ORIGINAL ARTICLE

Micromechanical Intervention in Sandwich Restoration

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ABSTRACT

Objective: To evaluate the sealing ability of two different types of Glass Ionomer Cements (GICs) used for sandwich restorations and assess the effect of acid etching of GIC on microleakage at GIC-resin composite interface.

Study Design: Experimental study.

Place and Duration of Study: Department of Operative, DIEKIOHS (DUHS) and NED University, Karachi, from February to June 2011.

Methodology: Eighty cavities were prepared on the proximal surfaces of 40 permanent human premolars (2 cavities per tooth), assigned to 4 groups (n=20) and restored as follows: Group CIE - Conventional GIC (CI) was applied onto the axial and cervical cavity walls, allowed setting for 5 minutes and acid etched (E) along the cavity margins with 37% phosphoric acid for 15 seconds, washed for 30 seconds and dried; the adhesive system was applied and light cured for 10 seconds, completing the restoration with composite resin light cured for 40 seconds; Group CIN - same as Group CIE, except for acid etching of the CI surface; Group RME - same as CIE, but using a resin modified GIC (RMGIC); Group RMN - same as Group RME, except for acid etching of the RMGIC surface. Specimens were soaked in 1% methylene blue dye solution at 37ºC for 24 hours, rinsed under running water for 15 minutes, bisected mesiodistally and dye penetration was measured following the ISO/TS 11405-2003 standard. Kruskal Wallis and post Hoc tests significant differences in the microleakage among all the four groups.

Results: There was a significant difference between the two groups of GICs (RMGIC and CI, p=0.001). There was no significant difference in between the two sub-groups that is between CIN and CIE (p=0.656), and between Groups RME and RMN (p=0.995).

Conclusion: Phosphoric acid etching of GIC, prior to the placement of composite resin, does not improve the sealing ability of sandwich restorations. RMGIC was more effective in preventing dye penetration at the GIC-resin composite dentine interfaces than CI.

Key Words: *Glass ionomer. Microleakage. Sandwich technique.*

INTRODUCTION

Chemical adhesion in dentistry has been groomed up by Acid Etchiing Technique.[1] Through this the issue of bonding of dental materials to enamel has been solved but to dentine is still more difficult.[1] In the 1970s, Dennis Smith developed the first chemically adhesive dental cement, called polycarboxylate cement.[2] Later, Wilson, Crisp, and McLean derived glass ionomer cement from silicate cements.[3] GIC has been classified into two broad categories of chemical cure – GIC and resin modified dual cure.[4]

The advantages of Resin Modified Glass Ionomer Cement (RMGIC) include improved tensile and compressive strength compared to Zinc Phosphate (ZP) and GIC and resistance to water contamination during initial setting reaction compared to GIC.[5] Disadvantages include that RMGIC is hydrophilic[6] that leads to water adsorption and hygroscopic expansion lead to crack formation, cement deterioration and leakage.[6,7]

Sandwich restoration or "composite-laminated GIC" technique has been used in class 1,2,5 cavities,[8-10] with composite materials for large restorations on both vital and endodontically treated teeth.[8,9] The main purpose for using this technique is not only to provide base against thermal, and chemical insults to the pulp but also to reduce the polymerization shrinkage of composite by reducing the bulk of restorative material.[2,3,8] There are two types – closed and open sandwich techniques. When a glass ionomer is placed in an area where there is no contact with the cavosurface of the preparation and the material is completely covered with the restorative material, it is called closed technique while open is vice versa.[8] According to manufacturers' instructions, both conventional and resin-modified GIC may be used for this purpose.[4,11] GIC provides a floor for etching thereby protect the pulp. Strength is improved as polymerization shrinkage of composite has been reduced by reducing bulk of material. Fluoride release prevents recurrent caries. Chemical bonding is available for the tooth substance.[12]

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Received: July 28, 2012; Accepted: September 03, 2015.

Though it is widely known that early GIC is sensitive to water imbalance during setting, there is a certain controversy regarding this issue with current GIC.[9] Due to this controversy, a clinical dilemma exists among dental practitioners when using GIC in combination with total-etch adhesives prior to composite placement.[1,6,9] This dilemma is not about the acid but rather water rinsing afterwards. Simply, some practitioners are not convinced that GIC should be exposed to water so early after the setting (3 minutes) or for immediately after light curing of resin modified GIC.[6,9,11]

The rationale of this study was to evaluate the sealing ability of different GIC materials used for the sandwich restoration technique and the effect of acid etching of GIC surface on microleakage between the glass ionomer and composite materials. The tested hypothesis was that the acid etching of GIC before the placement of the composite resin does not increase the sealing between both restorative materials.

The objective of the study was to compare the effect of acid etching on microleakage in the two types of glass ionomer cements when used in sandwich technique.

METHODOLOGY

Forty extracted non-carious human permanent pre-molars and molars with fully developed roots were randomly selected for this experimental designed study conducted at Department of Operative, DIEKIOHS (DUHS) and NED University, Karachi, from February to June 2011. Teeth with enamel cracks or fractures along with their crown aspect, dental pathology, malformations, carious lesions, restorations or erosions, attritions, were excluded. The teeth were cleaned of calculus, soft tissue and other debris, and stored in 2% chloramine solution at 5ºC for three months. Two window-like cavities were prepared on both proximal surfaces of each tooth using small diamond bur (s801 Swiss Tech) at high speed, in such a way that has height of 5 mm, width 3 mm, and depth of 2 mm.

The tested materials included a conventional GIC (CI) (Vitro Fill, DFL, BRAZIL), a light-cured RMGIC (Vitremer; 3M-ESPE, St. Paul, MN, USA), an Adhesive System (AS) (Adper Single Bond; 3M-ESPE, St. Paul, MN, USA) and a Composite Resin (CR) (Filtek Z250; 3M-ESPE, St. Paul, MN, USA).

All materials were handled at room temperature (23ºC) following the manufacturers' instructions. The 80 cavities were randomly assigned to 4 groups (n=20) and restored according to the sandwich technique. Both open and close techniques were used in such a way that below CEJ it was open while above CEJ it was closed sandwich technique. The experimental groups were as follows:

In group CIE (conventional GIC with etchant), CI were applied onto the axial and cervical cavity walls, allowed setting for 5 minutes and acid etched (E) along the cavity margins with 37% phosphoric acid for 15 seconds, washed with air-water spray for 30 seconds, and blotted with an absorbent sponge. The AS was applied and light cured (Blue Dent LED, Power Smart, China) for 10 seconds, completing the restoration with a layer of CR that was light cured for 40 seconds.

In group CIN (conventional GIC without etchant), CI were applied onto the axial and cervical cavity walls, allowed setting for 5 minutes. The AS was applied and light cured (Blue Dent LED, Power Smart China) for 10 seconds, completing the restoration with a layer of CR that was light cured for 40 seconds.

In group RME (light-cured RMGIC with etchant), Vitremer primer were applied, left for action for 30 seconds, air-thinned and light-cured (Blue Dent LED, Power Smart, China) for 20 seconds. Powder and liquid were mixed at a 1:1 ratio and applied onto the axial and cervical cavity walls and cured for 40 seconds. Acid etched (E) along the cavity margins with 35% phosphoric acid for 15 seconds, washed with air-water spray for 30 seconds, and blotted with an absorbent sponge. The AS were applied and light cured (Blue Dent LED, Power Smart, China) for 10 seconds, completing the restoration with a layer of CR that was light cured for 40 seconds.

In group RMN (light-cured RMGIC without etchant), Vitremer primer were applied, left for action for 30 seconds, air-thinned and light-cured (Blue Dent LED, Power Smart, China) for 20 seconds. Powder and liquid were mixed at a 1:1 ratio and applied onto the axial and cervical cavity walls and cured for 40 seconds. The AS was applied and light cured (Blue Dent LED, Power Smart, China) for 10 seconds, completing the restoration with a layer of CR that was light cured for 40 seconds.

All restorations were polished with Sof-Lex discs (Polishing Discs, 3M-ESPE, St. Paul, MN, USA). Teeth were coated with 3 layers of nail varnish, except for a window area that included the restoration and 1 mm around it, and soaked in 1% methylene blue dye solution at 37ºC for 24 hours, then rinse under running water for 15 minutes.

The teeth were bisected longitudinally and mesiodistally using carborandum disk. In this way, 1-mm-thick slices were obtained within the restored area giving 4 surfaces for inspection; two sides above the Cementoenamel Junction (CEJ) and 2 below the CEJ. Therefore, 4 surfaces per restoration were examined in a stereo-microscope (Metcom, Japan; magnification 15X) for marginal sealing and leakage (40 surfaces per group).

Representative images were recorded from all specimens and maximum degree of dye penetration was registered according to the following scores (ISO/TS 11405-2003).[13]

O = no dye penetration; 1 = dye penetration into the enamel portion of the cavity wall; 2 = dye penetration into the dentin portion of the cavity wall but not including the pulpal floor of the cavity; 3 = dye penetration including the pulpal floor of the cavity.

For computing sample size mean was evaluated from a previous study, and was put in the software using 95 confidence level and power of test as 80.

The data were statistically analyzed using SPSS version 16. Microleakage scores were analyzed per section side given 2 scores for each tooth. Level of significance was 0.05. As *Scores* were counted so the data was expressed as median (IQR). Shapiro Wilk test were performed to understand the test for normality. This test revealed $p < 0.001$ which indicated that the data was not normally distributed. Kruskal Wallis test was then used for determining if there were any significant differences in the microleakage among all the four groups.

RESULTS

The test found significant difference between the two groups of GICs (RMGIC and CI, $p < 0.001$) as shown in Table I. Tukey test revealed no significant difference between the two sub-groups, CIN and CIE (p=0.656), and between groups RME and RMN (p=0.995).

Table I: Comparison of microleakage between the groups.

Material	Microleakage* Median (IQR)	p-value b/w materials
CIE	3.0000 (0.00)[a]	< 0.0001
CIN	3.0000 (0.00)[a]	
RME	0.0000 (1.00)[b]	
RMN	0.5000 (1.00)[b]	

**Different letters imply significant difference between pair-wise groups.*

DISCUSSION

Polymerization shrinkage is one of dental clinicians' main issues when placing direct, posterior, resin-based composite restorations.[3] Although improvements have been made with resin-based composite materials, dental adhesives, filling techniques and light curing, but shrinkage problems remain.[3,4,10,14] To overcome this problem, use of GIC has been made as an under-filling material in conventional sandwich restoration that reduces considerably the bulk resin composite, thus the amount of polymerization shrinkage of the composite resin is decreased and the marginal adaptation may be improved.[7,8,15]

The so-called sandwich technique was used in this study using GIC as dentine replacement and a composite to replace enamel. It is only necessary to etch a GIC with acid if the restoration has been in place for some time and has fully matured that was why 5 minutes were given for conventional to set.

Both the closed and open techniques were used in this study. Open sandwich restorations shows better result in chapters of microleakage when we used RMGIC. But the closed technique is superior when conventional GIC has been applied as for carpeting dentine.[16]

The two main defined methods that are usually used to understand marginal gaps are either dye penetration[12,17] or Scanning Electron Microscopy (SEM). In dye penetration testing, which is one of the most common methods of assessing microleakage, the sample is subjected to a dye marker such as methylene blue, basic fuchsin silver nitrate, and rarely india ink; however, concerns have been raised, as there is lack of evidence supporting any correlation between clinical testing and *in vitro* dye penetration testing.[18] Similarly, SEM requires that the sample be subjected to multiple chemical preparations before the scanning process and this may lead to alteration or even destruction of the interfacial zones, and even under-estimation of the actual thickness of the hybrid layer.[19,20]

The bond strength between GIC and composite is influenced by, at least, four factors. The tensile strength of GIC is mostly dependent on the powder/liquid ratio. The viscosity of the bonding agent and its ability to wet the GIC's surface is the second factor. The others are the volumetric change in the composite resin during polymerization and the difficulties in packing and adaptation of the composite resin to the GIC without incorporation of voids.[6,7]

The value of tensile bond strength of GIC has been reported between 1 - 3 MPa. This can be further increased by acid conditioning to dentine followed by and application of a dilute aqueous solution of $FeCl_3$. Beside tooth substance, GIC can be well bonded to enamel, stainless steel, tin oxide - plated platinum and gold alloy.[21]

Regarding limitation of this study, we did not thermocycled the sample teeth rather than just incubate them 24 hours at 37ºC.[17,22,23] Thermocycling is a process used to reproduce the different temperatures to which the teeth are subjected during eating and drinking under clinical conditions.

As it was an *in vitro* study, its results would not be essential to translate to clinical practice, as the studies have found a very weak correlation between *in vitro* and clinical trials, and therefore, continuation in the form of clinical trials is required, to form clinically relevant conclusions.[24,25]

CONCLUSION

Sealing ability of sandwich restorations was independent to the etching of GIC prior to the placement of composite. RMGIC produced significantly less dye penetration than the conventional one, suggesting that RMGIC is more resistant to microleakage at the interface of sandwich.

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