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Comparative Evaluation of the Retentive Strength of Conventional Glass Ionomer Cement and an Adhesive Resin Cement for Luting Stainless Steel Crowns- An In-Vitro Study

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ABSTRACT:
Aim & Background: The luting cement enhances the restoration's retention in the prepared tooth, which is further enhanced when it bonds to the restoration and tooth surface. The present study was thus carried out to evaluate the retentive strength of conventional luting Glass Ionomer cement (GIC) and an adhesive resin cement to cement stainless steel crowns (SSC) in paediatric patients.
Methods: In this study, thirty recently extracted human primary molars were utilized. The teeth were prepared to receive SSCs. Subsequently, they were split into two groups, each consisting of fifteen teeth, at random to receive the two types of luting cements: conventional luting GIC and adhesive resin. After that, the teeth were kept for 24 hours in artificial saliva. Using an Instron Universal Testing Machine, the retentive strength of the crowns was assessed. Independent samples t-test was used to statistically analyse the data in order to determine each cement's retentive strength, with an alpha level of 5%.
Results: The retentive strength of Adhesive Resin Cement (23.73±5.60 kg/cm^2) was found to be significantly higher than GIC (12.16±2.80 kg/cm^2) (P<0.001).
Conclusion: It was concluded that the retentive strength of adhesive resin cement was higher than that of the conventional GIC.
Clinical Significance: There is a growing need for long-lasting, aesthetically pleasing restorations based on stronger adhesion, which is validated by the present study results.

Keywords: Adhesive, bonding, glass-ionomer, paediatric dentistry, retentive strength, stainless steel crowns

1. INTRODUCTION

Crowns are especially advised for teeth that have undergone pulp therapy or have significant decay damage. When using paediatric crowns, the tooth crown must be properly prepared to provide a good fit. [1]For a restoration to be successful, the crown must be retained in place by the tooth structure. The primary retention mechanism is the precise fit

of a metal crown border to the tooth surface in the portions of the prepared tooth that are undercut.[2,3]Retention of the restoration to the prepared tooth is improved by the luting cement.
When a load is applied to the repair, the cement resists fracture as well as mechanical displacement of the restoration. When the luting cement sticks to the tooth surface and restoration, the retention is further enhanced.[4]
Though it has numerous known drawbacks, most notably its lack of adhesion and solubility, zinc phosphate cement has traditionally been the most widely used luting cement.[5] The restoration's retention in the tooth preparation is improved by the luting cement. When a load is applied to the repair, the cement resists fracture as well as mechanical displacement of the restoration. When the luting cement adheres to the tooth surface and restoration, the retention is further enhanced.[6] There are a multitude of luting agents available currently. Even the most experienced doctor may struggle to select the best luting agent. A careful approach is needed for restorations involving metal, porcelain fused to metal, low- and high-strength ceramics, full or partial coverage, and the right cement choice should be determined by understanding the physical, biological, and other characteristics of both luting agents and restorative materials.[7]
In view of the mentioned observations, the present study was conducted to assess and compare the retentive strength of two luting cements to cement a stainless steel crown(SSC), namely, glass ionomer luting cement(GIC) (GC Fuji I, GC Corporation, Tokyo, Japan),and adhesive resin luting cements (Bifix SE,Voco, Germany).

2. MATERIALS AND METHODS

After obtaining approval from the Institutional Ethics Committee, thirty extracted human deciduous molars were procured. Using an ultrasonic scaler, each tooth was cleaned and then washed with water. Along their long axis, the teeth were embedded in plaster blocks 1 mm below the cementoenamel junction. A divider was used to measure the teeth's buccolingual and mesiodistal surfaces.
Every tooth was prepared using the same basic procedure. All the teeth were prepared with a standardized protocol. The occlusal surfaces were reduced uniformly 1–1.5 mm with no. 330 bur (S.S. White Technologies Inc., USA). The interproximal reduction was done with a no. 169L (S.S. White Technologies Inc., USA) 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.
Next, using contouring and crimping pliers, a prefabricated SSC (Kids stainless steel primary molar crown) was chosen, fitted, and crimped for each prepared tooth.
Using flux and silver solder, a 2cm diameter ring composed of 1mm stainless steel wire was welded to the crown's occlusal surface in order to attach it to universal testing equipment. After that, each tooth was fixed to a 15 mm by 1 mm acrylic block.
The teeth were then randomly distributed into 2 groups of 15 teeth each, to receive the two different types of luting cements.
Group I: Type 1 Luting GIC (GC Glass ionomer luting cement)
Group II: Adhesive resin cement (Bifix SE,Voco,Germany)
The cements were manipulated as per the manufacturer’s instructions. For Group I, after cleaning and drying the SSCs and the teeth specimens respectively, 1 drop of liquid for 1 level scoop of powder was dispensed on the mixing pad. The powder and liquid were mixed using an agate spatula. The mixing time was approximately 30 seconds. After the correct creamy consistency, the mixed cement was applied to the SS Crown to be luted. Then the

crown was seated properly and allowed to set. The excess cement was removed in the rubbery elastic stage by using an explorer.

For Group II specimens, the material was squeezed out from the tube until the material was delivered evenly from both chambers. The material was applied immediately and directly on to the prepared crown. The indicated extra oral working time was 90 secs. The crown was gently seated with finger pressure on to the tooth preparation allowing the cement to flow from all margins in order to leave slight excess amount. The material was tack-cured for 5 secs, following which the excess material was removed with the help of a sickle scaler. The cemented crown was left for self-curing by leaving it for 4 mins. After that, the cemented crown was light-cured for 20 secs on each surface. The excess cured material was removed using a finishing diamond bur.

All teeth were stored in prepared artificial saliva at 37°C for 24 hours. The Universal Testing Machine (Instron, USA) was then used to determine the luting cements' retentive strength, with a crosshead speed of 2 mm/min (Figure 1). The applied load is aligned with the tooth's long axis. Up until the first indications of dislodgement in the cemented stainless-steel crown, the applied weight is progressively increased. This process was used for each sample, and the retentive strength was determined by dividing the force by the crown's surface area. Three-dimensional scanning, which offers a detailed contour of the object and aids in determining the appropriate surface area, was used to obtain the surface area of the crown.

Statistical Analysis

The collected data was tabulated in a spreadsheet using Microsoft Excel 2021 and then statistical analysis was carried out using the GraphPad Prism for Windows, Version 10.1 (GraphPad Software, La Jolla California USA). A Shapiro-Wilk's test and a visual inspection of the histograms, standard Q-Q plots, and box plots showed that the collected data were approximately normally distributed for all the study variables

Descriptive statistics were used to report the quantitative variables in terms of mean (central tendency) and Standard deviation (SD). Parametric tests were carried out for inferential statistics. An independent samples t-test was used to analyse the differences between the two groups. The *P* value of ≤0.05 was considered as the level of significance.

3. RESULTS

Figure 1: Specimen undergoing bond strength testing in the universal testing machine.

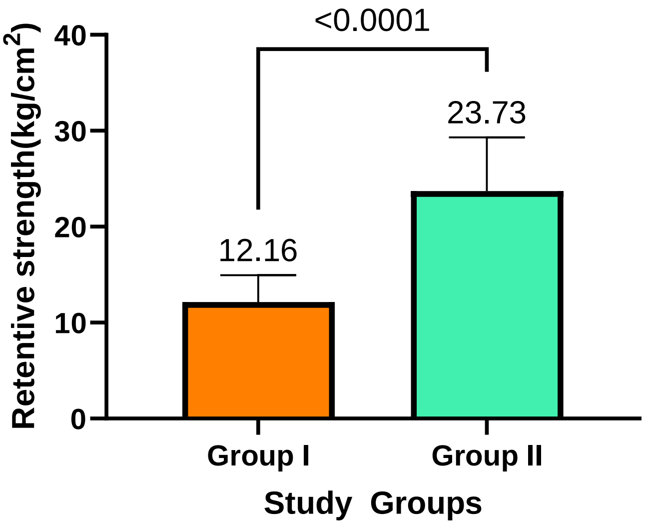

Figure 2: Bar Graph showing the mean Retentive strength(kg/cm^2) of the two luting cement groups and the significant comparisons between them

Table 1: Retentive strength of the two luting cements

Sl no.	Group I: Glass Ionomer Cement			Group II: 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)
1	25.32	2.09	12.14	45.2	1.48	30.54
2	20.8	1.48	14.05	52.33	2.36	22.17
3	19.5	2.36	8.26	50.92	2.09	24.42
4	30.32	1.88	16.07	34.27	1.25	27.52
5	28.22	2.68	10.52	27.4	1.88	14.57
6	26.08	2.16	12.09	46.56	1.53	30.39
7	21.42	1.53	13.99	53.9	2.44	22.07
8	20.09	2.41	8.22	52.45	2.16	24.3
9	31.23	1.95	16.05	35.3	1.29	27.39
10	29.07	2.77	10.48	28.22	1.95	14.5
11	26.86	2.23	12.03	47.95	1.59	30.25
12	22.07	1.59	13.92	55.52	2.53	21.96
13	20.69	2.53	8.18	54.02	2.23	24.19
14	32.17	2.01	15.97	36.36	1.33	27.26
15	29.94	2.87	10.43	29.07	2.01	14.43
Mean ±SD	12.16±2.80			23.73±5.60		
Min-Max	8.18-16.07			14.43-30.54		

SD:Standard deviation, Min-minimum value; Max:Maximum value

Table 1 and Figure 2 show the comparison of the retentive strength between GIC and Adhesive Resin Cement. The retentive strength of Adhesive Resin Cement (23.73±5.60 kg/cm^2) was found to be significantly higher than GIC (12.16±2.80 kg/cm^2) (*P*<0.001).

4. DISCUSSION-

A persistent challenge for pediatric dentists has been the restoration of severely damaged primary teeth. These teeth have been restored using a variety of restorative materials. Stainless steel crowns are reasonably simple to utilize and have shown to be effective. [8,9]

Dental cements are essential for the retention of crowns on primary teeth, according to several studies.[10,11]

When it came to cementing restorations made of gold and non-precious alloys, clinical practitioners have long preferred zinc-phosphate cement, which belongs to the standard cement group. The results of several clinical trials indicating restoration longevity of up to twenty years support the general effectiveness of this method, which encourages its usage for cementing crowns and bridges [12,13]

But polycarboxylate and glass-ionomer cements were first commercialized in the early 1970s, and in 2002 Hecht and Ludstech created a new class of adhesive cements called resin cements that were based on composite resins and intended for use in ceramic restorations.

Zinc phosphate, zinc polycarboxylate, and luting GIC were examined in a prior study. The retentive strength of polycarboxylate cement was found to be lower by the authors.[10] Higher-strength cements are preferable because they offer a solid supporting foundation against applied stresses, improving retention and preventing crown dislodgement. Therefore, the goal of this study was to evaluate the retention strength of two luting cements—a GIC and an adhesive resin cement and—with that of a glass ionomer cement that is commonly used.

The retention of a fixed prosthesis depends on a number of parameters. Typically, stronger forces are needed to loosen a crown that is cemented using a material with a higher tensile strength. There's little doubt that additional characteristics like film thickness, fracture toughness, compressive and shear strengths, and more are equally important. To improve retention, cement that has the ability to chemically attach to the prosthetic surface and tooth can also be employed.[10]

The results of the present study as shown in Table 1 and depicted in Figure 2 where we found that the mean retentive strength of GIC was 12.16±2.80, with the highest value obtained being 8.18 kg/cm^2 and the lowest being 16.07 kg/cm^2. The mean retentive strength of self-adhesive resin cement was 23.73±5.60 kg/cm^2, with values ranging from 14.43 kg/cm^2 to 30.54 kg/cm^2. Statistical analysis also indicated that the strength of the GIC was significantly lower than that of the adhesive resin cement, which aligns with the results of Subramaniam *et al.*[9], Kameli *et al.*[14], Browing *et al.*[15], and Krunic *et al.*[16]. Parisay *et al.*[17], in a recently conducted study compared the retentive strength of four luting cements with SSCs in primary molars comprising, zinc phosphate cement, zinc polycarboxylate, GIC, and self-adhesive resin, and inferred that zinc phosphate demonstrated the highest retentive strength, followed by self-adhesive resin cement, GIC with zinc polycarboxylate showing the least retentive strength. The authors contemplated that the usage of a bonding agent would have conferred lesser retentive properties to self-adhesive resin cement in their study than zinc phosphate cement. In a 2004 study, Yilmaz *et al.*[18]examined the tensile strength of SSCs cemented on primary molar teeth using glass ionomer, resin-modified glass ionomer, and resin cement. They demonstrated that there was no discernible difference in the bond strengths of glass ionomer and resin cement, and that resin cement's bond strength was substantially higher than that of resin-modified glass ionomer, consistent with the findings of the present study.

The value of glass ionomer's retentive strength has seemed to be varied in literature. [11,19]The variance may result from the ratio of powder to liquid as well as the sensitivity of the glass ionomer luting cement to manipulation. [20] So much so, that even experts and educated staff have also demonstrated a significant variance in the mixing ratio, ranging from 20% to 64%. [9,21]

Despite the fact that covalent connections are formed between the standard glass ionomer and the tooth structure through interfacial interaction, these bonds have no effect on retention. [22]

Notwithstanding their strong adhesive properties, conventional glass ionomer cements have an undeserved reputation for being untrustworthy because a small percentage of crowns fracture under extremely low stress, which is likely to happen in a clinical setting.[23]

Furthermore, the low retention of glass ionomer cement may result from spontaneous cohesive fracture of the cement, which is caused by high stress generated by contraction during setting and compounded by cement adhesion constraints to the dentin walls and crown in a geometric configuration with limited opportunities for stress relief through plastic deformation or cement flow. Another reason for fracture at lower stresses is the standard glass ionomer cement's low tensile strength and fracture toughness[19], besides contracting volumetrically in both humid and dehydrated conditions.[24]

The results of this study indicated that resin cement had somewhat better qualities. Resin cement generally has the following benefits: very low oral solubility, low film thickness, and strong strength. Dentists have shown a strong interest in resin cements due to their exceptional bonding capacity.[25] Because these cements are auto-mixed, manual mixing is not necessary, which saves time, eliminates issues caused by an improper ratio of powder to liquid, and ultimately improves the convenience of use. The only limiting factor associated with the usage of resin cement remains its cost.

The main limitation of the present study is its in-vitro study design and the inability of a long-term evaluation of the retentive strength, which needs to be addressed in further research with a larger sample size to validate the results of the present study.

5. CONCLUSION

Within the limitations and the parameters of the present study, it can be concluded that adhesive resin cements have significantly higher retentive strength than conventional luting GIC. However, the cement selection should rely on each patient's unique demands, which the clinician should determine.

Clinical significance

The future of dental luting cements looks bright as long as technology continues to progress and there is a growing need for long-lasting, aesthetically pleasing restorations based on stronger adhesion. The current study validates the higher retentive strength of adhesive resin cement in bonding SSCs.

Abbreviations

GIC: Glass ionomer cement; SSC: stainless steel crowns; SD: Standard deviation; Min-Minimum; Max: Maximum

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