowns and teeth cemented with resin modified glass ionomer cement after application of AdheSE was observed. The values were statistically significant (control—2.6 MPa and AdheSE—4.4 MPa) with p-value 0.01.

In this study, the forces required to dislodge ranged from 1.3 MPa to 5.4 MPa depending on the dentinal sealer used. The most important finding of this study was that the glutaraldehyde-based dentinal sealer which also is a resin primer (Gluma desensitizer) and resin adhesive (AdheSE) did not reduce the retention of cast metal crowns luted with glass ionomer cement.

Previous study by Edward SJ et al confirmed the above finding.[5] In that study it was reported that one step adhesive (resin sealer) bonding agent slightly increased the retention with the glass ionomer cements. Resin modified glass ionomer cement provided significantly higher retention. This was documented by Glen JH, which shows that glass ionomer cement and resin sealer provides a tensile stress of 4.23 MPa = 0.93.[9] This is comparable to this study value in which 4.04 MPa was achieved following the use of resin-modified glass ionomer cement and AdheSE (resin-based sealer).

In this study, only the numerical values of debonding forces (in Newton) were measured. The nature of failures (cohesive or adhesive) was not evaluated. Further research by SEM studies will confirm the nature of failures between the cement and the tooth, within the cement layer or whether the failure has occurred between the cement and the crown.

CONCLUSION

The use of AdheSE/resin-based dentinal sealer showed increase in bond strength of the crowns luted with resin-modified glass ionomer cement when compared with control group. The hydroxyethyl methacrylate in the AdheSE/resin-based sealer bind chemically to acid polymers of resin-modified glass ionomer cement. This study advocates the use of resin based sealer or a glutaraldehyde-based sealer before cementation of the crowns. The cavity varnish, however, reduces the bond strength is not acceptable.

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