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A comparative study of shear bond strength of two adhesive liners to nanocomposite

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ABSTRACT

Aim: To compare the shear bond strength of resin-modified glass ionomer and nano-filled flowable composite liners to nanocomposite restorative material. **Materials and Methods:** In this *in vitro* study, 24 specimens were prepared in acrylic blocks for the study with 12 in each group. Group I consisted of resin-modified glass ionomer liner (GC Fuji II LC Improved) bonded to a cylinder of nanocomposite (Z350 Universal Restorative) whereas in Group II flowable composite liner (Filtek Z350 Flowable Restorative) was bonded to a cylinder of nanocomposite (Z350 Universal Restorative). Shear bond strength was determined using Instron Universal testing machine. Student's independent sample *t* test was used for analysis. **Results:** The mean shear bond strength value of Group I was greater than Group II and the difference was statistically significant ($P = 0.001$). **Conclusion:** Resin-modified glass ionomer appears to be a more compatible liner under nanocomposite restoration than flowable composite as it exhibited significantly higher shear bond strength.

CLINICAL RELEVANCE TO INTERDISCIPLINARY DENTISTRY

- Resin-modified glass ionomer and flowable composites have been used as liners under resin composite restorations in both primary and permanent teeth to compensate for their polymerization shrinkage.
- Adequate bonding of liners to composites is as important as bonding to dentin for the success of this technique.
- Bonding of resin-modified glass ionomer liner to nanocomposite restorative material is better than flowable composite liner and hence should be preferred over flowable composite as a liner.

Key words: Bond strength, cavity liner, nanocomposite

INTRODUCTION

Composite resins have been widely used in the restoration of posterior teeth due to increasing demand for esthetics as well as dramatic improvement in newer generation bonding agents and resin composite formulations.^[1] The currently available nanocomposite restorative systems are suitable for both anterior and posterior restorations as they provide adequate resistance in high stress bearing areas and superior esthetics than microhybrids.^[2]

However, shrinkage during polymerization of composites still remains a concern and hence restorative techniques that reduce the level of stress due to resin composite polymerization shrinkage have been suggested.^[3,4] One of the methods is to create a stress-absorbing layer, by placing a cavity liner or base of low-viscosity/low-elastic modulus materials such as resin-modified glass ionomers, filled adhesives, flowable composites and compomers. This layer increases the strain capacity, reduces the stresses at the adhesive interface and also decreases microleakage.^[5]

Glass ionomer liners have been used under composite restoration, which is referred to as lamination or the sandwich technique. Initially conventional cure glass ionomer cement was used, but failures occurred due to low cohesive strength and minimal bonding of glass ionomer to composites.^[6] Hence resin-modified glass ionomers that have better cohesive strength are

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avored as cavity liners under composite restorations.^[7] Bond strength of resin-modified glass ionomer to both the dentin and the resin composite is better than the conventional glass ionomer. The hydroxy ethyl methacrylate (HEMA) in the cement forms a chemical bond with resin composite, which is further improved by application of the resin bonding agent.^[8]

Flowable resin-based materials have been used as liners beneath composites due to their low viscosity, high elasticity and wettability. The first generation of flowable composites had same filler particles as that of microhybrid composites but with reduced filler content.^[9,10] Currently nano-filled flowable composites that have better physical properties are available. Due to its low viscosity and since it is a bond between two resin layers, flowable composite is expected to bond well with the more viscous resin composite.^[11] Contrary to this, Miguez *et al.*^[12] reported presence of gap formations between flowable and hybrid composite layers when observed under optical microscope. In a study done by Shawkat *et al.*,^[13] incremental bond strength between composite layers was dependent on the viscosity of the resin. The least viscous resins had low incremental bond strength. Moreover, the higher shrinkage of flowable composites indicates a potential for higher interfacial stresses.^[14]

While bond strength between dentin and the liner is an important criteria contributing to the clinical success of a composite restoration, the bond between the lining material and resin composite is also critical for the success of a restoration as loss of bond between the liner and composite would amount to failure of restoration. Bond strength of resin-modified glass ionomer liner to microhybrid composite has been studied earlier^[6,15,16] but it has not been studied comparing with bond strength of flowable composite to the composite restorative material, especially the currently available nanocomposites. The aim of the present study was to compare the shear bond strength of resin-modified glass ionomer and nano-filled flowable composite liners to nano-filled composite.

MATERIALS AND METHODS

Twenty four specimens were prepared using acrylic blocks for the study. A total number of 6 acrylic blocks was prepared using cuboidal aluminum mold of 50 mm × 60 mm dimension, which were polished with 220, 320 and 400 grit carbide polishing paper. In each block, four wells of 8 mm diameter and 2.5 mm depth were prepared by drilling hole in it. The acrylic blocks were divided into two groups with 12 specimens in each group.

Group I

The powder and liquid of resin-modified glass ionomer (Fuji II LC Improved, GC Dental Corp, Japan) was hand-mixed according to manufacturer's instructions. The wells were filled with light cure glass ionomer liner using a plastic filling instrument and covered with a glass plate to produce a smooth surface and permit light for curing the materials. The specimens were light cured for 20 s as per the manufacturer's recommendations. The glass plate was carefully removed to ensure that glass ionomer surface was smooth and not pitted. A total etch dental adhesive (Adper™ Single Bond 2 Adhesive, 3M ESPE, USA) was applied using a light brushing motion with the nylon bristled brush for 10 s, air thinned for 3 s and light cured for 20 s. Then a cylinder of nanocomposite resin (Filtek Z 350 Universal Restorative, 3M ESPE, USA) was added over the layer of resin-modified glass ionomer in increments of 2 mm and light cured for 40 s.

Group II

The wells were injected with nanofilled flowable composite (Filtek™ Z350 Flowable Restorative, 3M ESPE, USA) and covered with a glass plate to produce a smooth surface and permit light for curing the surfaces and light cured for 40 s. A cylinder of nanocomposite resin (Filtek Z 350 Universal Restorative, 3M ESPE, USA) was added and cured as in the previous group.

Light curing was done using Cool Blue™ LED (Milestone Scientific, Livingston, NJ, USA) with a light intensity of 400 mW/cm² for all the specimens. The cylinder of composite resin was made using a transparent polycarbonate ring of 5 mm internal diameter and 5.5 mm height. The composite was cured from all the sides to ensure complete curing of the material. After curing the polycarbonate ring was removed.

Bonded specimens were stored in distilled water at 37 ± 2°C for 24 h, followed by thermocycling (1500 cycles) in 5°C and 55°C water baths with 1 min dwell times, after which the specimens underwent shear bonding test. Shear testing of the bonded specimens was performed using a knife edge blade in Instron Universal Testing Machine (Model H 4206, Instron Corp) with a cross head speed of 1 mm/min and a maximum loading of 200 N. The acrylic blocks were positioned in the lower cross head. The long axis of the cylinder of the composite and lining materials was parallel to the direction of debonding force applied. The load required to fracture the specimen was determined by the electronic sensor on the graph.

Statistical analysis

The readings were tabulated in megapascals (MPa). Data was analyzed using SPSS for Windows release 11.5 (SPSS,

Chicago, IL, USA). The mean and standard deviation were calculated and both the groups were compared by using Student's unpaired or independent sample *t* test at a significance level of 0.05.

RESULTS

The mean shear bond strength value of resin-modified glass ionomer bonded to nanocomposite (Group I) was greater than that of flowable composite bonded to nanocomposites (Group II) (3.94 ± 0.19 and 3.22 ± 0.4 MPa, respectively). Statistical analysis using Student's independent sample *t* test for difference of means showed that the difference between two groups was significant ($P = 0.001$; $t = 5.632$) [Figure 1].

DISCUSSION

In this study, resin-modified glass ionomer cement showed significantly greater shear bond strength to nanocomposite than nanofilled flowable composites. Bonding between resin-modified glass ionomer and composite is chemical in nature due to availability of unsaturated double bonds in air inhibited layer of resin-modified glass ionomer cements. Unpolymerized hydroxyethyl methacrylate (HEMA) on the surface of GC Fuji II LC (Improved) increases the surface wetting capability of the bonding agent while unsaturated methacrylate pendants which are available in polyacid chain of the polymerized resin-modified glass ionomer cement form covalent bonds with the resin bonding agent. Cross-linking of polyacrylic acid during polymerization increases the strength of cement and ultimately adhesive bond strength to resin composite.^[6,17]

Due to low filler loading, flowable composites have greater elasticity and flexibility. As a result of these properties, flowable composites show better adaptation to the cavity walls and can compensate for polymerization shrinkage of resin composite restorative materials. However, they also undergo more volumetric shrinkage than composites of higher viscosity leading to interfacial stress build up between the two layers of composites. This leads to

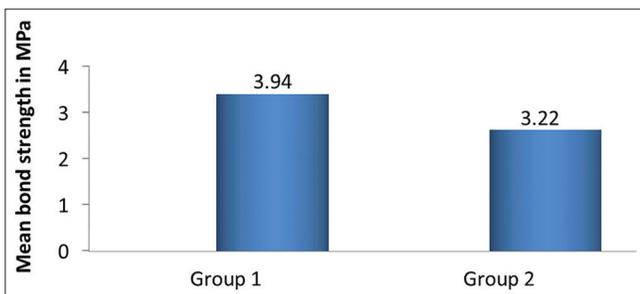


Figure 1: Mean shear bond strengths of resin-modified glass ionomer and flowable composite to resin composite

deflection of the overlying high modulus composite restorative material.^[5,14] Also, the residual polymerization contraction force of the flowable composite can offset the beneficial effect of low modulus of elasticity.^[11] This explains the lower shear bond values of the flowable composite group seen in this study. The increased amount of BisGMA/TEGDMA in the higher viscosity composites results in a dramatic increase in free radical concentration, which affects the reaction speed, where Rp_{max} is reached more quickly due to rapid onset of auto-acceleration.^[13] Thus the reaction speed of the nanocomposite may be greater than the nano-filled flowable composites leading to decrease in the formation of covalent bonds between two layers of composite.

In a study by Castaneda-Espinosa *et al.*,^[11] resin-modified liner showed significantly low polymerization contraction forces than flowable composite which was attributed to the lower modulus of elasticity of the resin-modified glass ionomer. This in turn results in less microleakage and better marginal adaptation also, as demonstrated in other studies.^[18,19] Though both resin-modified glass ionomers and flowable composites are known to undergo polymerization shrinkage, water uptake can act as a compensatory mechanism.^[20] In our study, the specimens were immersed in water for 24 h prior to shear testing. In clinical situation, the water source can be of pulpal origin or from the external environment when resin-modified glass ionomers are used as liners in open sandwich restorations.^[5,20] The compensation by hygroscopic expansion for polymerization shrinkage is slower in case of resin composites as compared to resin-modified glass ionomers as shown in a study by Versluis *et al.*^[21] The short period of water immersion in this study could have resulted in lesser scope for hygroscopic expansion of composites.

Different mechanical tests have been used to assess the bonding of restorative materials. Testing in shear mode is a relatively simple, reproducible and widely accepted test.^[22,23] Our study serves as a screening test for comparison of efficacy of bonding of resin-modified glass ionomer and nano-filled flowable composite to nanocomposite. In future, micro tensile or micro shear bond strength tests coupled with microscopic analysis of the fracture surfaces need to be carried out to produce a more consistent and complete description of the fracture process and modes of failure.^[24] Further studies are necessary to evaluate the effectiveness of adhesive cavity liners under nanocomposites.

CONCLUSION

Under the conditions of this study, bonding of resin-modified glass ionomer liner to nanocomposite restorative material is better than flowable composite liner.

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