ARTICLE 3

THE EFFECT OF RESIN DESENSITIZING AGENTS ON CROWN RETENTION

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ABSTRACT

Many dentists use resin primers and adhesives to prevent post-cementation sensitivity of teeth restored with crowns. However, little information is available regarding the effect of these resins on crown retention. This laboratory study concluded that two popular resins, Gluma Desensitizer (Heraeus Kulzer) and One-Step (Bisco Dental Products), had little or no effect on the retention of crowns luted with zinc phosphate, glass ionomer or resin-modified glass ionomer cements.

The phenomenon of dentinal hypersensitivity is best explained by Brännström's hydrodynamic theory.[1] When exposed dentinal tubules are stimulated by changes in temperature or osmotic pressure, tubular fluid is displaced. Fluid movement is conveyed to nerve fibers in the pulp, causing stimulation that is interpreted as pain. Teeth that are prepared for restorations, especially large amalgams or crowns, are at risk of developing hypersensitivity because a large number of tubules are exposed during preparation. Desiccation and frictional heat generated by preparation increase the likelihood of hypersensitivity.

Tooth sensitivity after cementation of crowns, therefore, is not an uncommon problem,[2] and many dentists now use resin desensitizing agents to prevent its occurrence.[3] Sealing of dentin with resins has been shown to greatly decrease hypersensitivity.[4-7]

Adhesives such as One-Step (Bisco Dental Products) mechanically occlude open tubules with resin, thus sealing them from the oral environment. Primers such as Gluma Desensitizer (Heraeus Kulzer), an aqueous solution of hydroxyethyl methacrylate, or HEMA, and glutaraldehyde, also can reduce hypersensitivity by occluding dentinal tubules, possibly by precipitating plasma proteins in the dentinal fluid.[4,5,8]

Application of Gluma Desensitizer apparently has no effect on the shear bond strength of resin cements to dentin or on retention of crowns luted with resin cement.[9,10] However, the use of resin primers and adhesives might reduce crown retention when glass ionomer, polycarboxylate and zinc phosphate are used as luting agents.[10] It also is possible that the adhesion of some resin-modified glass ionomers could be adversely affected.[11] Surprisingly little investigation has been done in this area, given that the use of resin desensitizers is already widespread and may become a standard technique in restorative dentistry.[3]

We undertook a study to investigate the effect of two resin-based dentin desensitizing agents on the retention of crowns luted with various dental cements.

MATERIALS AND METHODS

We obtained and débrided 30 human molar teeth shortly after they were extracted. The teeth were disinfected by immersion in a 0.5 percent aqueous chloramine solution for one week, and then were stored in distilled water until they were used in the experiment.

We mounted the teeth in 1-inch-diameter phenolic ring molds using self-cure acrylic resin. Tapered and short roots were notched first to ensure their retention in the acrylic. We used a surveyor to position the long axis of the clinical crown parallel to that of the mold. The molds were numbered and stored in tap water.

We prepared the specimens for complete crown coverage using a specially designed apparatus to standardize the preparations (Figure 1). The occlusal surface was flattened to the depth of the central groove and was perpendicular to the long axis of the clinical crown.

Specimens were mounted on a moveable surveyor table, and preparations were done with a high-speed handpiece attached to a surveyor. The axial walls of each tooth were prepared to a height of 4 millimeters and a taper of 2.4 degrees (per wall) using a high-speed diamond bur. Approximately 1 to 1.5 mm of axial tooth structure was removed by preparation. We used air-water spray continuously to prevent desiccation during preparation procedures.

To determine the axial surface area of each preparation, we cut tinfoil strips to correspond with the circumference of the prepared axial surfaces. These strips were adapted to the prepared specimens and cut where they overlapped. The circumference of each preparation was determined by measuring the length of the foil strip. The specimens were ranked according to circumference—stratified into large, medium and small groups—and then randomly assigned to a control group and two experimental groups (10 specimens per group). Although individual teeth ranged in size from 25 mm to 35 mm, the mean circumferences of the three groups were nearly identical (ranging from 29.8 mm to 30.7 mm).

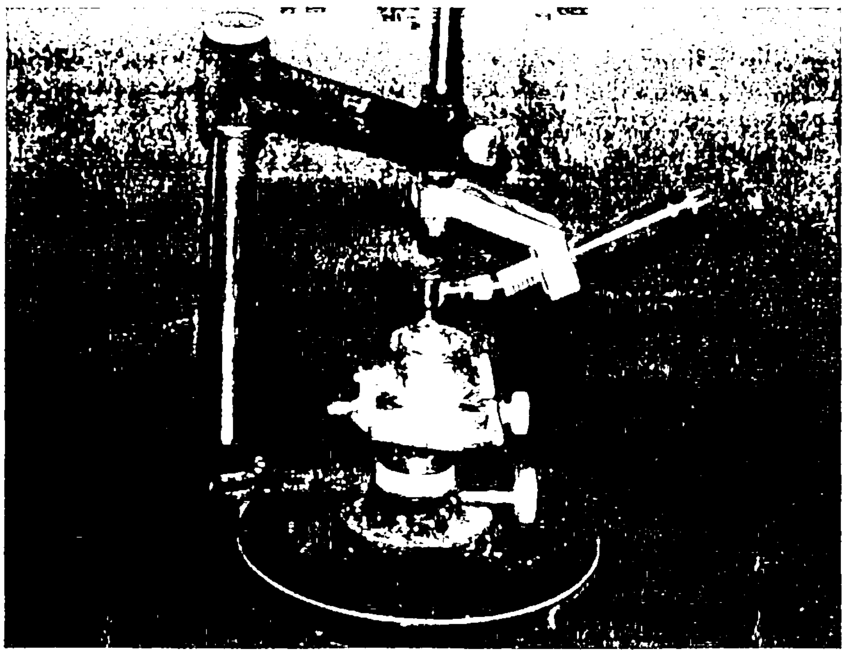
Figure 1. Device used to standardize crown preparations.

Full-crown patterns were waxed directly on the prepared teeth. Doughnut-shaped plexiglass templates fabricated from $^1/_4$-inch tubing were oriented parallel to the long axis of the prepared teeth and luted to the occlusal surfaces of the patterns to provide for attachment of the casting to the testing device described below (Figure 2). The patterns were removed from the teeth and cast in a silver-palladium casting alloy (Ney-Oro 76, Ney Dental International). The castings were air-abraded with 50-micrometer aluminum oxide powder, tried on the prepared teeth and adjusted to proper fit using a small round bur in a high-speed handpiece.

Before cementation, the castings were completely dried and air-abraded with aluminum oxide. Ten of the teeth were treated with One-Step and 10 with Gluma Desensitizer; 10 were left untreated as controls. Both of the resin materials were applied strictly according to manufacturers' directions. Gluma Desensitizer was applied by gentle but firm rubbing using a cotton pledget for 30 seconds. The dentin surface was dried with compressed air after Gluma was applied.

For One-Step, dentin was cleaned with a flour of pumice slurry and was etched for 15 seconds using 32 percent phosphoric acid. After rinsing and removing excess moisture, we applied two coats of the primer/adhesive containing Bis-

GMA, biphenyl dimethacrylate, or BPDM, and HEMA in acetone. We removed excess solvent using compressed air spray for 10 seconds. Additional primer was applied only if the surface did not appear glossy. The resin was cured with a 10-second exposure to visible light (Optilux 401, Kerr/Demetron). We removed the air-inhibited layer by wiping with a moistened gauze square.

All resin applications were performed immediately before crown cementation, which is one of the methods commonly used by clinicians.[3] (Some clinicians perform desensitization immediately after preparation in addition to or instead of the pre-cementation procedure.)

First, we cemented the crowns, using zinc phosphate cement (Hy-Bond, Shofu Inc.). The cement was mixed to a powder-liquid ratio of approximately 2.9 grams per milliliter on a glass slab at room temperature. A thin layer of cement was applied to the inside of the crown and the crown was immediately cemented on the tooth using firm hand pressure. We removed excess cement after approximately 10 minutes.

After storage for 24 hours in tap water at room temperature, specimens were mounted in a universal testing machine in a path parallel to the axis of withdrawal. A crosshead speed of 0.5 mm/minute was applied in tension to each casting until the cement failed. The load at failure was recorded in newtons, or N.

We cleaned both crowns and teeth thoroughly and lightly roughened tooth surfaces with a fine diamond. The crowns were air-abraded with aluminum oxide. Dentin surfaces were treated as described previously and the crowns were recemented using an encapsulated conventional glass ionomer luting cement (Fuji I, GC America). The GI cement was mixed in a high-speed amalgamator for 10 seconds. Finally, the procedure was repeated and the crowns were cemented using resin-modified glass ionomer cement (Vitremer Luting Cement, 3M Dental Products Division). The cement was mixed by hand to the 1.6:1 powder-liquid ratio recommended by its manufacturer. The use of specimens as their own controls for retention of castings has been reported previously in the literature.[12-15]

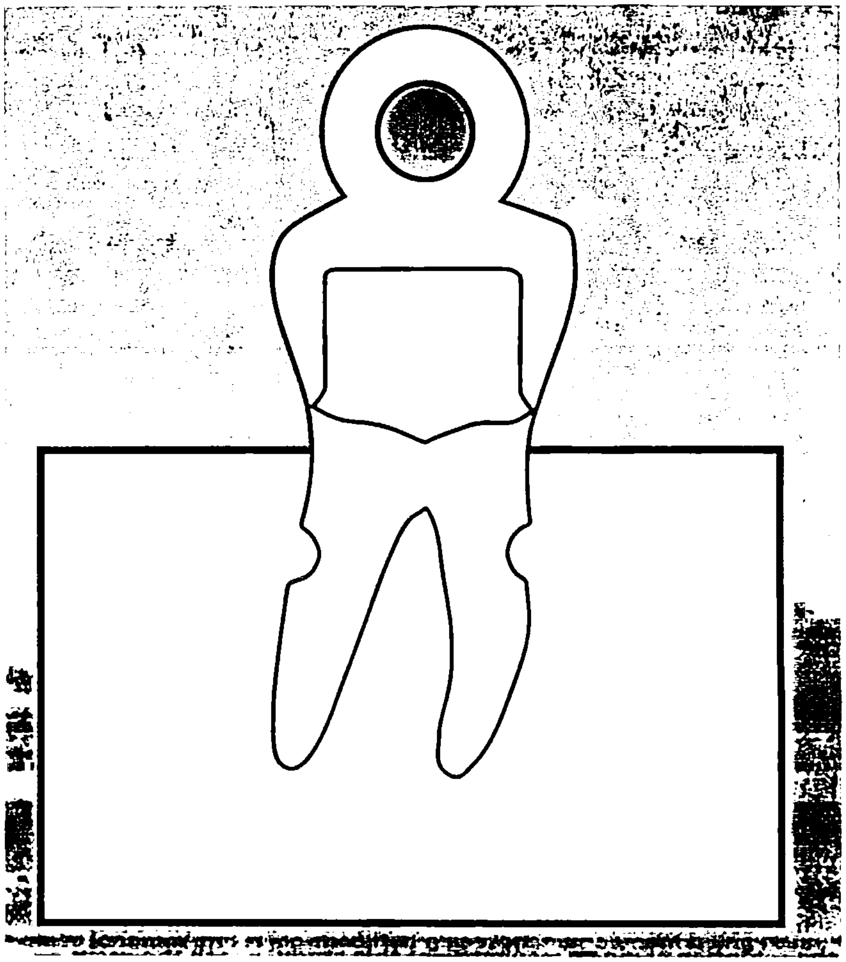

Figure 2. Schematic diagram of the experimental setup. The ring on top of the specimen was used to connect the casting to the testing device.

We calculated means and standard deviations of failure loads for each treatment group. We analyzed data using two-way analysis of variance, or ANOVA. Dentin treatment and cement type were the independent variables, and failure load was the dependent or outcome variable. We used Tukey's Honestly Significant Difference Test to determine the significance of differences between specific means. Repeated-measures ANOVA was not used because, over the course of the experiment, six specimens fractured either in the crown or roots and were replaced by additional specimens.

TABLE

MEAN FORCE* REQUIRED TO REMOVE CROWNS.

TREATMENT	TYPE OF CEMENT USED		
	Zinc Phosphate	Glass Ionomer	Resin-Modified Glass Ionomer
None (Control)	587 (400)	788 (401)	685 (156)
Gluma Desensitizer (Heraeus Kulzer)	449 (277)	653 (234)	748 (306)
One-Step (Bisco Dental Products)	479 (215)	872 (342)	713 (191)

*In newtons (± standard deviation).

RESULTS

The results of the study are summarized in the table and in Figure 3. The conventional glass ionomer cement had the highest mean retention to untreated dentin (788 N) and zinc phosphate had the lowest (587 N). Application of both resin desensitizers slightly decreased the retention of zinc phosphate cement, and it slightly increased the retention of the resin-modified glass ionomer cement. Retention of the conventional glass ionomer was somewhat less when Gluma Desensitizer was used, but somewhat greater when One-Step was used. Failures in all groups were generally "mixed," with some cement remaining in the crowns and some remaining on tooth surfaces.

ANOVA showed that the type of cement had a significant ($P = .002$) effect on crown retention, with both glass ionomers providing significantly higher retention than the zinc phosphate cement. However, surface treatment did not have a significant effect on retention ($P = .56$). Multiple pairwise comparisons of specific means revealed a significant ($P < .05$) difference only between the Gluma/zinc phosphate group and the One-Step/conventional glass ionomer group. None of the other differences between specific groups was statistically significant.

DISCUSSION

The most important finding of this study was that a resin primer (Gluma Desensitizer) and a resin adhesive (One-Step) did not reduce the retention of cast metal crowns luted with a zinc phosphate, conventional glass ionomer or resin-modified glass ionomer cement. A previous study[10] reported that All-Bond (Bisco Inc.), a resin adhesive system similar to One-Step, significantly reduced the retention of zinc phosphate and especially polycarboxylate cements. All-Bond also reduced the retention of a glass ionomer cement, but to a lesser degree. In contrast, the results of the present study indicate that One-Step may slightly increase retention with glass ionomer cements.

The force required to dislodge crowns was relatively high, ranging from 449 to 872 N. It is likely that all of the cement/desensitizer combinations evaluated in the present study would provide clinically acceptable retention on typical crown preparations.

The fact that the glass ionomers provided significantly higher retention than the zinc phosphate cement is not surprising, because similar results have been reported previously in the literature. McComb found that glass ionomer was 65 percent more retentive than zinc phosphate when used to cement Class I inlays.[13] For crowns, Omar reported retention values of 178 N using zinc phosphate and 255 to 299 N using glass ionomer cements.[14] Pameijer and Jefferies[16] reported values of 14.6 kilograms (143 N) for zinc phosphate and 25.6 kg (251 N) for glass ionomer on short, tapered preparations. Mausner and colleagues[10] reported the retention of zinc phosphate as 235 N and of glass ionomer as 383 N.

To provide a slightly different perspective on the retention values, force values can be divided by the average axial area of the crown preparations (120 mm^2) to calculate the amount of force per unit area required to dislodge the crowns. These calculations result in a fairly narrow range of values (3.7 to 4.9 megapascals for zinc phosphate and 5.4 to 7.3 MPa for the glass ionomers). Using similar methodology, Felton and colleagues[12] reported that the retention of crowns cemented with zinc phosphate cement under various conditions was 4.1 to 6.5 MPa. Gorodovsky and Zidan reported slightly lower values (3 MPa) for both zinc phosphate and glass ionomer cements.[17]

In contrast to zinc phosphate cement, glass ionomers actually

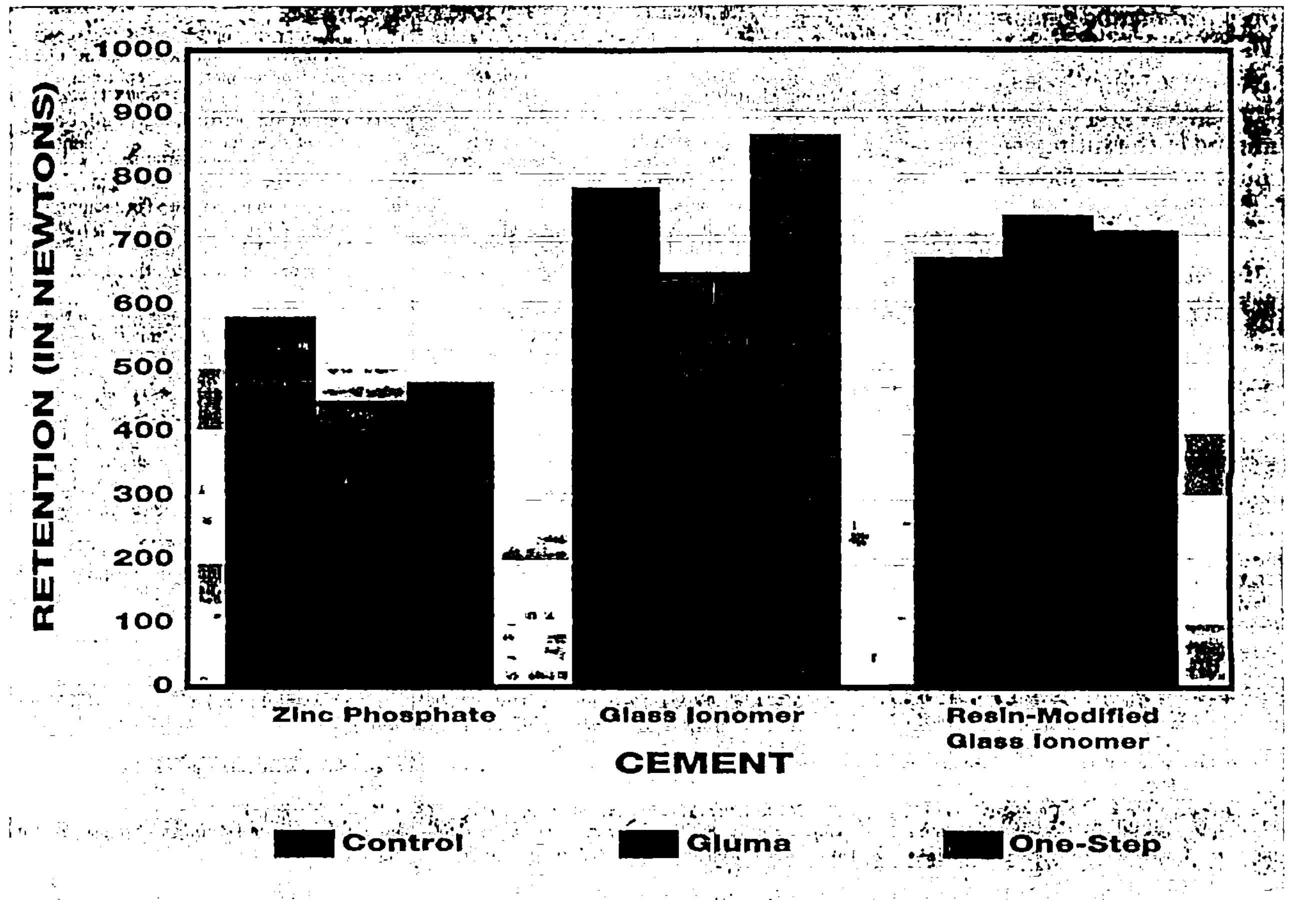

Figure 3. Retention of zinc phosphate, glass ionomer and resin-modified glass ionomer cement using resin desensitizers.

bond to dentin. Bonding occurs via an ion-exchange mechanism and micromechanical penetration of the dentin surface and, thus, has both chemical and physical aspects.[18] The results of this study raise doubt concerning the role of these adhesive mechanisms in retention of glass ionomer luting agents. For example, when the One-Step adhesive system is used on dentin, a resin film coats the surface and presumably would prevent any ionic interaction or penetration of glass ionomer into dentin. However, when One-Step was applied to dentin, the retention of a conventional glass ionomer cement did not decrease, but instead increased somewhat (although the difference was not statistically significant). Perhaps the greater strength and other physical properties of glass ionomer are more important factors than physicochemical adhesion for their improved retention relative to that of zinc phosphate cement.

In this study, the conventional and resin-modified glass ionomers provided essentially equivalent retention of crowns. According to the manufacturer of Vitremer Luting Cement, its mechanical properties are similar to those of Fuji I, and this might account for the lack of significant difference in retention.[19] A recent report from Clinical Research Associates showed that Vitremer was more retentive than Fuji I for noble-metal crowns, but that the two cements were nearly identical for base-metal crowns.[20]

CONCLUSION

While this study demonstrates that the use of a resin primer or an adhesive system has no effect on the retentive properties of three different luting cements, it does not answer the question of whether such agents need to be used. Certainly, resin desensitization of crown preparations has become a popular clinical technique[3] and has been shown to be effective for that purpose.[4] However, the use of resin desensitizers should not be a substitute for other aspects of proper clinical technique in crown preparation and cementation. Those other aspects—such as avoidance of tooth desiccation and correct proportioning and mixing of the luting agent[2,21]—must not be overlooked. ■

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1. Brännström M. Communication between the oral cavity and the dental pulp associated with restorative treatment. Oper Dent 1984;9:57-68.
2. Johnson GH, Powell LV, DeRouen TA. Evaluation and control of post-cementation pulpal sensitivity: zinc phosphate and glass ionomer luting cements. JADA 1993;124(11):38-46.
3. Clinical Research Associates. Tooth desensitization before crown cementation—'93. CRA Newsletter 1993;17(7):2-3.
4. Felton D, Bergenholtz G, Kanoy BE. Evaluation of the desensitizing effect of Gluma Dentin Bond on teeth prepared for complete-coverage restorations. Int J Prosthodont 1991;4:292-8.
5. Dondi dall'Orologio G, Malferrari S. Desensitizing effects of Gluma and Gluma 2000 on hypersensitive dentin. Am J Dent 1993;6:283-6.
6. Watanabe T, Sano M, Itoh K, Wakumoto S. The effects of primers on the sensitivity of dentin. Dent Mater J 1991;7:148-50.
7. Trowbridge H, Silver D. A review of current approaches to in-office management of tooth sensitivity. Dent Clin North Am 1990;34:561-81.
8. Bergenholtz G, Jontell M, Tuttle A, Knutsson G. Inhibition of serum albumin flux across exposed dentine following conditioning with GLUMA primer, glutaraldehyde, or potassium oxalates. J Dent 1993;21:220-7.
9. Reinhardt JW, Stephens NH, Fortin D. Effect of Gluma desensitization on dentin bond strength. Am J Dent 1995;8:170-2.
10. Mausner IK, Goldstein GR, Georgescu M. Effect of two dentinal desensitizing agents on retention of complete cast coping using four cements. J Prosthet Dent 1996;75:129-34.
11. Vargas MA, Fortin D, Swift EJ. Bond strengths of glass ionomers using a dentin adhesive. Am J Dent 1995;8:197-200.
12. Felton DA, Kanoy BE, White JT. Effect of cavity varnish on retention of cemented cast crowns. J Prosthet Dent 1987;57:411-4.
13. McComb D. Retention of castings with glass ionomer cement. J Prosthet Dent 1982;48:285-8.
14. Omar R. A comparative study of the retentive capacity of dental cementing agents. J Prosthet Dent 1988;60:35-40.
15. Pameijer CH, Holtén J, Glantz P-O, Randow K. Influence of low-viscosity liners on the retention of three luting materials. Int J Periodontics Restorative Dent 1992;12:195-205.
16. Pameijer CH, Jefferies SR. In vitro retention of crowns cemented with 8 luting materials (IADR abstract no. 134). J Dent Res 1994;73:118.
17. Gorodovsky S, Zidan O. Retentive strength, disintegration, and marginal quality of luting cements. J Prosthet Dent 1992;68:269-74.
18. Lin A, McIntyre NS, Davidson RD. Studies on the adhesion of glass-ionomer cements to dentin. J Dent Res 1992;71:1836-41.
19. 3M Dental Products Division. Vitremer Luting Cement technical product profile, St. Paul, Minn. 1994;24.
20. Clinical Research Associates. Glass ionomer-resin cements (GI-R). CRA Newsletter 1995;19(3):1-2.
21. Christensen GJ. Glass ionomer as a luting material. JADA 1990;120:59-68.