Original Article

THE EFFECTS OF MECHANICAL STRESSES ON THE COMPARATIVE MICROLEAKAGE OF TWO DIFFERENT RESTORATIVE MATERIALS

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ABSTRACT

Objectives:

To assess the effects of lateral mechanical stresses on the microleakage of resin modified glass ionomer and polyacids modified composites.

Study design and settings:

It was a comparative cross sectional study carried out jointly by Department of Dental Materials, Nishtar Institute of Dentistry, Multan and Department of Dental Materials, University Medical & Dental College, Faisalabad.

Materials and methods:

Fifty healthy, unrestored, extracted premolar teeth were collected and then randomly divided into two groups. Class V cavities were prepared at the cemento-enamel junctions and these teeth were restored with Fuji II.LC (GC America) and Dyract (Dentsply), 25 teeth in each group. Teeth from each group were subjected to 8400 cycle of lateral fatigue forces (49 N) at the occlusal half of the clinical crown in a machine. All the teeth were placed in 2% basic fuchsin dye for 24 hrs at 37°C. Teeth were then embedded in cold cure acrylic resin, sectioned longitudinally in–ISOMETA, and the dye penetration at the enamel and cementum margin were scored at 10 X magnification Stereo microscope.

Results:

Distinct leakage patterns were recorded. There was very little difference between the microleakage score of two materials at their incisal margins. But microleakage difference was greater for these two materials on gingival margins of these restorations, where Dyract showing better results.

Conclusion:

Among these two materials tested, Dyract showed lesser microleakage than Fuji II.LC.

Keywords: Mechanical stresses, restorative materials, microleakage, dental materials

INTRODUCTION

The effects of mechanical loading especially the lateral occlusal forces on teeth could be a causative factor in the development of non-carious cervical lesions. Alternating compressive and tensile stresses created by the flexure of teeth in the cervical area can cause the enamel and dentine in this area to crack and slowly erode.[1,2]

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A recent photo elastic study found that a un restored cervical lesion concentrated the stresses of occlusal forces at the apex of the notch type lesions.[3] The same study indicated that the stresses at the apex of the notch were reduced following the restoration of the lesion but that new concentrations of force then develop in the area of the occlusal and gingival margins of the restoration. These stresses have an effect on the interface between the tooth and a restoration placed in the cervical lesion.[4]

Marginal Microleakage is a dynamic phenomenon, which allows an exchange of fluid and bacteria along the tooth restorative interface. Microleakage of oral fluid has been associated with post-operative sensitivity, pulpal irritation, pulp necrosis, and secondary caries.[5,6]

Dental amalgam has long been the restorative material of choice due to its ability to adequately fill cavities with self-sealing margins. However, Public concerns for esthetic dentistry and the potential of mercury leakage from amalgam has popularized tooth colored restoration like glass ionomers and composites.[7] These materials are capable of forming strong bonds to enamel and dentine, release fluoride over a prolonged period, have good bio-compatibility, and have a co-efficient of thermal expansion close to that of tooth structure.[8]

To overcome the problems of moisture sensitivity and low early mechanical strength associated with the conventional glass-ionomer cements and at the same time maintain their clinical advantages, some hybrid visions of glass-ionomer cement were introduced.[9]

Polymerization shrinkage of resin composites induce stresses at the tooth/restoration interface which disrupt the restoration/tooth bond, resulting in the formation of gaps at the interfaces with a chemically activated composite.[10] Hygroscopic expansion counteracts some of the shrinkage, but it does not eliminate gap-formation.[11] Temperature changes and biting forces also contribute to the stress induction at the tooth/restoration interface, However little attention has been given in laboratory studies to the effect of thermal and mechanical stresses on microleakage.

Aims and objectives:

To assess the effects of mechanical stresses (occlusal and lateral loads) on the marginal microleakage of resin modified glass ionomer cements and poly acids modified composite materials.

MATERIALS AND METHODS

This cross sectional comparative study was conducted jointly by Department of Dental Materials, Nishtar Institute of Dentistry, Multan and Department of Dental Materials, University Medical & Dental College, Faisalabad.

Fifty extracted human premolar teeth were randomly allocated in Group-I, II. This sample size was decided keeping in view the constraint of availability of sound extracted human premolar teeth.

Inclusion criteria

Healthy, un-restored human extracted premolar teeth.

Exclusion criteria

Grossly carious teeth, fractured, previous endodontically treated teeth.

Materials

1. Fuji II LC	*GC America*
2. Dyract AP	*Dentsply/Caulk*

Data collection procedure

All the teeth were scaled and cleaned with slurry of pumice flour and stored in distilled water. Facial class V cavities 2mm in height (occlusogingival), 4mm in length (mesiodistal direction) and 2mm in depth were prepared with a No.330 tungsten carbide burr in an air turbine at the cementoenamel junction (CEJ). Occlusal margins were cut in enamel and the cervical margins in cementum. These were divided into two groups.

Group-I: 25 teeth filled with "Fuji II LC glass ionomer".

Group-II: 25 teeth filled with "Dyract" compomer.

After 24 hours the teeth were finished to contour, flush with the cavosurface margins, with a No.7901 carbide finishing burr with air and water spray in a high speed handpiece and medium, fine and super fine Sof-Lex disks, which was first lubricated with water and used in sequence with air–water spray in a low speed handpiece.

All the surfaces, except the restoration and 1mm from the margins, were coated with 2 layers of nail varnish. Teeth were embedded upto 2mm apical to the cervical wall of the restorations in acrylic resin in an aluminum cylindrical mold. All specimens were then stored in 37^{o}C water for 7 days. All teeth were subjected to mechanical stresses before testing for microleakage. An intermittent force of 44N and 8400 cycles of lateral fatigue forces were applied at the occlusal half of the clinical crown in a machine specially designed for this purpose. The cyclic loading apparatus consisted of a belt-driven cylinder with two attached drums suspended above an adjustable specimen table (Fig. 1). Each drum had four polyethylene bumpers spaced equidistantly around the perimeter of the drum. The bumpers on the left drum were offset from those on the right drum. This allowed a time interval for recovery from each impact prior to the next impact. The specimens were loaded in a threaded chuck system on the specimen table and tightened into place. This offset allowed a loading force to be applied in buccal and lingual directions at a 0.020 inch displacement. At a static loading, the 0.020-inch offset was calibrated by electronic scales to be equivalent to approximately 44N of force.

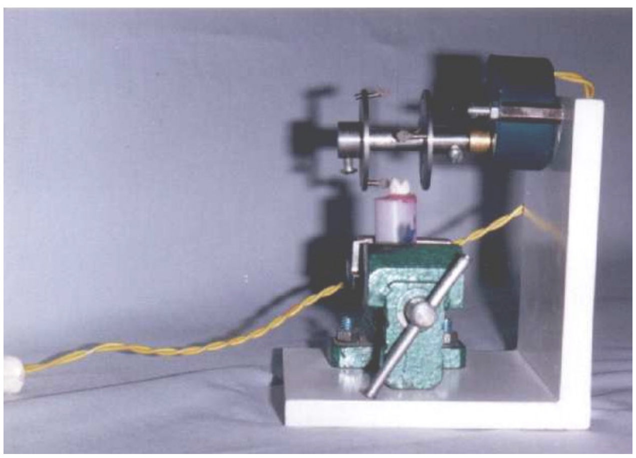

Fig. 1. Cyclic loading apparatus used to apply lateral fatigue forces to cervical resin modified glass ionomer and composite restorations.

With the specimen in a fixed position, the drums rotated and contacted either the buccal or lingual surface of the specimen, thus cyclically loading the specimen in the buccal and lingual directions. The specimen recovered under no load and was then loaded from the opposite direction. One rotation of the drum represented four complete buccal force-recovery lingual force-recovery cycles. The drum rotated at 35 rpm, which allowed a recovery time of 0.14 seconds between each impact. Each specimen was subjected to approximately, 400 cycles and then removed.

All the teeth were immersed in a solution of 2% basic fuchsin dye for 24 hours at room temperature. After removal of specimen from the dye solution, the superficial dye was removed with pumice slurry and rubber cup. Then teeth were mounted in a transparent resin to facilitate handling during sectioning, teeth were sectioned longitudinally with a low speed diamond saw using glycerine water irrigation in 6.0mm thick sections to evaluate die penetration. The sections were separated and the cut surfaces corresponding to the most mesial, central and the most distal portion of the tooth restoration interface were examined at the occlusal and gingival margin with a light-microscope at x10 magnification.

The presence of dye penetration at the interface of the restorative material and the tooth was considered as an indicator of marginal microleakage. Degree of microleakage at the occlusal and cervical margins was represented from 0-3 degree.

Degree 0	No penetration of dye
Degree 1	Penetration of dye along the occlusal or cervical wall limited to enamel
Degree 2	Penetration of dye less than the entire length of occlusal or cervical wall but not along the pulpal wall
Degree 3	Penetration of dye along the pulpal wall

Data analysis

SPSS version 17 was used for computation analysis of the data.

Means and SD for Microleakage in both groups was calculated using One-way ANOVA test.

In Table 1 Incisal and Gingival microleakage score of both Fuji II. LC and Dyract were shown after the application of lateral mechanical stresses and in Table 2 mean standard deviation and standard error of both materials and their P-value was calculated. There was very little difference between the microleakage score of two materials at their incisal margins. But microleakage difference was greater for these two materials on gingival margins of these restorations, where Dyract showing lesser microleakage. On comparison of microleakage of individual materials on these two different locations, Fuji II shows greater microleakage.

Table 1. Microleakage frequency score (by using mechanical stresses)

Material	Occlusal				Gingival			
	0	1	2	3	0	1	2	3
Fuji II LC n=22	9	6	3	4	8	6	4	4
Dyract n=23	10	6	4	3	7	6	6	3

Table 2. Mean microleakage.

Material	Occlusal			Gingival		
	Mean	*Std. Dev.*	*Std. Error*	Mean	*Std. Dev.*	*Std. Error*
Fuji II	0.66	0.25	0.053	0.80	0.27	0.057
Dyract	0.60	0.25	0.052	0.60	0.19	0.039
	p = 0.04			p = 0.012		

When these values were compared with microleakage scores of materials tested without application of mechanical stresses.[12] There were marked differences of leakage values both at incisal and gingival margins, showing the effect of mechanical stresses upon the tooth restoration interface.

From these two products evaluated after application of lateral mechanical stresses, Fuji II.LC glass ionomer cement revealed greater microleakage as compared to the Dyract resin composite, especially at the gingival margins. This is in contrast to the earlier work done without mechanical loading and with application of thermal cycling baths, where Fuji II.LC GIC shows lesser mean micro-leakage on the gingival margins.[12]

DISCUSSION

A large variety of methods have been described to compare the sealing efficiency of restorative systems.[13] However, Dye penetration tests are usually used because they are generally simple and fast methods.[14]

There is evidence that restorative materials may not bond to enamel or dentine with sufficient strength to resist the forces of contraction on polymerization, wear, mechanical loading or thermal cycling. When debonding occurs, bacteria, food debris or saliva may be drawn into the gap between the restoration and the tooth by capillary action resulting in microleakage.

Polymerization shrinkage of resin–containing restorative material may result in marginal discrepancies that lead to microleakage, marginal discoloration and sensitivity.[15]

Hygroscopic expansion can compensate, to some degree for polymerization in shrinkage.[16] Attin *et al.*[17] reported that Fuji II.LC glass ionomer cement expanded after curing and immersion in water, whereas Dyract resin composite and Vitremer glass ionomer cement revealed a total volumetric loss. Thus, they concluded that water expansion is one factor that may reduce the leakage. Our results partially agree with those of Yap *et al.*[18] who compared the microleakage of Dyract resin composite and Fuji II.LC glass ionomer cement and reported no statistically significant differences in microleakage score. Thermocycling causes contraction and expansion of the tooth and the restoration and because they have different co-efficient of thermal expansion, the adhesion between them may be broken.[12,19]

Mitra and Conway[20] reported that Fuji II.LC and Vitremer materials had co-efficient of thermal expansion of 31.5 and 11.5 PPM/^{o}C respectively, and silux plus microfilled composite 56.6 PPM/^{o}C. Dyract has a co-efficient of thermal expansion of 40.52 PPM/^{o}C. Also, because the resin component of the material adheres poorly to the cervical dentine than to enamel. This justify in part, that Dyract resin composite revealed more leakage at the gingival margin than at the enamel margin.

Qvist[21] showed that 71% of buccal and lingual class V restoration on third molars with antagonists showed evidence of bacterial penetration, while those with no antagonists showed only 25 bacterial penetration.

Almost all of the specimens showed some signs of staining caused by leakage. This may have been the result of contraction shrinkage during curing, which caused the resin to pull away from the cavo surface margin. Out study was designed to specifically investigate the effects of tooth flexure created by lateral cyclic loading on the amount of microleakage observed in cervical lesions restored. A restorative material with a low modulus of elasticity is usually considered to be more flexible and thus may be able to absorb some of the stress induced by the tooth flexure. This absorption could, theoretically, decrease in the amount of microleakage or debonding created by those forces.

A significantly greater amount of microleakage occurred at the dentine resin margin than at the enamel-resin. This difference was observed in both the specimens that were subjected to cyclic loading and those that were not. The flexural strength (at 24 hours) of resin modified glass ionomer is 25-60 MPa. It is clear that some of the weaker resin-modified glass ionomers are only marginally stronger than the conventional glass ionomer products. Similarly the flexural strength of Dyract AP (24 storage in water) is 9000ñ500 MPa.

No restorative material evaluated in our study completely resisted microleakage at the occlusal or gingvail walls of the tooth. Fuji II.LC glass ionomer cements revealed a statistically significant difference in microleakage with Dyract resin composite at gingvail margin. This leakage was likely the result of gaps created from the shrinkage of the resin during polymerization, with the amount of shrinkage directly related to the amount of the resins present in the material and adhesion of the material to the tooth.[9] The amount of resin in the final set restoration is between 4.5 to 6%, such as for Fuji II.LC and Vitremer glass ionomer cements. Dyract polyacid modified resin composite having a resin content of approximately 28%.

Because the resin component is responsible for the polymerization shrinkage, and Dyract resin has more resin than Fuji II.LC glass ionomer in its composition, it is possible that this is the reason for the greater microleakage at the gingival margin with Dyract resin composite. Another possibility for the compomer exhibiting more gingival leakage was the fact that the dentine was primed but not etched with phosphoric acid following the manufacturer's instructions. In a study, comparing etched and non-etched human molar dentin in trapezoidal class V restorations, the etched Dyract AP specimens demonstrated significantly less microleakage compared to the non-etched Dyract AP ($P<0.05$).[22]

The microleakage scores for Vitremer glass ionomer cement is even more than the Dyract AP resin composite which could be due to two reasons. Fuji II.LC is a resin modified glass ionomer in which the HEMA content is merely blended with a polyalkenoic acid liquid, whereas Vitremer, in addition to being a simple mixture of HEMA with polyalkenoic acid, is also modified by the attachment of polymerizable methacrylate side groups.[23] It is possible that Vitremer has more polymerizable resin that Fuji II.LC.

Uno *et al.* considered that difference observed between Vitremer and Fuji II.LC glass ionomer cements might be due to differences in maturation of setting reactions. Some authors have pointed out that significant dimensional changes and surface hardening can occur after initial light curing of the resin component of resin-modified glass ionomer and further contraction continue for the first 24 hours as the material matures.[24]

Although the results obtained from this study may not be directly extrapolated to the clinical situation, they provide some information regarding the performance of the restorative system. *In vitro* microleakage testing of dental materials is a commonly accepted evaluation technique of margin integrity. The practice of thermocycling specimens in hot/cold baths and lateral cyclic loading by a machine simulates thermal and fatigue stresses in the oral environment. Although every effort is made to model an in-vivo setting, thermocycling and mechanical loading does not totally equate to clinical durability. The present study adhered to procedures followed in previous in vitro microleakage studies laboratory studies attempts to reproduce clinical situation but not entirely reflect variables encountered with in-vivo performance.

CONCLUSION

None of the restorative materials tested completely sealed the tooth/restoration interface at cervical margins.

Significant more microleakage is observed in both material after lateral cyclic loading.

The Fuji II.LC showed greater microleakage than the Dyract composite resin tested especially at gingival margin under the effect of thermocycling and mechanical loading simulated to oral environment.

The amount of resin content of the material may influence the degree of microleakage.

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