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Original Research

Effect of Marginal Sealant on Shear Bond Strength of Glass Ionomer Cement: Used as A Luting Agent

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Abstract:

Background: Moisture sensitivity and dissolution has been a known drawback of glass ionomer cement (GIC). When used as a luting agent for cementation of casted indirect restoration, the exposed cement at the margins is often a primary factor for marginal leakage and consequent failure of the restoration. The following *in vitro* study was planned to evaluate the effect of a marginal sealant on GIC used as luting agent.

Materials and Methods: Sixty healthy extracted premolars were selected and prepared to receive metal-ceramic prosthesis. The prepared restorations were cemented using GIC and were divided randomly into two groups. The specimens in Group A were directly immersed in artificial saliva solution without any protection at the margins, while the exposed cement for Group B specimens was protected using a marginal sealant before immersing it in the artificial saliva solution. The specimens were tested after 24 h using a crown pull test on the universal testing machine to measure the shear bond strength of the cement.

Result: The specimens in Group B showed statistically significant difference from the specimens in Group A with the mean shear bond strength of 6.60 Mpa and 5.32 respectively.

Conclusion: Protection of GIC exposed at the margins of indirect cast restorations with a marginal sealant can significantly increase the longevity of the prosthesis by reducing the marginal leakage and perlocation of fluids.

Key Words: GIC, marginal leakage, marginal sealant

Introduction

Fixed prosthodontics is an art and science of restoring the damaged teeth and of replacing missing teeth with artificial substitutes that are not readily removed from the mouth.[1] These indirect restorations can be either made of cast metal, metal ceramic or all ceramic material and are attached to the prepared teeth by means of luting cement, which holds the restoration in place for an indefinite period of time filling the gap at the tooth-restoration interface. There are various factors that influence the retention of the casted restorations such as the surface area and height of the prepared tooth, parallelism of the opposing walls of the preparation, taper of the preparation, retentive guiding grooves and notches, accuracy of the casting and lastly the cementing medium.[2] Rosenstiel *et al.*[3] described the ideal luting agent as being biocompatible to the oral environment, resistant to microleakage, preventing caries or plaque, having sufficient strength to resist functional forces, having low water solubility and no water sorption, being adhesive, radiopaque, esthetic, easy to manipulate, low in cost, and low viscosity at mixing. All currently used definitive luting materials satisfy these requirements to some extent with clinical success.[4] Among the different luting agents available, glass ionomer cement (GIC) remains the most widely used luting cement in India.

Introduced in 1969 by Wilson and Kent, GIC offers the advantages like fluoride releasing, molecular bonding to tooth, ease of handling, intermediate mechanical properties, and excellent translucency. However, moisture sensitivity and dissolution of GIC has been a controversial issue with different school of thoughts regarding protection of the cement from oral environment.[5] In a study conducted by Wilson and Nicholson,[6] it was suggested that temporary protection after bulk removal with a varnish prevents dissolution of the ions as the matrix is still forming. In a study conducted by Curtis *et al.*,[7] it was found that leaving excess of GIC present during restoration seating undisturbed for 10 min will prevent any significant erosion in a wet field; in contrast, keeping the exposed cement dry for long leads to possible risks of dehydration and microcracking. Mount[8] in his study had recommended that newer generations of glass-ionomer luting cements are fast-setting with relatively high resistance to water within 5 min, hence the use of a waterproof varnish or resin sealer to cover the exposed cement is not necessary. Although marginal discrepancy between the prepared tooth and restoration of up to 50 μm is acceptable, the exposure of GIC at the margins to the oral environment can be sufficient to break the sealant effect, leading to microleakage and failure of the restoration. According to the study conducted by De Backer *et al.*[9] caries caused due to marginal microleakage (22.2%) and loss of retention (15.3%) was the most common cause of failure.

The aim of the following *in vitro* pilot study was to analyze the effect of light cured bonding resin, used to seal the GIC exposed at the margins of cemented metal ceramic crowns on the shear bond strength of the cement. The proposed hypothesis was that early water exposure weakens the matrix formation and sealing the margins post cementation procedure will protect the cement from salivary contamination thus preventing dissolution of ions, which may increase the shear bond strength of GIC.

Materials and Methods

Sixty extracted human premolars, all free of caries or restoration and extracted <6 months before the test were selected. They were cleaned of any organic material with an ultrasonic scaler and placed in a glass container with liquid sterilant (0.5% sodium hypochlorite) to keep them moist. The teeth were then mounted in autopolymerizing resin with horizontal notches on its root for retention such that the cement-enamel junction is 1 mm above the resin surface. The premolars were randomly divided into two groups with 30 samples in each.

Group A: Porcelain fused to metal crowns were cemented using GIC without the use of any marginal sealant

Group B: Porcelain fused to metal crowns were cemented using GIC with the use of a marginal sealant to protect the exposed cement at margins from salivary contamination.

A jig had been held firmly on a surveyor base and complete crown preparation were done using a high speed hand piece that was stabilized by a holding device (Figure 1) that can be moved in a horizontal plane to obtain a standard taper of 6° for all the preparation (Figure 2). Parallel-sided coarse straight fissure diamond burs were used to prepare axial surfaces and to establish a shoulder finish line. The occluso-cervical height for all the preparation was kept constant (4 mm) with a flat occlusal surface. The preparations were finished using finishing burs. Two layers of die spacer were applied to each specimen using a brush in a controlled fashion. The first layer was allowed to dry before the application of the next layer. As crown pull-off test was to be used to measure the shear bond strength. Accordingly, a 2 mm loop was in co-operated in the wax pattern, so that the metal coping is casted along with the loop (Figure 3). The casted metal copings were finished and polished following a standard protocol and ceramic build-up was done. The occlusal table was kept flat in the build-up too.

The metal ceramic restorations fabricated were then cemented on to the prepared teeth using GIC (GC Fuji I Glass Ionomer Luting Cement [GC Corporation. Tokyo, Japan]). The cement was mixed according to manufactures instructions and a controlled seating force of 25 Newton. The initial setting time for all the cemented specimens was kept constant (6 min). After the initial set, the excess of cement was removed using a probe. The specimens in Group A without any protective coating for the exposed cement at the margins were then directly immersed in artificial saliva solution for 24 h. The exposed cement at the margins of specimens in Group B were immediately sealed

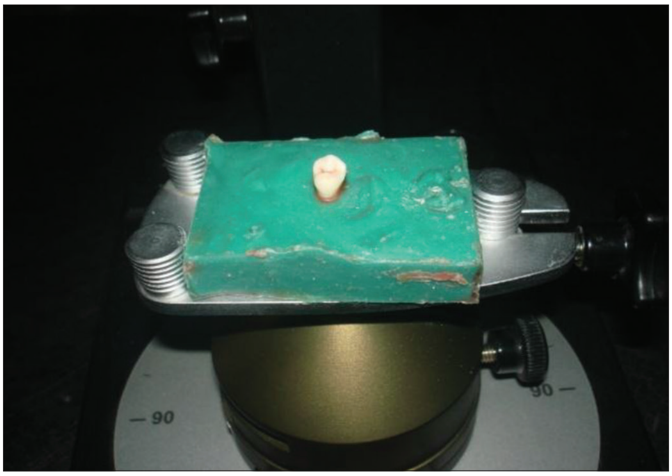


Figure 1: Stabilizing device.

Figure 2: Prepared tooth.

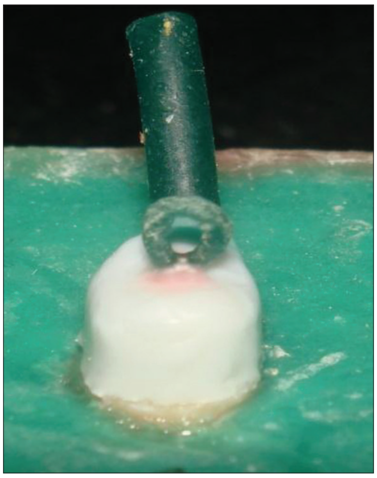


Figure 3: Wax pattern with loop in-cooperated.

using a bonding agent (Fuji coat LC-light cured coating agent for GIC) (Figure 4) applied with an applicator tip and light cured for 10 s following which they were immersed in artificial saliva solution for 24 h.

After storage for 24 h the shear bond strength of the cement was checked with crown pull test on universal testing machine (Instron, Star Testing System 248) with the cross head speed of 0.5 mm/min. An iron rod with hooks at both the ends was attached to the loop on the cemented metal ceramic crown on one end while the other end attached to the universal testing machine (Figure 5). The force at which the crown pulled off from the prepared tooth was noted in N/cm^2 and converted to megapascal. The shear bond strength of all the specimens was calculated accordingly and the acquired data was subjected to statistical analysis using unpaired *t*-test with a level of significance set to $P \leq 0.005$.

Result

Graph 1 shows the comparative pulling forces at which the crown was separated from the prepared tooth surface for the specimens of Group A and Group B. The mean for Group A and Group B specimens was 5.32 and 6.61 respectively (Graph 2). Data collected by the pilot study was computerized and analyzed using the Statistical Package for Social Sciences version 16.0. The normality of the data was checked using the Shapiro–Wilk tests, the data was normally distributed. The standard deviation of 0.31 and 0.53 for the respective group was observed. Parametric tests: Unpaired *t*-test was applied to check the level of significance (Tables 1 and 2). Unpaired *t*-test is applied to unpaired data of independent observations made of two different or separate groups to test if the difference between the two means is real or it can be attributed to sampling variability. The shear bond strength for Group B was found to be significantly more when compared to Group A ($P = 0.001$).

Figure 4: Fuji Lc Coat.

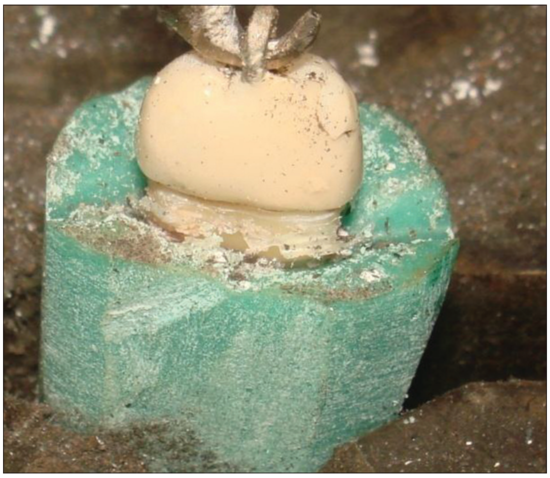


Figure 5: Crown pull test.

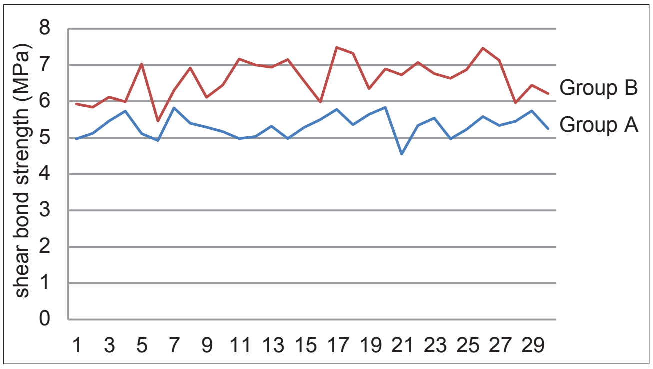
Discussion

Most commonly used treatment modality for replacement of missing teeth is fixed partial dentures with cast metal, metal

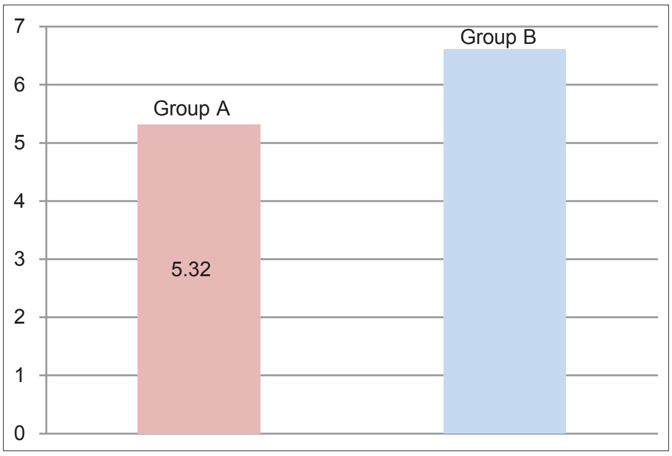
Table 1: Group statistics.

VAR00004	*N*	Mean	Standard deviation	Standard error mean
VAR00003				
Group A	30	5.3227	0.31058	0.05670
Group B	30	6.6080	0.53268	0.09725

VAR: Variance



Graph 1: Shear bond strength of Group A and Group B specimen.



Graph 2: Mean shear bond strength between Group A and Group B.

Table 2: Independent samples test.

	Levene's test for equality of variances		*t*-test for equality of means						
	F	Significance	*T*	df	Significance (2-tailed)	Mean difference	Standard error difference	95% confidence interval of the difference	
								Lower	Upper
VAR00003									
Equal variances assumed	12.544	0.001	−11.417	58	0.000	−1.28533	0.11258	−1.51068	−1.05999
Equal variances not assumed			−11.417	46.675	0.000	−1.28533	0.11258	−1.51185	−1.05882

VAR: Variance

ceramic and all-ceramic crowns. Any cast crown used as fixed partial denture has a variable amount of marginal discrepancy. It is important that the luting material fills the space between the restoration and the tooth structure to prevent tooth hypersensitivity, biofilm infiltration, marginal discoloration, and eventually secondary caries, all leading to failure of the prosthesis. The luting cements used for cementation of these casted crowns is exposed to the oral fluids at this marginal gap and is susceptible to solubility and marginal breakdown.

Marginal gap of a fixed dental prosthesis is a crucial factor in the long term success of the restoration. There are various factors that may contribute to the failure, one of which is the dissolution of the luting agent at the margins. The clinically accepted marginal gap is said to be 50 μm. When there is an increase in the marginal gap, there is a greater surface area of the luting cement exposed at the margin to oral fluids.

In this *in-vitro* study, the fabricated metal ceramic crowns were cemented using luting GIC on freshly extracted, prepared premolars. They were randomly segregated in two groups, Group A and Group B, respectively. The samples of Group B were then treated with a marginal sealant to protect the cement film exposing at the margins. Then samples of both groups were immersed in artificial saliva for 24 h after which they were tested for shear bond strength on a universal testing machine. The mean value calculated for Group A was comparatively lower (5.32) than that of the mean value of Group B (6.61). The difference was proved to be statistically significant ($P = 0.001$). The application of the resin sealant on the margins of the samples of Group B prevented the water contamination of the luting GIC during its initial set thereby maintaining the matrix formation and preventing leaching of ions. On the other hand, the Group A samples had exposed cement at the margins, which resulted in moisture contamination of the GIC during the initial set causing a weakened substructure. A better understanding of setting reaction of GIC is must here.

Glass ionomer cement is the most frequently used definitive luting cement for cast crowns. It consists of powder which is usually an aluminosilicate glass and contains fluoride to control glass formation and to modify the properties. The liquid consists of poly alkenoic acid (PAA), maleic acid, and other minor organic acids. The setting reaction of GIC involves an acid-base reaction of PAA. It is thought that the dissolution process of the aluminosilicate glasses involves two processes;[10] first, the ion exchange of these ions (Ca and Sr ions) with protons from PAA and second, these ions along with Al and F ions are also released through the glass dissolution process. Both migrate to the aqueous phase of cement and the cations ionically crosslink with the carboxyl groups of the PAA. In the glass structure, Al ions exist in predominantly four coordination state to accommodate the tetrahedral silicate network of the glass. However, during the formation of GIC and the release of Al from the glass into the aqueous phase, the coordination number for Al ions increases to six, where six ligands must be attached to the $Al3+$ cation.[11] Initial setting occurs in few minutes, but precipitation, gelation, and hydration occur for at least 24 h, and setting continues slowly for much longer periods.[12] These materials set and harden by a transfer of metal ions from the glass to the polyacrylic acid to form a salt hydrogel, which is the binding matrix.[13] Water is the reaction medium and also serves to hydrate the siliceous hydrogel and the metal polyalkenoate that are formed. It is an essential part of the cement structure. Therefore, the water balance must be controlled to permit sufficient maturation of the GIC before the restoration is exposed to the oral environment. If the setting cement is exposed to an aqueous environment too soon after placement, the setting process may be upset by leaching out of the ions.[14] According to Flick's first law, the flux goes from regions of high concentration to regions of low concentration, with magnitude that is proportional to the concentration gradient. Thus, the ions dissolution progresses form the outer surface to the inner, towards the tooth, due to ionic concentration gradient. As the ions from the outer surface dissolve, the ions adjacent, on the inner aspect, start to mobilize. This process continues to the point that, the GIC luting cement along the axial wall are compromised in their physical properties rendering decreased performance. This in turn results in an inefficient ability of the luting cement to provide resistance to dislodging forces along the long axis of the tooth.

Correlations between early exposure to water and reduced mechanical properties that lead to poor clinical performance have been demonstrated by various authors.[15] According to Holtan *et al.*, the GIC that was exposed to the oral environment, showed a microleakage pattern.[16] The resin coated GIC did now show such observations. They also observed some physical deterioration of the GIC on the immediate surface that was exposed to the simulation of the oral environment. Earl *et al*. have reported success with a low-viscosity, light-activated, unfilled, resin enamel bond that the real value of the esthetic glass-ionomer restoratives could be appreciated.[17,18] The application of a resin sealant maintains isolation for up to 24 h, by which time the acid-base reaction is sufficiently advanced to withstand both hydration and dehydration. Thus if any change has to occur, the initial 24 h are enough to cause dissolution of the cement at the margin.

Thus, the foresaid hypothesis was accepted to be true with statistically significant difference between the two groups. Thus indicating that the application of a medium that will create a barrier from water contamination of the luting GIC significantly affects its clinical performance with optimum physical properties and better longevity of the fixed prosthesis.

Conclusion

The above *in vitro* study focused light on a simple step during the clinical procedure of cementation with the most commonly used GIC. Water serves as reaction medium initially and then slowly hydrates the cross-linked matrix during the setting reaction of GIC. This process yields a stable gel structure that is stronger and less susceptible to moisture contamination. Accordingly any contamination occurring during the maturation phase of GIC will cause dissolution of the matrix forming cations and anions to the surrounding environment. Protection of the exposed cement at the margin of cemented cast crown helps to maintain the matrix formation phase thereby ensuring the marginal integrity of the restoration, which is invariably related to the success criterion of fixed partial dentures. Literature suggests that protection of GIC at the casted restoration margins as an essential clinical step,[19,20] but is often neglected by the practitioner with little knowledge about its consequences.

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