Retentive Strength of Luting Cements for Stainless Steel Crowns: An *in vitro* Study

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The present study evaluated and compared the retentive strength of three luting cements. A total of forty five freshly extracted human primary molars were used in this study. The teeth were prepared to receive stainless steel crowns. They were then randomly divided into three groups, of fifteen teeth each, so as to receive the three different luting cements: conventional glass ionomer, resin modified glass ionomer and adhesive resin. The teeth were then stored in artificial saliva for twenty four hours. The retentive strength of the crowns was determined by using a specially designed Instron Universal Testing Machine (Model 1011). The data was statistically analyzed using ANOVA to evaluate retentive strength for each cement and Tukey test for pair wise comparison. It was concluded that retentive strength of adhesive resin cement and resin modified glass ionomer cement was significantly higher than that of the conventional glass ionomer cement.

Keywords: *stainless steel crowns, glass ionomer cement, resin modified glass ionomer cement, adhesive resin cement*

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INTRODUCTION

Retention of a crown to tooth structure is critical for the success of a restoration. The main retentive feature is the close adaptation of a metal crown margin to the tooth surface in the undercut areas of the prepared tooth.[1, 2] Dental luting cements provide the link between the prosthesis and prepared tooth structure. Traditionally, zinc phosphate cement has been the most popular material despite its well documented disadvantage, particularly solubility and lack of adhesion.[3] The luting cement increases the retention of the restoration to the tooth preparation. The cement provides mechanical resistance to displacement of restoration and also resists fracture when a load is applied to the restoration. The retention is further improved when the luting cement adheres to the tooth surface and restoration.[4]

Conventional glass ionomers are popular principally because they release fluoride which prevents recurrent caries.[3] The development of Resin modified glass ionomer cement offers the benefit of both resins and conventional glass ionomer cement, i.e., adhesion and fluoride release,[5] along with improved physical properties that reduce the chance of cohesive failure. Adhesive resins have been introduced as they provide a stronger bond to the base material than glass ionomer cement and they also adhere to precious alloys, when the metal surface is treated to enhance the bond.[6]

Cements used for luting of crowns are one of the contributory factors for its retention.[7] Hence, this study was undertaken to assess and compare the retentive strength of three luting cements, namely, glass ionomer luting cement (GC Fuji I, GC Corporation, Tokyo, Japan), resin modified glass ionomer luting cements (FujiCEM ,GC Corporation, Tokyo, Japan) and adhesive resin luting cements (Rely X ARC 3M ESPE).

MATERIALS AND METHOD

The present *in vitro* study was carried out in the Department of Pedodontics and Preventive dentistry, The Oxford Dental College, Hospital and Research Centre, in association with the Department of Oral Pathology, The Oxford Dental

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A total of forty five freshly extracted human deciduous molars were used in this study. Each tooth was cleaned with a hand scaler, rinsed with water and mounted in plaster so as to expose only the entire crown. Tooth preparation was done with a no. 330 bur to uniformly reducing the occlusal surface by about 1 to 1.5 mm. The interproximal reduction was done with a no. 169L bur held at an angle to the long axis of the tooth. Ledges and undercuts were removed. Sharp angles were rounded. Reduction of the buccal surface was done only in teeth with a large buccal bulge, especially in the mandibular first molars. The pretrimmed, precontoured and prefestooned stainless steel crowns (3M ESPE) were then fitted on each tooth after crimping and contouring to have a good marginal fit. Two opposing attachments (lingual shields) were then soldered to the crown so as to facilitate its easy removal. The teeth were randomly distributed into 3 groups of 15 teeth each, to receive the three different types of luting cements. The teeth were then mounted in self cure acrylic resin blocks.

The cements were manipulated as *per* the manufacturer's instructions. Sufficient cement was placed in the crowns and seated with hand pressure. For the adhesive resin cement, the teeth were acid etched for thirty seconds followed by rinsing. The Adper Single Bond 2 (3M ESPE) was then applied and light cured for ten seconds. The crowns were treated with ceramic primer and adhesive resin cement was placed. After seating the crowns, the margins were light cured for thirty seconds. After ten minutes, excess cement was removed from the crown margins. All teeth were stored in prepared artificial saliva[7] and incubated at 37ºC for 24 hours.

The retentive strength of the luting cements was then determined by using a specially designed Instron Universal Testing Machine (Model 1011) fitted with an Instron recorder. The cross head speed of Instron was 2mm/minute. The load applied was directed parallel to the long axis of the tooth. The load applied was gradually increased until the cemented stainless steel crown showed first signs of dislodgement. The retentive strength values were recorded and expressed in terms of load/area. In order to determine the surface area of crowns, they were cut opened, flattened and their surfaces developed on graph sheets.[8]

The observations were analyzed statistically by using the

Table 1. Retentive strength of three luting cements

Sl No	Glass Ionomer Cement			Resin Modified Glass Ionomer Cement			Adhesive Resin Cement		
	Load Applied	Surface Area (cm^2)	Retentive Strength kg/cm^2	Load Applied	Surface Area (cm^2)	Retentive Strength kg/cm^2	Load Applied	Surface Area (cm^2)	Retentive Strength kg/cm^2
1	24.35	2.52	9.66	28.12	2.52	11.15	28.42	2.085	13.66
2	26.73	2.085	12.85	32.65	2.085	15.69	44.75	2.245	19.77
3	28.57	2.085	13.73	46.02	2.245	20.54	31.23	1.68	18.58
4	28.62	2.245	12.77	41.80	1.68	24.88	45.85	2.07	22.14
5	22.32	2.245	9.96	35.55	1.68	21.16	35.27	2.07	17.03
6	19.62	1.68	11.67	34.25	2.07	16.54	30.25	1.445	21.00
7	21.20	1.68	12.61	44.10	2.52	17.50	24.90	1.445	17.29
8	21.27	2.07	10.27	34.25	2.52	13.59	48.17	2.52	19.11
9	18.80	1.445	13.05	28.12	2.52	11.15	54.77	2.52	21.73
10	31.55	1.58	19.96	40.12	2.36	17.00	32.87	2.36	13.92
11	19.57	2.52	7.76	52.35	2.36	22.18	31.92	1.125	28.50
12	22.17	2.52	8.79	30.25	1.125	27.00	37.53	2.085	18.04
13	21.02	2.36	8.9	40.87	2.085	19.64	41.92	2.36	17.76
14	22.65	1.12	20.22	28.07	1.58	17.76	43.93	2.36	18.61
15	22.22	1.3	12.84	37.65	2.36	15.95	25.77	1.455	17.77
Range	7.76-20.22 kg/cm^2			11.15-27.00 kg/cm^2			13.66-28.50 kg/cm^2		
Median	12.34 kg/cm^2			18.12 kg/cm^2			19.07 kg/cm^2		
Standard deviation	3.65			4.56			3.57		

ANOVA for comparing retentive strength between cements and Tukey one way analysis variance was used to find the pair wise significance of force (kg/cm^2) between the groups.

RESULTS

The retentive strength values for glass ionomer luting cement ranged from 7.76 to 20.22 kg/cm^2. The mean value was 12.34 kg/cm^2, with a standard deviation of 3.65. For resin modified glass ionomer luting cement the retentive strength values ranged from 11.15 to 27.00 kg/cm^2. The mean value was 18.12 kg/cm^2, with a standard deviation of 4.56. The retentive strength values for adhesive resin cement ranged from 13.66-28.50 kg/cm^2. The mean value was 19.07 kg/cm^2 with a standard deviation of 3.57. (Table 1). Comparison of the luting cements showed retentive strength of both adhesive resin cement and resin modified glass ionomer luting cement to be significantly higher than that of glass ionomer luting cement ($P<0.001$). No significant difference was seen between the retentive strength of resin modified glass ionomer luting cement and adhesive resin cements ($P=0.881$) (Table 2).

Table 2. Comparsion Of Retentive Strength Of Three Luting Cements

Glass Ionomer vs Resin Modified Glass Ionomer	F=12.001 P<0.001** Significant
Glass Ionomer vs Adhesive Resin	F=12.001 P<0.001** Significant
Resin Modified Glass Ionomer vs Adhesive Resin	P=0.881 Not Significant

DISCUSSION

The restoration of extensively damaged primary molars has always been a challenge for the pediatric dentist. Different types of restorative materials have been used to restore these teeth. Stainless steel crowns have proved efficacious and are relatively easy to use.[9]

A number of studies have shown that the use of dental cements is vital for retention of crowns on primary molars.[8,10,11] A study compared zinc polycarboxylate, zinc phosphate and glass ionomer luting cements. The authors concluded that polycarboxylate cement had a lower retentive strength.[8] One should favor higher strength cements to enhance retention and prevent dislodgment of crowns by providing a firm supportive base against applied forces. Hence, the purpose of this study was to compare the retentive strength of a conventionally used glass ionomer cement with that of two newer adhesive cements, a resin modified glass ionomer cement and an adhesive resin cement.

There are several factors that have an influence on the retention of a fixed prosthesis. Generally greater forces are required to dislodge the crown cemented with a material that has higher tensile strength. Undoubtedly other properties such as compressive strength and shear strength, fracture toughness, and film thickness are also involved. The use of cement with potential chemical bonding to the tooth and prosthetic surface may also be used to enhance retention.[11]

There has been a variation in the retentive strength value of glass ionomer.[10, 12] This variation could be due to sensitivity of glass ionomer luting cement to manipulation and also the powder: liquid ratio.[13] Experienced and trained personnel have also shown a wide variation of 20% to 64% in the mixing ratio.[14]

The compressive strength value of resin modified glass ionomer cement is in the range of 85-126 MPa.[15] Along with compressive strength, its tensile strength (13-24 MPa) and bond strength to dentin (10-12 MPa) are also higher than that of glass ionomer cement. This explains the higher retentive strength value of resin modified glass ionomer luting cement

Though conventional glass ionomer interacts interfacially with the tooth structure creating covalent bonds, the role of these bonds is not significant in increasing retention.[16] Despite their adhesive properties, conventional glass ionomer cements have gained an anecdotal reputation of unreliability, because a number of crowns fail at very low load, which are likely to be encountered clinically.[17]

The low retention of glass ionomer cement could be due to spontaneous cohesive fracture of the cement, due to high stress generated by contraction on setting, compounded by constraints of cement adhesion to the crown and dentin walls, in geometric configuration where few opportunities for relief of stress by plastic deformation or cement flow exists. The low tensile strength and fracture toughness of conventional glass ionomer cement is also another cause of fracture at lower loads.[12] It has also been reported that the volumetric contraction of conventional glass ionomer cements is in the range of 2.1% to 3.4%, even under the condition of 100% relative humidity, and greater under the condition of dehydration.[18] Both conventional and resin modified glass ionomer cements dehydrate and contract extremely rapidly in air or humidity.[19] Addition of resin to the brittle composition of conventional glass ionomer cement significantly increases its fracture toughness.[20]

The compressive strength, flexural strength and modulus of elasticity of resin composites are significantly higher than conventional glass ionomer cements and resin modified glass ionomer cements.[21] Goldman reported that fine particle composites have a higher modulus of elasticity, very high fracture energy and fracture toughness and small inherent flaw size compared to conventional glass ionomer cement.[22] The diametric tensile strength of conventional glass ionomer cements is significantly lower than that of resin modified glass ionomer cements, which in turn is less than resin cements.[23]

The results of the present study showed a wide variation in all the three groups. This could be due to the fact that hand pressure was applied to seat the crown on to the tooth surface instead of using standardized pressure. On the other hand this procedure was comparable to the true clinical situation where cementation pressure is generally controlled manually.

The current study did not show a significant difference in the retentive strength of adhesive resin and resin modified glass ionomer luting cements. This could be explained by the fact that retentive strength was determined after twenty four hours. Dual cure resin cements continue slow polymerization process mediated by chemical reactive system. This phenomenon leads to increased degree of cross linking within the material with increasing time and as a result there is an increase in strength.[24]

However, this advantage is offset by ability of the resin modified glass ionomer luting cement to release fluoride and the increased number of clinical steps and consequent time required to cement a crown with resin composite cement.[25] Hence the choice of cement would depend on the needs of an individual patient, which should be decided by the clinician.

CONCLUSION

Retentive strength of adhesive resin cement and resin modified glass ionomer luting cements was significantly higher than that of glass ionomer luting cement.

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