

Effects of polycarboxylate and glass ionomer cements on stainless steel crown retention

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Abstract

Retentive properties of three dental cements were tested using stainless steel crowns fitted to extracted third molar teeth. No significant difference was found between the overall mean retentive forces of the polycarboxylate cement and the two glass ionomer cements. Mechanical retention of the crowns was not a factor in the overall retentive value.

Few studies have investigated the retention of stainless steel crowns. Savide et al.¹ studied five types of preparations encountered in dental practice and their effects on the retention of stainless steel crowns, while Mathewson² compared cementing agents for stainless steel crowns. Both studies compared the retention of stainless steel crowns with and without cementation (i.e., mechanical retention from the crown alone and retention due to cementation), and both found the retention due to cementation to be far greater than that gained from mechanical retention alone.

Mathewson² found the highest retentive strengths using copper phosphate cement. He attributed this strength to the low pH of the cement during the setting reaction and a possible acid-etching effect on the tooth creating a better bond between the cement and the tooth. He also speculated that the acidity of the cement potentially was harmful to pulp tissues in vital teeth. The next most retentive cements found by Mathewson were zinc phosphate and polycarboxylate. They are currently the most widely used luting agents today.

The zinc phosphate cements rely on a mechanical interlocking between the cement and tooth structure and therefore have a lower adhesive strength, although they do have a rather high compressive strength.³ Zinc phosphate cements are also a potentially caustic substance to vital pulp tissue due to their low pH.⁴ The polycarboxylates form an ionic bond with enamel and dentin^{3,5} and have a higher adhesive strength than zinc phosphate.

They also have a somewhat lower compressive strength^{3,6} than zinc phosphate cements. One advantage of polycarboxylate over zinc phosphate cements is that they are relatively nontoxic to vital tissue.^{7,8,9}

Recently, glass ionomer cement has been made available commercially in North America. It forms a strong ionic bond to enamel, dentin, and nickel-chrome alloys giving it a high adhesive strength.¹⁰⁻¹⁶ The unique composition and structure of Al⁺³ and Ca⁺² ions and polyacrylic acid solution give it a high compressive strength.^{6,10,12} It also has been found to be relatively nontoxic to vital pulp tissue.¹⁷

The purpose of this investigation was to compare the retentive properties of two glass ionomer cements and one polycarboxylate cement.

Methods and Materials

Materials utilized were two glass ionomer cements, referred to as glass ionomer cement A^a and glass ionomer cement B^b, and a polycarboxylate cement.^c All luting cements were mixed at the respective manufacturers' recommendations.

A total of 18 extracted noncarious human third molars were embedded in acrylic blocks and stainless steel crowns^d were cemented with the three different cements. All three cements were used on each preparation with all possible preparation-cementation sequences being tested. The specific cementing sequence was assigned to each preparation utilizing a table of random numbers to minimize any bias due to the order of the cements or any preparation variance. Each tooth was subjected to a 30-second toothbrush prophylaxis with fine pumice followed by a distilled water wash and 15 seconds of drying with compressed, oil-free air.

^a Chembond, L.D. Caulk Co., Milford, Del.

^b Fuji Type I, G-C Industrial Corp., Tokyo.

^c Durelon, Premier Dental Products, Norristown, Pa.

^d Unitek Corp., Monrovia, Calif.

The crown preparation was similar to the type recommended by Mink and Bennett in 1968.¹⁸ The occlusal surface of the third molar was reduced uniformly 2 mm. The proximal surfaces were prepared so that the contact areas were broken and all mesial and distal undercuts were removed.

First permanent molar stainless steel crowns,^d were fitted for proper size and were uniformly contoured and crimped. A #114^d pliers was used to contour the buccal and lingual surfaces as described by Savide.¹ This method was used to place a continuous crimp along the buccal and lingual crown margins so that all margins were in contact with the prepared tooth surface. The proximal margins were left uncountoured and uncrimped.

The stainless steel crowns were altered by placing a hole through the central part of the occlusal surface with a #6 round bur. A one-inch nail was inserted through the hole from the undersurface of the crown for subsequent gripping by the test machine.

A separate stainless steel crown was fitted for each trial of crown retention, i.e., a new crown was fitted for each cement used and for the no-cement trials on the individual preparations. All crowns were seated to a predetermined reference position on the preparations approximately 1 mm above the cemento-enamel junction. After setting times had elapsed the specimens were placed in 100% humidity at 37°C for 24 hours before testing. All excess cement was removed from crown margins before mounting in the test apparatus (Figure 1).

The experimental data consisted of two types: retentive forces and failure patterns. The retentive force was defined as the force required to separate the crowns from the tooth preparations. It was applied with an Instron^e testing machine at a crosshead speed of 0.05 in/min. The loads required for separation were recorded

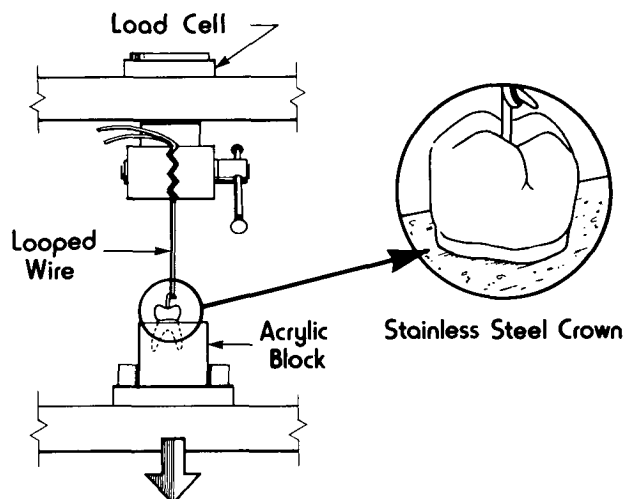


Figure 1. Assembly for shear testing.

^e Instron Universal Testing Machine, Canton, Mass.

graphically. The failure patterns were recorded for each tooth after the crown was removed. They were one of three categories: (a) cement adhered mostly to crown, (b) cement adhered to tooth and crown, and (c) cement adhered mostly to tooth.

Mean forces required for each cement were compared using Duncan's new multiple range test. The analysis was performed in units of log force to comply with the assumptions necessary for ANOVA techniques, i.e., normality, equal variance, and independence.¹⁹ The calculations were performed using the general linear models procedure of the statistical analysis system.²⁰ Group similarities were established using Duncan's new multiple range test and t-test.²¹

Results

As illustrated in Figure 2, most of the retention of the stainless steel crowns was due to the influence of the cements. This is demonstrated by the obvious difference between the control (uncemented) and the cemented samples. No significant differences occurred between cements, as demonstrated by the Duncan's new multiple range test.

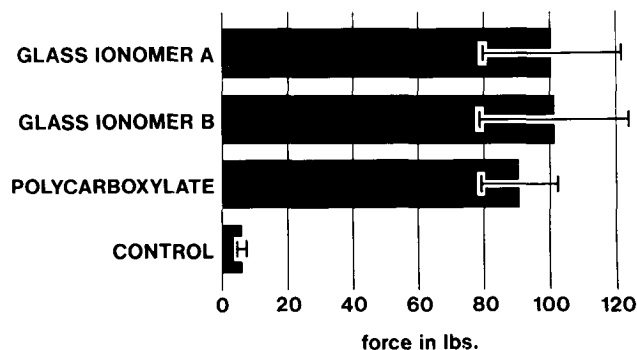


Figure 2. Comparative retentive strengths.

Table 1 compares adhesion sites. All polycarboxylate samples fractured, leaving varying amounts of cement adhering both to the tooth and the crown (Figures 3 and 4). The cement fractured in all glass ionomer samples leaving all the cement still adhering to the tooth; macroscopically, none was left on the crown.

Using all three cements on the same tooth created the possibility of interactions between the cements which could have altered their retentive forces. The analysis of variance demonstrated a possible weak effect from the order of cementation. A comparison was made between the retentive forces of the three cements related to their

Table 1. Location of Adhesion of Cement

	Crown Only	Crown and Tooth	Tooth Only
Polycarboxylate	—	18	—
Glass Ionomer A	—	—	18
Glass Ionomer B	—	—	18

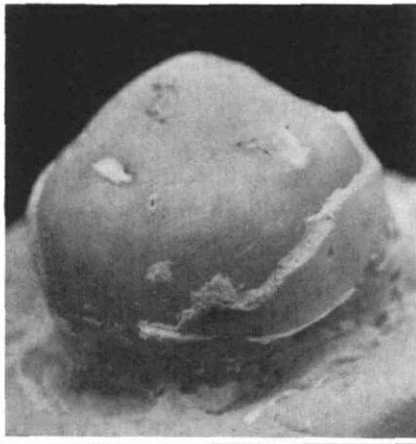


Figure 3. (left) Polycarboxylate cement adhering to prepared tooth surfaces.

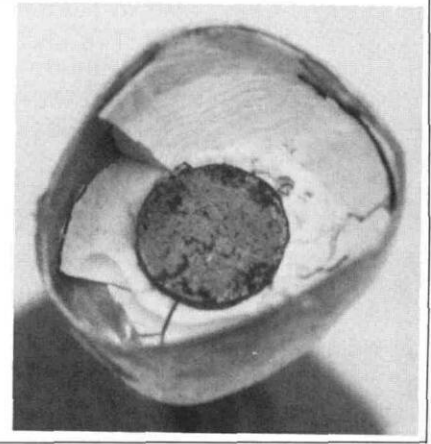


Figure 4. (right) Polycarboxylate cement adhering to inside surface of crown.

cementation order, i.e., being the first, the second, or the last cement in the cementing sequence used on the tooth. A slight, although statistically significant higher value was found for glass ionomer cement A ($p < .05$) when it was used as the first cement in the sequence. No other significant differences in retentive force were found between the cements when used as the middle or last cement in the sequence. There was no effect on the retentive values due to differences in the individual specimens.

Discussion

Comparing these results with similar studies, the retentive forces were similar to those found by Savide¹ using dentoform-type teeth but, interestingly, the values were twice as great on average as those found by Mathewson,² who used natural teeth. Myers et al.,²² utilizing a similar method, also found values that were approximately 50% of the values for this study. These differences could be due to variations in the preparations used by the individual studies.

The noncemented crowns showed very limited mechanical retention, with cementation by any type of cement greatly improving the retentive values and completely overshadowing the mechanical retention demonstrated by the noncemented control group. This indicates that the mechanical retention did not contribute significantly to the separation resistance of the stainless steel crowns, which is consistent with the results reported by Mathewson² and Myers et al.²²

There were three possible places of cement failure: (1) at the tooth-cement interface, (2) at the cement-crown interface, and (3) within the cement itself. Therefore, the site of cement failure was recorded in the testing. The polycarboxylate samples showed both an adhesive and cohesive failure of the cement as demonstrated by the cement adhering both to the tooth and the crown. The glass ionomer samples showed an adhesive failure between the cement and stainless steel crown as demonstrated by the cement adhering entirely to the tooth with none left adhering to the crown macroscopically.

Such a cement failure indicated a cement-tooth bonding for the glass ionomers stronger than that of polycarboxylate cement. The higher retentive forces for the glass ionomer also indicated a stronger cement-stainless steel bonding than the polycarboxylate, although this bond is in a force range similar to that needed to cause a cohesive/adhesive failure of the polycarboxylate cement.

These conclusions are similar to those of previous studies showing that glass ionomers have higher tensile strength and form stronger bonds to tooth structure and to stainless steel than the polycarboxylate cements.¹³

Even though the value for glass ionomer A was statistically significant, its real difference from the others is small. The required retention for stainless steel crowns is unknown and many dental cements (including the zinc phosphates and other weaker bonding cements) already have proven their clinical adequacy in retention of stainless steel crowns.¹ This seems to indicate that the critical retention strength is less than the measured values for all three of the cements. The similarity of the retentive values shown in this study, suggests that the selection of a cementing agent will depend more on other clinical factors. The practitioner should evaluate working and setting times, solubility, fluoride content, and other benefits as well as higher retentive values in determining cement selection.

Summary and Conclusions

An in vitro study of three dental cements was performed to test their retention of stainless steel crowns on extracted third molars with the following results.

1. Mechanical retention did not contribute to stainless steel crown retention.
2. The fracture site of the polycarboxylate cement indicated an adhesive and cohesive failure of the cement.
3. The fracture sites for the glass ionomer cements indicated an adhesive failure between the cement and the stainless steel crown.
4. There was no difference between the overall mean retentive forces for the three cements.

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Quotable Quotes

The demonstration of the intimate relation of bacteria to certain fevers and other diseases would seem at first to greatly simplify the work of the physician in searching for efficient remedies. Put in plain English the problem is: Find some element or compound that is fatal to bacteria and administer it in the way best calculated to reach the mischievous fungi in the patient's blood. The problem is easier stated than solved. The lower forms of life that appear to cause the trouble are able to live and thrive under the widest possible range of conditions, so that, as far as is known, any reagent able to kill them would be much more quickly fatal to the patients. It is barely possible that these vicious organisms may be reached and killed by some drug in doses the human system can tolerate, but the prospect is certainly not bright.

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