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ORIGINAL ARTICLE

Comparing the Effect of a Resin Based Sealer on Crown Retention for Three Types of Cements: An In Vitro Study

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Abstract To determine the effect of resin based sealer on retention of casting cemented with three different luting agents. 55 extracted molar teeth were prepared with a flat occlusal surface, 20° taper and 4 mm axial height. The axial surface of each specimen was determined. The specimen were then distributed into five groups based on decreasing surface area, so each cementation group contained 11 specimens with similar mean axial surface area. A two-step, single bottle universal adhesive system (One-Step—Resinomer, Bisco) was used to seal dentin after the tooth preparation. Sealer was not used on the control specimens except for the modified-resin cement (Resinomer, Bisco) specimens that required use of adhesive with cementation. Using ceramometal (Wirobond®, BEGO), a casting was produced for each specimen and cemented with either zinc phosphate (Harvard), glass ionomer (Vivaglass) or modified resin cement (Resinomer) with single bottle adhesive. All the castings were cemented with a force of 20 kg. Castings were thermal cycled at 5 and 55 °C for 2,500 cycles and were then removed along the path of insertion using a universal testing machine at 0.5 mm/min. A single-factor ANOVA was used with a = 0.05. The nature of failure was also recorded. The mean stress removal for non sealed zinc phosphate, sealed zinc phosphate, non sealed glass ionomer, sealed glass ionomer and modified resin cement was found to be 3.56, 1.92, 2.40, 4.26, 6.95 MPa respectively. Zinc phosphate cement remained principally on the castings when the tooth surface was treated with the sealer and was found on both the tooth and the casting when the sealer was not used. Fracture of root before dislodgement was seen in 9 of 11 specimens with modified resin cement. Resin sealer decreases the retention of the castings when used with zinc phosphate and increases it when used with glass ionomer cement. The highest mean dislodgement force was measured with modified resin cement.

Keywords Resin based sealer · Zinc phosphate cement · Glass ionomer cement · Modified resin cement · Retention

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Introduction

Fixed Prosthodontics is a very demanding and challenging branch of dentistry. There are various problems encountered during and after fixed prosthodontics treatment [1–3]. Post-operative dentinal sensitivity is one of them. Dentin reduction and exposure of the prepared tooth surface can lead to increased dentin permeability and subsequent pulpal irritation. This phenomenon of dentinal hypersensitivity is best explained by Brannstrom's hydrodynamic theory [4–6].

Teeth which are prepared extensively for large amalgam restorations or crowns are at an enhanced risk of developing hypersensitivity because of the large number of tubules getting exposed during the preparation. Desiccation, frictional heat generation during preparation [7] and chemical irritation from the luting agent [8] are important factors that increase the likelihood of hypersensitivity.

Retention of cast restoration is one of the basic principle criteria for success in Fixed Prosthodontics. It is mainly affected by principles of tooth preparations and partially by variations in casting procedure, properties and thickness of luting agents and post environmental stresses [1–3]. Post cementation hypersensitivity is the most common problem encountered in the clinical practice because of the acidic nature of luting agents [8]. In an effort to control post operative sensitivity, a number of dentinal sealers have been described in the literature which are applied following crown preparation [9]. These dentinal sealers may have adverse or beneficial effect on retention of restoration, as these sealers may affect the bond strength of luting agents with the tooth structure [10]. These sealers are basically glutaraldehyde and resin based. Sealing of dentinal tubules with resin based sealer has been shown to greatly decrease hypersensitivity [11–14].

Most the studies [11–14] conducted in the past compare the efficiency of different types of sealers in reducing the dentinal hypersensitivity, but very few of them describes the effect of these sealers [15–19] on retention of crowns cemented with different types of luting agents. So this study was conducted to investigate the effect of resin based sealer on crown retention for three commonly used cements i.e. zinc phosphate, glass ionomer and modified resin cement.

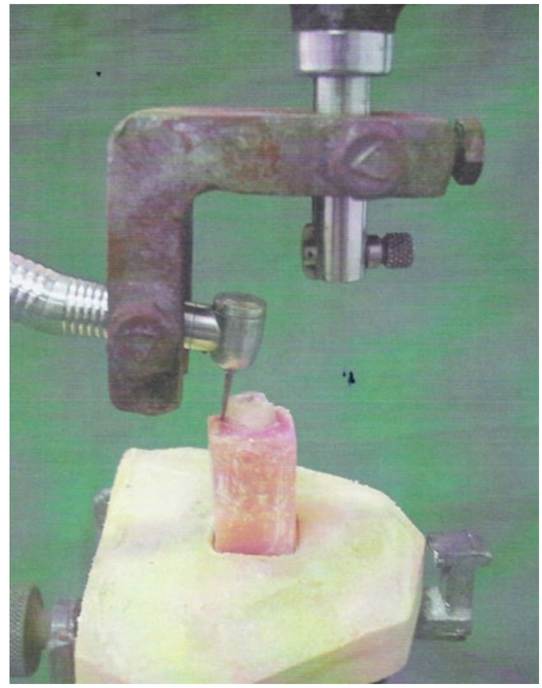

Fig. 1 Hand piece attachment on NEY surveyor

Materials and Methods

55 noncarious, unrestored, recently extracted molars were selected for this study. Immediately after extraction, the teeth were cleaned to remove surface debris, sterilized for a short time in 0.5 % sodium hypochlorite solution and then stored in water at room temperature. The roots of the teeth were roughened and then embedded into autopolymerizing resin block. These blocks were prepared using silicon putty custom made moulds. Teeth were mounted into the block with cemento-enamel junction positioned 1 mm above the top of the block. After mounting, teeth were stored in sterile water which was changed daily.

A high speed hand piece was fixed onto one of the custom made metal attachment which was designed to fit in Ney surveyor (Fig. 1), so that the diamond bur was oriented at an angle of 10° from a vertical axis to create a total convergence angle of 20°. The tooth with acrylic block was secured vertically in a custom-made jig held firmly in a surveyor base. A parallel sided, coarse diamond bur with round tip was used to prepare axial surface and a chamfer finish line was established in each specimen. The occlusal surface was sectioned flat 5 mm above the top of block. Axial reduction was done by rotating the surveyor base against the diamond bur.

Impressions for each specimen were made with polyvinyl silicone impression material (Virtual 380®, Ivoclar vivadent Inc., Amherst, NY, USA). Die for each specimen was prepared with type IV gypsum product (Elite Rock, Zhermack SpA, Italy). Three coats of die spacer (Pico-Fit, Renfert GmbH, Hilzingen, Germany.) were applied on each die in a controlled fashion, with time provided for the previous layer to dry. Die lubricant (Picosep, Renfert GmbH, Hilzingen, Germany.) was painted on the die and excess of it was removed with a gentle stream of air. The die was subsequently dipped twice in molten wax to achieve a constant thickness of 1 mm. A wax loop was then fabricated and added to the center of the wax pattern. All the 55 specimens were prepared in the same manner. The wax pattern was sprued and invested with a phosphate bonded investment (DeguVest impact, DeguDent, Germany.) and the crown was made from a base metal porcelain metal alloy (Wirobond® 280, BEGO, Herbst GmbH & Co., Bremen, Germany). Minor adjustments were carried out to seat the casting on the die and the fitting of the completed restoration was again verified on the preparation prior to cementation (Fig. 2). The internal surface was cleansed using a steam cleanser to remove debris and was also air abraded with silica particles.

Prior to cementation, the perimeter of each preparation was measured with a suture thread and scale. The perimeter for each tooth was multiplied by the axial length (4 mm) to calculate the total axial surface area of each preparation and axial surfaces were demarcated on each specimen block. Then after, the preparation were ranked by decreasing surface area and distributed into five groups. So that each cementation group contained 11 specimens with similar mean axial surface area. These groups were named

Fig. 2 Cemented casting

A, B, C, D and E. Two groups were used as control for zinc phosphate (Harvard; Harvard Dental International GmbH Margaretenstr, Hoppegarten, Germany) and glass ionomer cements (Vivaglass; Ivoclar vivadent Inc., Amherst, NY, USA). (Group B—zinc phosphate control, Group D—Glass ionomer control). Three groups were used for three different cements along with resin based sealer. (Group A—zinc phosphate + sealer, Group C—glass ionomer + sealer, Group E—modified resin cement). Modified resin cement (Resinomer, Bisco Inc., Irving Park Rd, Schaumburg, IL.) had no control group. For Group A, C and E, dentin was etched for 15 s with 32 % phosphoric acid. Then after, the preparation was rinsed for 20 s and moisture was removed. Two coats of resin sealer were applied, thoroughly dried with air, and light polymerized for 10 s. For Group E, internal surface of casting was treated with one coat of resin sealer. The control Group B and D were not treated with resin sealer. Prepared teeth and casting were paired for cementation that were Group A and B with zinc phosphate cement, Group C and D with glass ionomer cement and Group E with modified resin cement. Manufacturer's directions were followed for manipulation of all three luting agents. The paired casting were lined with cement and initially seated with strong finger pressure. Then the assembled teeth and casting were placed in a loading device and subjected to an axial force of 20 kg for 10 min. The excess cement was removed from the margins and the specimens were placed in water at room temperature for 24 h. Twenty-four hours after cementation, the crowns were cycled between water reservoirs at 5 and 55 °C for 2,500 cycles, using a 30 s dwell time at each temperature. Crowns were subjected to axial dislodgement force until failure on universal testing machine (Instron) at a cross head speed of 0.5 mm/min. The force at dislodgement and the nature of debonding were recorded. Immediately following casting dislodgment, two observers independently examined the casting and tooth without magnification to arrive at the type of failure modes based on criteria given in Table 1. When differences existed between examiners, a consensus was achieved by reexamination. Dislodgement force was converted to stress using the axial surface area calculated for each preparation.

Data and Results

All data were analyzed by SPSS (13 releases) statistical software. Mean axial surface area is given in Table 2. The data reflect a uniform distribution of surface area across all cement groups. Table 3 shows the results for stress at failure for all groups. The mean stress for zinc phosphate control group was 3.56 MPa (0.21 SD), compared to 1.92 MPa (0.15 SD) when the sealer was applied. This result shows that 53 % reduction in retentive stress with the use of the sealer. The stress for removal of crowns cemented with glass ionomer cement was 2.41 MPa (0.25 SD), which was statistically equivalent to the group using zinc phosphate with sealer. The group using glass ionomer with sealer, however, demonstrated a crown removal stress of 4.26 MPa (0.20 SD), or a 57 % increase in stress compared to the control. The mean removal stress for castings cemented with the modified resin cement was 6.93 MPa (0.58 SD). This group exhibited the maximum mean crown removal stress with no equivalency to other mean values. Table 4 shows the results for characterization of failure modes. The failure mode for zinc phosphate control group was evenly distributed among all the four failure types. For zinc phosphate with sealer group, the cement was predominantly found on the casting. For both resin sealer or non-sealer groups, cement was remaining principally on tooth surface after removal of crown. The failure mode for modified resin cement was root fracture. These data graphically demonstrate the progression of the five cementing systems in approaching the cohesive strength of the root.

Discussion

The research hypothesis that application of a resin sealer to dentin would decrease casting retention for zinc phosphate

Table 1 Characterization of type of failure

Failure type	Description
1	Cement principally on tooth (>3/4 axial surface)
2	Cement on both casting and tooth
3	Cement principally on casting (>3/4 axial surface area)
4	Fracture of tooth root without casting separation

Table 2 Mean axial surface area and associated standard deviation of prepared test tooth grouping

Technique	Area (mm^2)	SD
Zinc phosphate (B)	119	14
Zinc phosphate + sealer (A)	109	13
Glass ionomer (D)	116	16
Glass ionomer + sealer (C)	113	12
Modified resin cement (E)	113	11

Table 3 Removal stress of casting and standard deviation

Cement types	Mean	SD
Zinc phosphate + sealer	1.9209	0.15202
Zinc phosphate	3.5682	0.21353
Glass ionomer + sealer	4.2609	0.19634
Glass ionomer	2.4082	0.25810
Modified Resin cement	6.9591	0.58838

Table 4 The results for characterization of failure modes

		Failure type			
		1	2	3	4
Zinc phosphate	No. of specimen	2	3	3	3
	Percentage	18.1	27.2	27.2	27.2
Zinc phosphate + sealer	No. of specimen	1	2	8	0
	Percentage	9.09	18.1	72.7	0.0
Glass ionomer	No. of specimen	6	2	1	2
	Percentage	54.5	18.1	9.09	18.1
Glass ionomer + sealer	No. of specimen	7	1	0	3
	Percentage	63.3	9.09	0.0	27.2
Modified resin cement	No. of specimen	1	1	2	7
	Percentage	9.09	9.09	18.1	63.6

and not affect glass ionomer cement was only partially correct. The resin sealer reduced casting retention significantly (53 %) for zinc phosphate cement as anticipated but contributed to a 57 % increase in retention for glass ionomer cement.

In this study the tooth preparation was standardized with 10° axial taper because it has been shown that the retention of crown increases exponentially [20] with decrease in taper from 10°. So in order to have effect of both cement as well as mechanical tooth preparation, the preparations were standardized at 10° and it has also been shown that most of the times clinically the preparations have angle of convergence not less than 10°. [21].

The results obtained were different as compared to that obtained by Swift et al. [22]. They found that using same single bottle, two step resin based sealer as a dentin desensitizer, did not have any effect on casting retention when cemented with zinc phosphate, glass ionomer or resin modified cement because the taper of prepared tooth was of lesser degree and the prepared teeth were reused after casting removal for recementation with successive cements, that might have lead to an increase in the cement space but in this study the teeth were not reused and also 10° taper was standardized for each preparation.

Results obtained were similar to that shown by Mausner et al. [23] and Yim et al. [10] from their studies. Casting retention decreased when resin sealer was used with zinc phosphate, but a similar effect for glass ionomer was not shown. The beneficial adhesive effect was not demonstrated with glass ionomer cement. In this study, conical shaped preparations were used and this lead to more axial reduction of molars than normal. Due to this, less amount of intertubular dentin was available for bonding than that encountered in present study which used more conservative axial tooth preparation.

In a study examining the effect of a polymerizable material (All-Bond 2), and a nonpolymerizable desensitizer (Gluma Desensitizer), Gluma desensitizer (glutaraldehyde-based sealing system) significantly decreased crown retention. With resin cement and resin-modified glass ionomer, use of All-Bond 2 desensitizer significantly increased crown retention values. Both dentin desensitizers significantly decreased the retentive strength of crowns cemented with zinc phosphate cement. The research hypothesis that use of dentin desensitizers that have the ability to chemically react with the cement will provide enhanced crown retention. The Gluma desensitizer exhibits no chemical interaction with glass ionomer cement and resin cement [24]. While All-Bond 2 desensitizer is capable of polymerizing with cementing agent (glass ionomer and resin cement) and increases crown retention.

The application of resin sealer to dentin would decrease about 53 % of casting retention. Zinc phosphate attains its retentive qualities by mechanical adhesion between prepared dentin and internal surface of casting. The teeth were prepared with a coarse diamond bur and castings were air borne particle abraded before cementation to simulate the ideal clinical circumstances for such mechanical adhesion. But the application of resin based sealer on prepared dentin would impair the mechanical adhesion between dentin and zinc phosphate cement. So resin based sealer decreases the retention of casting cemented with zinc phosphate cement. The cement resided on casting when the sealer was used with zinc phosphate in 8 out of 11 specimens (72 %). This is in contrast to mixed mode of attachment noted with zinc phosphate (control Group). Therefore it is concluded that the resin sealer eliminates some of the dentin surface irregularities by which the retention with zinc phosphate is gained (Figs. 3, 4).

In comparison with zinc phosphate, the retention of casting cemented with glass ionomer cement was significantly increased after application of resin based sealer. The casting retention was increased 57 % when used with sealer. Although chemical bonding of glass ionomer to dentin has not been definitively proved, it has long been postulated that glass ionomer gains a degree of adhesion from ionic interaction of carboxyl ions with calcium ions in the tooth structure. The glass ionomer luting agent used contains reactants such as poly acrylic, itaconic and polymaleic acids, along with calcium fluoroalumina silica glass. Although there may be loss of the ionic bonding to dentine when sealing with a primer, the acid polymers of the glass ionomer may have a chemical affinity to the resin sealer, which contains bisphenyl dimethacrylate, Bis-GMA, and hydroxyethyl methacrylate (HEMA) monomers. After setting of the glass ionomer cement against the sealer, this interface may be akin to a polymerized resin modified glass ionomer. Another explanation of this behavior is that the resin sealer may function as a stress reliever during casting dislodgement, resulting in higher removal stress. Whatever the mechanism for adhesion, it is clear that use of the two step, single bottle multipurpose bonding system created an improved condition for adhesion of glass ionomer luting cements to dentine.

Glass ionomer cement may have chemical affinity with tooth structure. When sealer was applied to the dentin, the affinity of glass ionomer with tooth structure may be changed. But after settings of the glass ionomer cement against sealer this interface may be like a polymerized resin modified glass ionomer. For both the control and the sealed teeth, the failure mode was the same, with cement principally remaining on tooth (60 %) (Figs. 5, 6).

When comparing the control group (Group B and D), the mean retentive stress for castings cemented with glass ionomer cement was lower than that for zinc phosphate. The retentive stress increased significantly for casting cemented with glass ionomer after the dentin sealer was used, so that the removal stress was equivalent to that for the zinc phosphate (control group).

The modified resin luting agent was the most adhesive luting system with cast dislodgement stress exceeding the root cohesive stress in most situations (because tooth fractures before casting separation). Thus it is likely that the actual dislodgement stress is higher than the mean value for root fracture. Even without this consideration, dislodgement force for modified resin cement was approximately 50 % greater than the next closest group (Group C).

For modified resin cement, casting dislodgement stress exceeds the root cohesive stress in most situations (Type 4

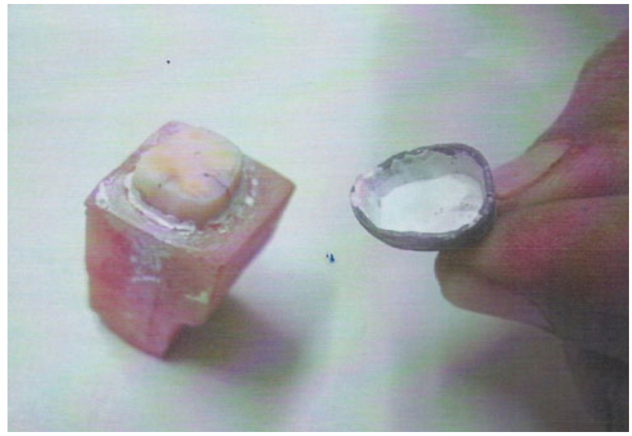

Fig. 4 Zinc phosphate cement with resin sealer showing cement on casting only

Fig. 3 Zinc phosphate cement without resin sealer showing mixed mode of failure

Fig. 5 Glass ionomer cement without resin sealer showing cement principally on dentin

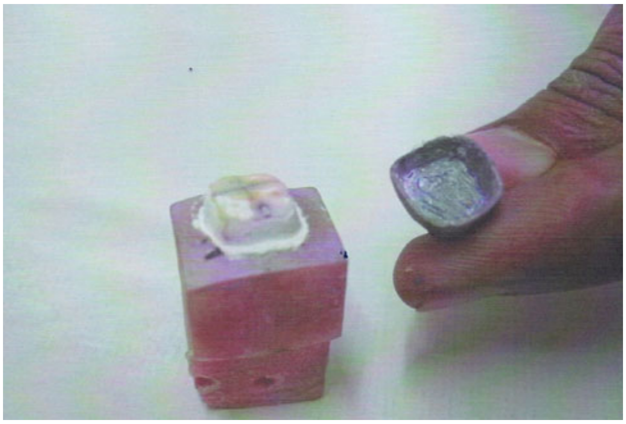

Fig. 6 Glass ionomer cement with resin sealer showing cement principally on dentin

Failure). Thus it is likely that the actual dislodgement stress is higher than the mean values shown. Modified resin cement is adhesive system used with acid etching and dentin bonding agents and bond to the tooth structure attained by light polymerization and chemical polymerization (dual cure system). Acid etching increases the area for adhesion to tooth structure. This bond strength is very strong and it might be stronger than the tooth also, so in many specimens, tooth root fractures before casting specimen was dislodged (Fig. 7).

The resin based sealer is not indicated after tooth preparation when crowns are to be luted with zinc phosphate cement because of decrease in the retention of casting. Resin based sealer may be used successfully with glass ionomer and modified resin cement. In a situation where the clinical crown is short or high angle of convergence is present the modified resin cement may retain the casting best.

Additional studies are also required to determine the effect of resin based sealer on wide variety of commercially available different luting agents. This study was carried out with 20° angle of convergence of preparation, so further more study is required with different degree angle of convergence.

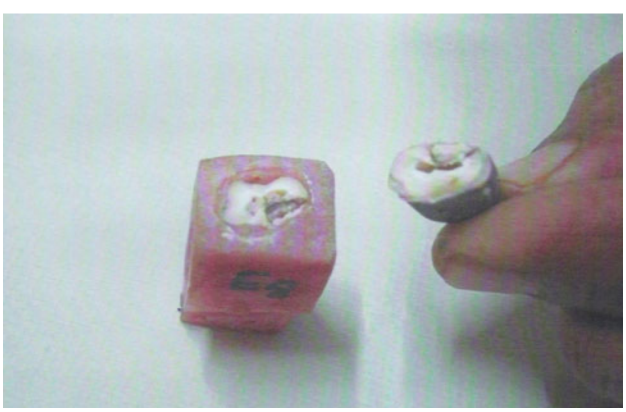

Fig. 7 Modified resin cement with resin sealer showing fractured tooth structure, rather than crown dislodgement

The specific brands selected for testing in this study were representative of a broad range of products within that classification. As only a single product for each classification was tested, global statements regarding all products within a category cannot be made with certainty. However, it is expected that the general trends and concepts developed in this research will be valid for a number of products within a category.

Conclusion

The resin based sealer reduced 47 % crown retention for casting cemented with zinc phosphate cement, when used as a dentin desensitizing agent for crown preparation. Use of resin based sealer with glass ionomer cement increased 77 % of crown retention which is nearly equivalent to that of the zinc phosphate alone. Modified resin cement produced a significantly greater mean dislodgement stress, generally exceeding the strength of tooth.

Modified resin cement is the most retentive cement compared to all other cements used in this study. So it is suggested that modified resin cement gives good results in short clinical crown height and high angle of convergence.

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