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Evaluation of Shear Bond Strength of Two Resin-Modified Glass-Ionomer Cements

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EVALUATION OF SHEAR BOND STRENGTH OF TWO RESIN-MODIFIED

GLASS-IONOMER CEMENTS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

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Abstract

EVALUATION OF SHEAR BOND STRENGTH OF TWO RESIN-MODIFIED GLASS IONOMER CEMENTS

By Emily Y Ro, DDS

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Purpose: To compare the in-vitro shear bond strengths of a new paste-paste formulation of resin-modified glass-ionomer cement (Rm-GIC) to an exising powder-liquid formulation. The study will test the hypothesis that the new paste-paste formulation of Rm-GIC (Fuji-Cem^{TM}, GC Corp, Tokyo, Japan) has the same bond strength as an existing popular powder-liquid formulation of Rm-GIC (Rely-X^{TM} Luting Cement, 3M, St. Paul, MN)

Materials and Methods: A total of 33 human molars were sectioned parallel to the occlusal surface to expose mid-coronal dentin and mounted parallel to the bond shearing device on the universal testing machine (Instron). For Group I samples (Rely-X, n=15), the powder and liquid were measured and adjusted to achieve a ratio of 1.6 and mixed for 30 seconds as recommended by the manufacturer. For Group II (Fuji-Cem, n=18), the paste-paste was expressed from the paste-dispenser provided by the manufacturer and mixed for 10 seconds as recommended. After testing, the teeth from group II were bonded on a different site with the same material but mixed for 20 seconds (n=18). To ensure a uniform flow and bond surface area, the mixed cement was syringed into a cylindrical mould (diameter 2.38mm, height 2mm) and allowed to set under constant force. All samples were subjected to fracture by shear loading on a universal testing machine (Instron) at a uniform crosshead speed of .02” per minute and expressed as MPa. Values were analyzed at the $p<0.05$ level for differences between the two cement groups, and different mixing times in Group II.

Results: Wilcoxon rank sums test showed significantly higher shear bond strength values for Rely-X compared to Fuji-Cem mixed both at 10 seconds and 20 seconds. Mixing for 20 seconds resulted in stronger bonds for Fuji-Cem compared to 10 seconds, but was still significantly lower than Rely-X.

Conclusions: Within the limitations of the study, the Rely-X powder-liquid formula shows a significantly stronger dentin shear bond strength when compared to the new paste-paste formula of resin-modified glass ionomer cement, Fuji-Cem.

CHAPTER 1. Introduction

Despite its high solubility and lack of adhesion, zinc phosphate cement has been the luting agent of choice for over 90 years and has shown to provide acceptable long-term clinical performance[1]. This may indicate that retention of cast restorations is influenced by other factors that have been established in the literature. Kaufman et al.[2] in 1961 named factors influencing retention, including preparation factors (parameters such as surface area, height, surface texture), influence of casting (adaptation to tooth, texture) and type of cementing medium (type of cement, film thickness, values of compressive and shear strength).

According to Ergin and Gemalmaz [3], retention failure of crowns may be due to a combination of masticatory forces repeated over a period of time, which include direct compressive forces, some resultant shear lateral forces, and a small component of tensile force.

Although convergence angle, height and total surface area of a preparation are factors influencing retention, dentin bonding has also improved the retentive properties of luting cements, with the introduction of glass ionomer cements, and more recently with improved mechanical properties of resin-modified glass ionomer cements (Rm-GIC). With these newer bonding cements, studies have consistently shown increased retention due to bonding both to dentin and casting.[4]

Advantages of glass-ionomer cements also include an improved coefficient of thermal expansion similar to dentin and enamel, physicochemical adhesion to multiple substrates, biocompatibility and fluoride release, and high strength and insolubility in the oral environment.[5, 6, 7] There are also reports of decreased post cementation sensitivity[8,12], and reduced microleakage of metallic crowns cemented with resin based cements.[3] The main advantage given by Ergin and Gemalmaz[3] is the lack of technique sensitivity since multiple bonding steps are not required.

Rm-GIC's are a combination of glass ionomer and resin chemistries set by an acid-base reaction between aluminosilicate glass powder and an aqueous solution of polyalkenoic acids modified with methacrylate groups, as well as chemically initiated free-radical polymerization of methacrylate units.[8, 10] The highest bond strength values observed with Rm-GIC's in relation to conventional glass ionomer cements are due possibly to the formation of a hybrid layer, the advancements in dentinal wetting by the HEMA contained in Rm-GICs, better mechanical properties and the individual composition of the materials.[5,11]

Higher flexural strength and diametral tensile strength are reported in laboratory tests that also show unique desirable microproperties of RM-GIC's that allow adhesion to moist tooth structure and base metals.[6]

Most studies on the retention of cast restorations focus on direct tensile loading tests using preparations and castings of standard dimensions luted with different types of cement.[2,3,4,9] These studies report consistently higher retentive values exceeding clinically expected debonding forces with adhesive cements compared to zinc phosphate.[8] Ergin and

Gemalmaz[3] demonstrated that the lowest retentive values obtained for Rm-GICs were still much higher than the highest values for zinc phosphate. El-Mowafy et al.[4] reported better retention with resin-based cements versus zinc phosphate even with tooth preparations incorporating unfavorable convergence and height. They thought that the retentive values would probably be even higher for an ideally prepared tooth.

Pameijer and Jefferies[9] in their evaluation of retention for 18 luting agents found that glass-ionomer cements such as Ketac-Cem and Rm-GICs such as Vitremer have significiantly greater retentive values than conventional glass ionomer cements. Yim et al.[12] showed that Rm-GIC's showed greater retention than glass ionomer cements or zinc phosphate though less than resin cements.

These studies attempt to standardize crown preparations and castings to minimize the influence of mechanical retention from the castings, while emphasizing retention arising solely from cements. However, retention values can vary from study to study due to differences in method. Evaluation of mode of fracture in these studies find failures to be either adhesive, cohesive or mixed. A difficulty arises in comparing different cements regarding their bond strength using the clinical simulation. The cement can either remain bonded to the tooth, to the casting, or fracture within the material which would represent a truly cohesive failure. These studies have demonstrated the superiority in retention of castings with resin-modified glass ionomer cements relative to zinc phosphate cement, which can be mainly attributed to dentin bonding. Therefore, a simple laboratory study comparing tensile and shear bonding strength of new resin-modified glass ionomer cements to dentin, eliminating all other factors of retention may give an indication of retentive strength.

Pereira et al.[5] showed that the highest diametral tensile strength was demonstrated with Rm-GICs compared to conventional GICs. Presence of cohesive and mixed failures means bond strength values represent only the tensile bond strength of the cement rather than the tooth-cement interface.

The requirements of dental luting agents for fixed prosthodontics include thin film thickness that results from low viscosity, and improved retention and stability of a restoration. With improved adhesive technology, it is now possible to use a luting agent that both chemically bonds to tooth surface and the surface of the restoration. Dentin bonding is a desirable property of resin-modified glass ionomer cements as it has an effect on retention, microleakage, reduction of sensitivity, and better adaptation of the casting to the tooth. Rm-GIC's are available in powder-liquid forms, with optimum powder-liquid ratios provided by the manufacturers for optimum strengths. Though less technique sensitive than resin cements, inconsistencies can arise from using the powder liquid forms from dispensing errors which can have an effect on bond strength.[13,14] GC Corp. has introduced a paste-paste dispensing mechanism for a new modified glass ionomer cement, Fuji-CEM™, with the claim that it provides a more consistent strength and viscosity, providing optimum dentin bonding and luting strength. This paste-paste dispensing form can aid in less waste of materials and more consistent and predictable strength in bonding. Ergin and Gemalmaz[3] noted smaller standard deviation (SD) values for zinc phosphate cement and attributed this to lower technique sensitivity. Higher SD's were reported for

Rm-GICs which indicate that better retentive values could be obtained if values were more consistent.

The powder/liquid (P/L) ratio of glass-ionomer cements has a definite influence on the mechanical properties of the materials. The physical properties of glass ionomer cements are mostly influenced by the P/L ratio. Increase in powder content can decrease translucency and working time, while increasing compressive and diametral tensile stress.[5,15]

Wilder et al.[13] found that bonding is improved with moist dentin surfaces, while the P/L ratio should create low enough viscosity to promote wetting of the surface. In-vitro evaluation of viscosity showed that an increase in P/L ratio from 2.25 to 3.25 for Fuji II LC doubled the film thickness from 75 um to 150 um. Hand-proportioning and hand-mixing can produce inconsistencies in the physical properties of set materials. According to Wilder, factors related to dispensing affects wetting and adhesion. Increased P/L ratio occurs when overpacking or packing “tightly” into the scoop, dispensing a partial drop of liquid, or dispensing before the liquid bottle is completely inverted.

Billington et al.[14] further showed that the P/L ratios obtained in clinical practice are consistently lower than that recommended by manufacturers, which can impair mechanical properties such as compressive and diametral tensile strengths. A decrease in P/L ratio from 6.8:1 to 5:1 resulted in compressive and diametral strengths that were half than the optimum.

The powder-liquid dispensing scoop and dropper system for proportioning the powder-liquid has been the subject of widespread criticism. Despite attempts by manufacturers to produce improved dispensing systems, these are not used routinely in dental practice, which can result in impaired mechanical properties.[14]

Great dispersion of results of individual measurements is usually attributed to inaccuracy of the method or to the nature of the materials tested. With a study that controls for most factors, method inaccuracy can be minimized and hopefully lead to more accurate testing of the materials being compared.[16] This study provides a simpler method for measuring retention of cements based solely on bond strength to dentin, eliminating possible confounding factors such as taper and height of preparation, and bonding to casting.

CHAPTER 2. Materials and Methods

Thirty intact recently extracted human molars were stored in 10% NaOCl solution for 24 hours then in tap water at room temperature. A low-speed diamond disk saw (Buehler[R], Lake Bluff, IL) with water coolant was used to section the teeth parallel to the occlusal plane to expose mid-coronal dentin and any enamel flash was smoothed with a carbide disc. Mounting cylinders were filled with autocured Tray resin and drilled to provide space for each individual tooth. Teeth were mounted in the cylinders using light cured acrylic resin (Triad[R], Dentsply International, York PA) so that bonding surfaces were parallel to the Instron bond shearing device.

Teeth were randomly divided into two groups (n=15). The samples were cleaned with a clean soft toothbrush under running water for 20 seconds, and excess water removed with a gentle stream of filtered air. The samples were placed under an Ultradent (Ultradent Products, Inc., South Jordan, Utah) bonding jig (Patent Pending) in order to bond a uniform amount of cement onto the dentin bonding surface. The Ultradent bonding jig contains a cylindrical mould resulting in samples with a defined bond area (diameter 2.38mm) and heigth (2mm). The cements were mixed following manufacturers' instructions as shown in Table 1 and loaded into a Centrix syringe (CR[R]Tubes & Plugs, Centrix Inc., Shelton, CT). For Group I, the powder and liquid were measured and adjusted to achieve the recommended ratio of 1.6 to 1 for standardization and mixed for 30 seconds.

For Group II, the paste-paste were dispensed from the paste dispenser and mixed for 10 seconds as recommended by the manufacturer. The cements were syringed into the Ultradent bonding mould while it was slightly raised to ensure a uniform flow onto the bonding surface and avoid trapping air bubbles. The jig was then lowered and secured to the tooth surface. Excess cement was removed before setting using the tip of Kerr Applicators™ (Kerr Corp, Orange, CA).

	Commercial Name	Manufacturer	Lot#	Dispensing formulation	Mode of dispensing
Group I	Rely-X™	3M, St. Paul, MN	20030331	Powder-liquid	Three scoops of powder and three drops of liquid, measured and adjusted to achieve recommended ratio of 1.6:1
Group II	GC FujiCem™	GC Corp, Tokyo, Japan	0211072	Paste-Paste	Equal amounts of paste:paste extruded from the Paste-Pak Catridge loaded onto a dispenser as provided by the manufacturer

Table 1. Groups tested, commercial name of products tested, their manufacturers, and mode of dispensing

Samples were allowed to set under constant force of 5 lbs. for 15 minutes in the incubator at mouth temperature (37^0 C) using a polyvinylsiloxane (3M Express™, 3M Dental Products, St. Paul, MN) putty mould that was placed over the mounting jig and held in place by a weight (Figure 1). The samples were removed from the pressure jig and allowed to set in the incubator for an additional 30 minutes with the polyvinylsiloxane mould still in place. The samples were carefully separated from the mold by lifting the Ultradent jig while securing the sample with a rounded hand instrument to allow the bond to remain undisturbed.

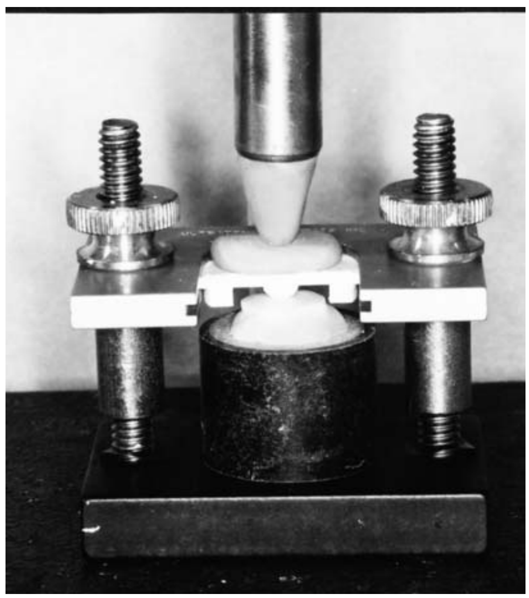

Fig 1. Samples setting under pressure.
Samples were loaded with cement, sealed with a polyvinylsiloxane mould, and allowed to set under constant force of 5 lbs.

Samples were stored in water for 5 days in the incubator at 37^{o} C. Excess cement was removed with the aid of a microscope (30X) and 25 scalpel blade to standardize the bond area. Samples were placed in the appropriate loading jig and tested for shear bond strength using the crosshead pin mounted in a universal testing machine (Instron Corp., Canton, MA) at a crosshead speed of 0.02" per minute. (Figure 2) The force required to fracture the specimen was recorded in pounds (lbs.) and the shear bond strength was calculated as the ratio of fracture load and bonding area and expressed in megapascals (MPa).

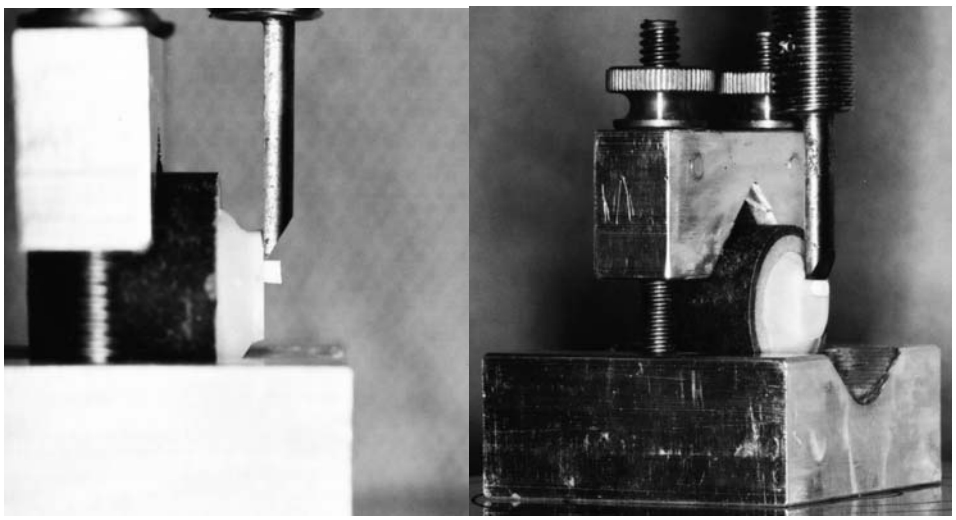

Fig 2.Shear Bond Strength Test.
Samples were loaded into a jig and mounted for shear test loading in a universal testing machine (Instron).

The mode of failure was noted after a visual examination using a light microscope under 30X magnification. Failures were recorded as adhesive (those which occur between the cement and tooth structure, cohesive (those which occur within the cement or tooth structure), or mixed (combination of adhesive and cohesive).

Because of the high number of samples that failed at extremely low values in group II, three more samples were made following the described protocol (n=18). Experimental testing and examination of samples under a microscope using different mixing protocols for Group II showed improved samples at 20 second mix. At 30 seconds, the cement appeared to become more viscous without change in microscopic properties.

After testing for shear bond strength at 10 second mix, the eighteen teeth in group II were cleaned and any remaining cement removed with a 25 scalpel blade with the aid of a microscope at 30X magnification. Samples were manipulated following the described protocol and bonded on a different dentin site after mixing the cement for 20 seconds.

To test the hypothesis that there is no difference between the two cements, and no improvement with mixing the paste-paste system for 20 seconds rather than the recommended 10 seconds, the non-parametric data is analyzed using the Wilcoxon signed-ranks test.

CHAPTER 3. Results

None of the samples from both groups debonded spontaneously during storage. However, during testing, three samples from Group II debonded immediately upon loading, thus resulting in no recorded value. The lowest recorded value in this study was 0.1 MPa, therefore all samples that debonded without a recorded reading were assigned a value of 0.1 MPa for statistical analysis.

When making the mixes, differences were noted in Fuji-Cem and therefore two mixing times were used for this material, 10 seconds as recommended by the manufacturer, and 20 seconds as determined by preliminary mixing evaluation. Table 2 shows the means, standard deviations and confidence intervals for the two mixes of Fuji Cem. Wilcoxon rank sums test revealed a significant difference ($p = 0.0174$).

Table 2. Shear Bond Strength (MPa) of Fuji-Cem 10 & 20 sec mixes

Fuji-Cem mix (sec)	**n**	**Mean**	**Std Dev**	**Lower 95%**	**Upper 95%**
10	18	2.45111	2.34696	1.2840	3.6182
20	18	4.67611	2.84075	3.2634	6.0888

Because the differences in the two mixes were somewhat significant, separate comparisons were made between Rely-X and Fuji-Cem mixed for 10 seconds, and Fuji-Cem mixed for 20 seconds. Table 3 shows the means, standard deviations and confidence intervals for both Fuji-Cem mixes, and Rely–X. Wilcoxon rank sums test revealed a significant difference between Rely-X and Fuji-Cem mixed for 10 seconds ($p < 0.0001$). A significant difference was also noted between Rely-X and Fuji-Cem mixed for 20 seconds ($p = 0.0002$)

Table 3. Shear Bond Strength (MPa) of Fuji-Cem 10 and 20 Sec Mixes, and Rely-X

Material	**n**	**Mean**	**Std Dev**	**Lower 95%**	**Upper 95%**
Fuji Cem (10 sec)	18	2.45111	2.34696	1.2840	3.618
Fuji Cem (20 sec)	18	4.67611	2.84075	3.2634	6.089
Rely-X	15	9.04667	2.67458	7.5655	10.528

Figure 3 shows a plot of each material's data, with the mean indicated by the centerline bounded by error bars, and the standard deviation indicated by the outlying wider lines.

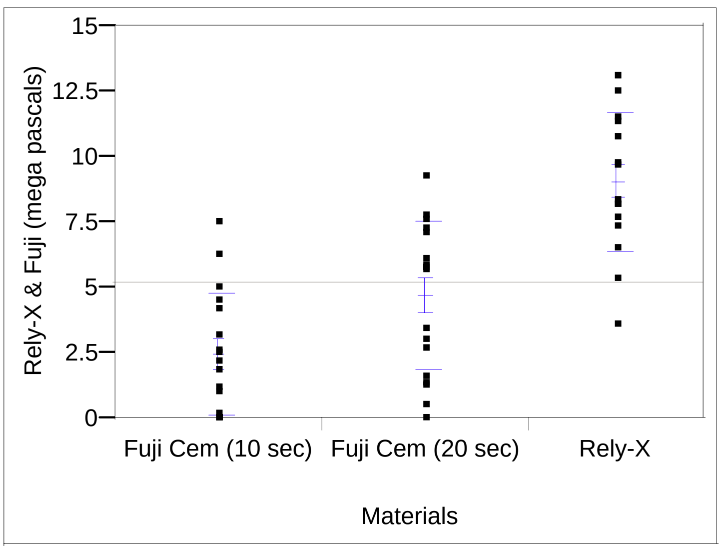

Figure 3. Plot of Shear Bond Strength (MPa) for Fuji-Cem 10 sec. mix and 20 sec. mix, and Rely-X

Table 4 reports the types of failure noted under visual examination at 30X magnification. Most failures were either cohesive or mixed cohesive adhesive.

Table 4. Types of failure (adhesive, cohesive or mixed) for Fuji-Cem 10 and 20 mixes and Rely-X, at 30X magnification, as percent (%) of n

	n	**Adhesive**	**Cohesive**	**Mixed**
Fuji-Cem (10s)	18	22.2	27.8	44.4
Fuji-Cem (20s)	18	11.1	50	38.9
Rely-X	15	0	40	60

CHAPTER 4. Discussion

Shear bond strength tests a combination of tensile and compressive forces within the material as well as the bond between the material and the tooth surface. When a crown is luted to the tooth, the cement tooth interface is subjected to a combination of these forces. This study attempted to isolate this factor for comparison of a popular resin-modified glass-ionomer cement used in clinical practice and a new cement being marketed as the first paste-paste formulation of resin-modified glass ionomer cement. The mechanical and bond strength properties for these two materials have not been previously studied or reported in the literature. It is unknown how the paste-paste formulation affects the chemical composition and its mechanical properties and whether it truly provides a consistent powder-liquid ratio within its composition.

The evaluation period of 5 days and allowance of 45 minutes setting time takes into account the initial cure of GICs, followed by the 24 hour reaction phase, with the 5 day storage allowed for any strength that might be gained over time.[16,17] No effort was made in this study to allow for 100% humidity conditions during setting, although it has been reported that bonding and strength characteristics of luting cements can be affected by humidity and thermal conditions.[3,18] The samples were allowed to set in a sealed environment and because the same conditions applied to both groups, it is felt that this did not introduce a confounding error. However, visual examination of the samples after testing showed that the Fuji-Cem samples that fractured at extremely low values showed some evidence of crazing around the edges, which leads to the suspicion that some of the samples were not completely sealed in the Ultradent jig, and there may have been some exposure to dry conditions in the incubator during setting. At the same time, because the Group I samples were subjected to the same conditions, it may be likely that Fuji-Cem may be more susceptible to dry, thermal conditions.

Several factors can influence the bond strength, one of which is the type of dental substrate. Dentin has a heterogeneous surface consisting of approximately 30% organic matter by volume, and consequently has low surface energy.[19] Because this study used extracted teeth, the dentin surface can vary from tooth to tooth. It has also been reported that because of the change in size of dentinal tubules from the surface to the pulp chamber, dentin bonding strength can also vary within the tooth, depending on the bond site.[20] This may be one of the factors contributing to the standard deviation for each group.

Another factor that may have influenced the results is the operator's mixing technique. Mixing efficacy seems to have an influence on the quality of the resulting samples. For Group II, the paste-paste formulation resulted in two pastes of similar color (one white, the second light-yellow), which made it difficult to visually determine whether the two pastes had completely been incorporated. The 10 second mixing time recommended by the manufacturer resulted in a high number of faulty samples that failed at low values. Examination under a microscope at 30X magnification showed a high density of voids within a translucent film formed by squeezing the mix between glass microscope slides. This high density of voids can both decrease the bond area, as well as contribute to fracture propagation by stress concentration around the voids. Examination of each paste system separately under the microscope revealed inherent voids in the paste, which then become incorporated into the mix. Examination of the Rely-X mix under a microscope also showed voids but the substrate appeared denser. Improved samples were obtained after mixing for 20 seconds compared to 10 seconds, resulting in higher overall values that were statistically significant. However, it is unknown from this study whether longer mixing time can have a significantly adverse effect on other desirable properties of the material (i.e. viscosity) as a luting cement, although the manufacturer allows longer mixing times (15sec.) for multiple crowns.

The presence of cohesive and mixed failures means that bond strength values represent only the tensile bond strength of the cement rather than the strength of the tooth-cement interface.[5,10] This type of failure has been commonly reported in the literature for glass-ionomer based cements.[5,21,22] It is expected of materials of high or large porosity. This may indicate that the interfacial strength of the bond is actually higher than the inherent strength of the material.[11] The shear bond strengths of the resin-modified glass ionomer cements investigated in this study were in the range of 0.1 to 9.4 Mpa (Mean 4.7+/-2.8) for Fuji-Cem when mixed for 20 seconds and 3.7 to 13.2 Mpa (Mean 9.0+/-2.7) for Rely-X, and more cohesive and mixed failures were observed. The findings in this study may indicate that Rely-X shows better strength properties when compared to Fuji-Cem, but further studies are needed. Shear bond strength values are a function of stress distribution and concentration that is characteristic of the particular strength-based test employed,[11,16,21,22] and therefore direct comparisons with previous studies cannot be made due to differences in method and composition of materials tested. A consistent and reproducible method of testing needs to be developed to allow for constant evaluation and comparisons to new luting cements introduced in the market.

The physical properties of glass ionomer based cements can be influenced by the powder:liquid ratio.[5,14,15] For luting cements, the powder:liquid ratio is lower to allow for a lower viscosity, but an optimum ratio is desired for strength characteristics.[5] To standardize the powder:liquid ratio of the samples in Group I, the powder and liquid were dispensed with the scoop and liquid dispenser as recommended by the manufacturer, then measured to the nearest 0.001 g and re-adjusted to meet the 1.6 optimum ratio. It was found that even though following closely the instructions on how to use the liquid dispenser and scoop provided by the manufacturer, the amount of liquid dispensed was not consistent, and it was almost always necessary to add more powder to achieve the recommended ratio. Although additional studies are needed, there is an indication that the powder:liquid ratio achieved free-hand clinically may be less than optimum, which may result in different and possibly less than optimum strength values of the cement. A study by Billington et al. [14] investigating the powder/liquid ratios routinely used clinically in general practice found a wide range in resulting ratios from that recommended by the manufacturer, with all mixes containing less powder. An average 26% decrease in powder:liquid ratio was achieved by dental assistants compared to that recommended by the manufacturer, which resulted in a decrease of 47% in compressive strength and 53% in diametral strengths of the glass ionomer restorative material tested. Although the bond strengths achieved with the powder-liquid formula of Rely-X was relatively high, the values may not represent true values that could be achieved in clinical practice unless routinely measured to achieve the recommended ratio and properly mixed.

For Group II, the paste-paste formulation gave the illusion of a better mix due to ease of manipulation and dispensing. However, it is unknown whether the formulation incorporates a consistent ratio of materials and unless a significant number of batches are tested, it is unknown whether the strength properties will be consistent from mix to mix and batch to batch. Further studies on compressive and diametral tensile tests as well as microscopic evaluation on concentration of voids in the material are needed for more definitive conclusions on the mechanical properties.

The use of primers were not used in this study although previous studies have reported improved bond strengths with the use of conditioners.[10,23] Preliminary testing with the use of the respective conditioners for the two materials tested showed no difference in the parameter being tested. The use of a primer or conditioner helps remove the smear layer and demineralize the superficial layer of dentin, allowing the HEMA incorporated in the RmGICs to penetrate the exposed collagen fiber network[10,23] Since this was a comparative study, the application of a conditioner and subsequent drying of the surface would have introduced another uncontrolled variable. In addition, the use of a primer or conditioner is not common clinical practice when using luting cements for crowns and was therefore not used in this study

The effect of aging and thermocycling has been demonstrated to decrease the properties of conventional glass ionomer cements by deteriorating the surface integrity and by enhancing crack propagation.[24] The decrease in mechanical properties is dampened with a higher resin component as with resin-modified glass ionomer cements,[24] but it is nevertheless apparent that more studies are needed to show the effect of aging. This study did not study the effect of aging and thermocycling on the resin-modified glass ionomer cements tested and therefore no conclusion can be made regarding the long-term clinical performance of the cements. However, because of the comparative nature of the study, the results show that a closer look at the properties of new Rm-GIC's is needed before concluding that a more convenient dispensing mechanism (paste-paste) leads to better properties of material. Further evaluation is needed to determine the comparative laboratory strength of these cements and the long-term clinical performance.

CHAPTER 5. Conclusions

This study compared the shear-bond strengths of a commonly used powder-liquid formulation of Rm-GIC (Rely-X) to a new paste-paste formulation of Rm-GIC (Fuji-Cem). Within the limitations of this in-vitro study, the following conclusions were made:

1. The shear bond strength of Fuji-Cem was significantly lower when compared to Rely X.
2. The bond strength was significantly improved for Fuji-Cem when mixed for 20 seconds rather than the manufacturer recommended 10 seconds, but was significantly lower than Rely-X.

References

References

1. Creugers, NHJ, Kayser AF, Van't Hof MA. A meta-analysis of durability data on conventional fixed bridges. Community dent. Oral Epidemiol 1994;22:448-52.

2. Kaufman EG, Coelho DH, Colin L. Factors influencing the retention of cemented gold castings. J Prosth Dent 1961;11:487-502.

3. Ergin S. Gemalmaz D. Retentive properties of five different luting cements on base and noble metal copings. J Prosth Dent 2002;88:491-7.

4. El-Mowafy OM, Fenton AH, Forrester N, Milenkovic M. Retention of metal ceramic crowns cemented with resin cements: Effects of preparation taper and height. J Prosth Dent 1996;76:524-9.

5. Pereira LCG, Nunes MCP, Dibb RGP, Powers JM, Roulet JF, Navarro MF. Mechanical properties and bond strength of glass ionomer cements. J Adhes Dent 2002;4:73-80.

6. Xie D, Brantley WA, Culbertson BM, Wang G. Mechanical properties and microstructures of glass-ionomer cements. Dent Mat 2000;16:129-138.

7. Diaz-Arnold AM, Vargas MA, Haselton DR. Current status of luting agents for fixed prosthodontics. J Prosth Dent 1999;81:135-41.

8. Smith DC. A new dental cement. Br Dent J 1968;124:381-4.

9. Pameijer CH, Jefferies SR. Retentive properties and film thickness of 18 luting agents and systems. Gen Dent 1996;44:524-30.

10. Pereira PN, Yamada T, Inokoshi S, Burrow MF, Sano H, Tagami J. Adhesion of resin-modified glass ionomer cements using resin bonding systems. J Dent 1998;26(5):279-85.

11. Fritz UB, Finger WJ, Uno S. Resin-modified glass ionomer cements: Bonding to enamel and dentin. Dent Mater 1996 12:161-166.

12. Yim NH, Rueggeberg FA, Caughman WF, Gardner FM, Pashley DH. Effect of dentin desensitizers and cementing agents on retention of full crowns using standardized crown preparations. J Prosthet Dent 2000;83:459-65.

13. Wilder AD, Boghosian, Bayne SC, Heymann HO, Sturdevant JR, Roberson TM. Effect of powder/liquid ratio on the clinical and laboratory performance of resin-modified glass-ionomers. J of Dent 1998;26(4):369-377.

14. Billington RW, Williams JA, Pearson GJ. Variation in powder/liquid ratio of a restorative glass-ionomer cement used in dental practice. Br Dent J 1990;169:164-167.

15. Hibino Y, Kuramochi K, Hoshino T, Moriyama A, Watanabe Y, Nakajima H. Relationship between the strength of glass ionomers and their adhesive strength to metals. Dent Mater 2002;18:552-557.

16. Tagger M, Tagger E, Tjan AHL, Bakland LK. Measurement of adhesion of endodontic sealers to dentin. J Endo 2002;28(5), 351-354.

17. Cattani-Lorente MA, Godin C, Meyer JM. Mechanical behavior of glass ionomer cements affected by long-term storage in water. Dent Mater 1994;10:37-44.

18. Ishijima T, Caputo AA, Mito R. Adhesion of resin to cast alloys. J Prosthet Dent 1992;67:445-9.

19. Beech D. Adhesion in the oral environment: biophysical and biochemical considerations. Int Dent J 1978;28:338-347.

20. Yoshikawa T, Sano H, Burrow MF, Tagami J, Pashley DH. Effects of dentin depth and cavity configuration on bond strength. J Dent Res 1999;78(4):899-905.

21. Yip HK, Tay FR, Ngo HC, Smales RJ, Pashley DH. Bonding of contemporary glass ionomer cements to dentin. Dent Mater 2001;17:456-470.

22. Gordan VV, Boyer D, Soderholm KJ. Enamel and dentine shear bond strength of two resin modified glass ionomers and two resin based adhesives. J Dent 1998;26:497-503.

23. Tay FR, Smales RJ, Ngo H, Wei SHY, Pashley DH. Effect of different conditioning protocols on adhesion of a GIC to Dentin. J Adhes Dent 2001;3:153-167.

24. Bapna MS, Gadia CM, Drummond JL. Effects of aging and cyclic loading on the mechanical properties of glass ionomer cements. Eur J Oral Sci 2002;110:330-334

25. Moon PC, Brooks CN, Loveland CK. Dentin Shear Bond Strength of Two Flowable and Two Packable Composites. Virginia Commonwealth University, General Practice Department, poster presentation.

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