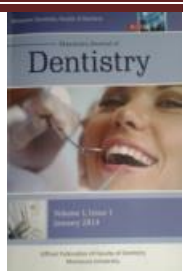
# *Influence of different surface treatments on shear bond strength of a highly viscous glass ionomer cement bonded to a nanocomposite filling material using sandwich technique*

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***Abstract:***
**Aim of study: This study aimed to evaluate the influence of different surface treatments on shear bond strength of a highly viscous glass ionomer cement bonded to a nanocomposite filling material using sandwich technique.**
**Materials &Methods: Sixty specimens (n=60) of a new HVGIC were divided into three main equal groups according to surface treatment protocols, group I (control): was treated with total etch adhesive, group II was treated with sandblasting with Al2o3 particles, group III was treated with sandblasting with Al2o3 and total etch adhesive. After surface treatment in all groups nanofilled composite resins were applied. Shear bond strength has been evaluated by using universal testing machine. The data were statically analyzed. Scanning Electron Microscope (SEM) was used to examine the mode of failure.**
**Results: The highest mean shear bond strength value was for group III with a significantly difference from group I (control) which showed lowest mean value. High incidence of mixed failure (adhesive-cohesive failure) was demonstrated among I & II groups. The predominant mode was cohesive failure in group III.**
**Conclusion: sandblasting with Al2o3 and total etch adhesive was the most effective technique to treat glass ionomer surface in sandwich technique..**

## *Introduction*

Glass ionomer cements (GICs) have advantages over other restorative materials such as chemical adhesion to tooth structure, fluoride release, coefficients of thermal expansion and contraction similar to dentin, high biocompatibility, protective and remineralizing action on dental tissues. Highly viscous glass ionomer cements (HVGICs) have gained popularity in dentistry, especially in pediatric dentistry. Where this material is considered an applicable option to restore dental caries lesions. Additionally, they may facilitate the tooth restorative procedure and enable the dentine-pulp complex to react against the caries process.1-4

Nanohybrid and nanofilled composites provide a more highly filled and polishable composite materials that can be used in the posterior region as well as aesthetic areas of the oral cavity. These materials are produced with nanofiller technology and formulated with nanomer and nanocluster filler particles.5 The sandwich or "composite-laminated GICs" technique employs the bonding ability of GICs to seal the cavity floor, prevent microleakage and enhancing clinical servicing. In class II and class V resin composite restorations, it is recommended to use GICs liner at the gingival floor, particularly when the margin is extended to the root surface.6-10

The success of the sandwich technique depends on the strength of the bond between the GICs and the resin composite materials in addition to the strength of the bond between the GICs and dentin. HVGICs have the advantages of the glass ionomer family (i.e., fluoride release, hydrophilic nature, and chemical adhesion to dental tissues), enhanced mechanical and wear properties and promising clinical results as permanent filling. These characteristics may be useful when implementing a sandwich technique11-14

The aim of this study is to evaluate the influence of different surface treatments on shear bond strength of a highly viscous glass ionomer cement bonded to a nanocomposite filling material using sandwich technique

Materials & Methods

Table 1: Materials used in the study, their composition and manufacturer.

| Materials | Patch number | Composition | Manufacturer |
|---|---|---|---|
| Equia Forte Fil Bulk Fill Glass Hybrid Restorative A3 | Powder/Liquid ratio(g/g) 0.40/013.(0.10 mL) per capsule | 180424A | Traditional Glass Ionomer Structure, poly acrylic acid and calcium fluoro-alumino silicate glass base with highly reactive fluoro-alumino silicate filler (< 4Mm). | GC Corporation Tokyo, Japan |
| Filtek TM Z350 XT Universal Restorative A3.5 Body Shade 4g | Nanofilled composite | N992231 | Bis-GMA, UDMA, TEGDMA, PEGDMA and bis-EMA resins. All shaded are radiopaque. The fillers are a combination of non-agglomerated/ non-aggregated 20 nm silica filler, a non-agglomerated/ non-aggregated 4-11 nm zirconia filler, and an aggregated zirconia/ silica cluster filler (comprised of 20 nm silica and 4-11nm zirconia particles). The Body shades have an average cluster particle size of 0.6 to 20 microns. The inorganic filler loading is about and 78.5% by wt (66.3 %by volume). | 3M ESPE 2510 Conway Avenue St. Paul, MN 55144-1000 USA |
| Adper TM Single Bond 2 Adhesive 6g | Fifth generation | Etch and rinse Adhesive system | N980585 | Bis-GMA, HEMA, dimethacrylates, ethanol, water, a novel photoinitiator system and a methacrylate functional copolymer of polyacrylic and polyitaconic acids10% by weight of 5 nanometer-diameter colloidal filler. | 3M ESPE 2510 Conway Avenue St. Paul, MN 55144 USA |
| Scotchbond™ Universal Etchant – Etching gel | 3 ml Syringe | 635389 | 34% phosphoric acid with a pH of approximately 0.1 | 3M ESPE 41453 Neuss-Germany |

Methods:

I. preparation of specimens

Sixty specimens (n=60) were fabricated in acrylic blocks (2.5 x 2.5). First, a central hole was created at the top of each acrylic block, presenting with (3mm height x 6 mm diameter). Equia forte fil bulkfil glass hybrid restorative capsule was shaked on a hard surface to loosen the powder, then it was activated by pushing the plunger until it flushed with the main body, immediately the capsule placed into a metal applicap capsule applier (3M, ESPE, ApplicapTM/ MaxicapTM, LOT 57316) and click the liver once. After that, the capsule was removed and set on amalgamator for 10 s according to the manufacturer's instruction.

Then, the mixed capsule was removed from the amalgamator and loaded into a capsule applier, two clicks to prime the capsule then injected into the hole of the acrylic block. The excess of GIC was removed by celluloid strip. After that, each sample was visually inspected to ensure adequate surface integrity with no physical defects.15 Specimens were divided into three groups, according to surface treatment protocols:

Group I: Total etch adhesive (control group).

Group II: Sandblasting with aluminum oxide particles.

Group III: Sandblasting with aluminum oxide particles& total etch adhesive.

Group I: Total etch adhesive

Specimens of group I (n=20) have been treated with scotchbondTM universal etchant for 15 s then rinsed with air-water spray for 30 s and blotted excess water with a moist cotton pellet to prevent dehydration of the specimens before bonding.16

Group II: Sandblasting with aluminum oxide particles

Specimens of group II (n=20) were sandblasted with microJato (microblaster, bio-art, plus, SN-3887), aluminium oxide ($Al_2O_3$ particles, mean particle size 50 µm) at a pressure of 2 psi for 15 s and kept at a distance about 10 mm between the face of the microblaster needle tip and the surface of glass ionomer during blasting. After sandblasting, all samples were rinsed under running water for 30 s then air dried.17

Group III: Sandblasting with aluminum oxide particles& total etch adhesive

Specimens of group III (n=20) were sandblasted ($Al_2O_3$ particles, mean particle size 50 µm) at a pressure of 2 psi for 15 s and kept at a distance about 10 mm between the face of the microblaster needle tip and the surface of glass ionomer during blasting. After sandblasting, all samples were rinsed under running water for 30 s and air dried. Then, treated with scotchbondTM universal etchant, for 15 s and washed with air-water spray for 30 s and excess water was blotted with a moist cotton pellet to prevent dehydration of the specimens before bonding.

II. Application of nanofilled composite resin

In Group I, II and III after surface treatment and before applications of nanofilled composite resin. First, adhesive adper TM single bond 2 adhesive was applied to all specimens in each group immediately according to manufacturer´s instruction for 15 s with gentle agitation using a fully saturated applicator. Then, it was mildly air-dried and light-cured for 10 s. Then nanofilled composite was applied to the surface of

glass ionomer. The composite was applied in tefflon mold with (3mm height x 6 mm diameter). Each tefflon mold was filled with two increments of nanofilled composite, then light cured for 40 s. The specimens were all stored in distilled water for 24 hours at room temperature. After that, teflon mold was removed as shown in.15

III. Shear bond strength testing and failure mode determination

For SBS test, thirty specimens (10 specimen from each group) were stored in distilled water for 24 hours at room temperature. SBS was evaluated using a chisel-shaped rod of the Universal Testing Machine (LKOYDX Instrument) at a crosshead speed of 1 mm/min until failure occurs. The force at failure was recorded in Newtons (N); then, SBS values were calculated in MPa. After the test, the failure modes of each specimen on both surfaces, were evaluated under a stereomicroscope (TUCSEN, USB2.0 H Series. OLYMPUS SZ61) at (X 1.2) magnification.

The fractured specimen from each group was further sputter-coated with gold Sputter Coating Evaporator and examined using SEM and by energy dispersive x-ray analysis for the SEM (Oxford X-Max 20) at magnification (X 80).18

Results

The results showed that mean SBS value was higher in group III (6.17±0.303) Mpa, followed by group II as it was (4.75±0.15) Mpa ranged from 4.47 to 4.99 Mpa. On the other hand, the lower value was observed group I (4.07±0.23) Mpa as showen in (table 2) and (figure 1). One-way ANOVA showed that there was statistically significant difference observed between the studied groups (p value <0.05).

Mode of failure

Failure mode and the number of occurrences are presented in (table 3) and (figure 2-4). Three types of failure were observed in this study in composite- glass ionomer interface adhesive failure, cohesive failure and mixed failure. The predominant mode was mixed failure in group II and group I in percentage (50%). On the other hand, the predominant mode in group III was cohesive failure in percentage (60%).

Discussion

The results of this study confirmed that, the combination of sandblasting with acid etching provides greater SBS than either acid etching or sandblasting alone.19 The roughness of the surface left after sandblasting with aluminum oxide (Al2O3 particles, mean particle size 50 μm) (group II ) was much higher than the chemical dissolution effect induced by acid etching (group I). Also, in the current study, the highest value of bond strength between HVGICs and composite resin was found after surface treatment by both sandblasting and acid etching in group III. This can be explained by the ability of acid etching and sandblasting to increase the surface roughness parameters and hence SBS values.

These results were in accordance with Suma S, et al19 Wiechmann D20 Canay S, et al21 Türköz C, et al22 and Cal-Neto JP23 and who stated that Al2O3 sandblasting combined with phosphoric acid etching had significantly higher bond strength values when compared to either etching or sandblasting alone. The sandblasting procedure creates irregularities in the surface that could enhance the mechanical interlocking effect, increasing the surface area and therefore, increasing the total surface energy. However, acid etching results in modifications of the organic matter and decalcification of the inorganic component of enamel. Acid etching is a form of micro-etching, whereas sandblasting can be regarded as a form of macro-etching. Sandblasting was used to remove unfavorable oxide and contaminants, and the resulting increased surface roughness proved convenient for bonding.

On the other hand, these finding disagrees with Brosh T, et al24, Pakshir HR, et al25 who stated that The combination of sandblasting and acid etching did not improve the bonding. This could be attributed to the irregularities that appeared when sandblasting was added before etching which may cause air pockets between the surface and the etching agent and negated the theoretical retention-increasing effect of the sandblasting procedure. Also, the explanation for the previous disagreement with these studies may be due to the sandblasting procedure which was done at different pressures which ranges from 60-80 psi and at different time 3-5 s, while at this study sandblasting was done at pressure of 2 psi for 15 s.

SEM observations showed relative irregularities of the cement surfaces after surface treatments with etching after sandblasting when compared to specimens after surface treated with sandblasting or acid etching and before surface treatment. The data of the present study were in agreement with Suma S, et al19 which showed that sandblasting followed by acid etching resulting in increased surface roughness which proved convenient for bonding and produce surfaces with adequate bond strength. Acid etching alone results in significantly low bond strength when compared with the combination between sandblasting and acid etching.

Regarding the failure mode, three types of failure were detected; adhesive failure at the GIC-adhesive interface, cohesive failure at the composite-adhesive interface and mixed adhesive-cohesive failure with resin remaining on both components after de-bonding. The site of fracture was assessed by measuring the percentage of adhesive material adhering to both the GICs and composite resin interfaces (table 3) and (figure 2-4). The predominant failure mode was mixed failure in group I in percentage (50%) with dominant adhesive failure in GICs in percentage (40%). While in group II was mixed failure in percentage (50%) with dominant cohesive failure in GICs in percentage (30%). On the other hand, the predominant failure mode in group III was cohesive failure in GICs percentage (60%) and mixed failure in percentage (30%).

The cohesive failure pattern of cements was the predominant failure mode in group II & III, which demonstrated the positive effects of these surface treatments in improving the mechanical adhesion between GIC and composite resin.

These results were agreed with Otsuka E, et al26 who demonstrated that when fracture modes shifted to cohesive failure, it demonstrates the positive effects of these surface treatments in improving the mechanical adhesion between GIC and composite resin. Surface irregularities of GICs with acid etching or sandblasting were observed, all of the fracture modes shifted to cohesive failure in cement for both groups,

which demonstrates the positive effects of these surface treatments in improving the mechanical adhesion between conventional GIC and composite resin. These results were also in accordance with Suma S, et al19 who stated that the combination of sandblasting with acid etching provides greater SBS when compared to acid etching alone. It demonstrated that acid etching group to enamel showed the lowest mean shear bond strength on de-bonding and that fracture modes shifted to adhesive failure. While, in sandblasted & acid etched group the failure modes shifted to cohesive and showed the highest mean shear bond strength on de-bonding.

Table 2. Mean and standard deviation of shear bond strength values (Mpa) for studied groups.

| Shear bond strength | Etching group (n=20) | sandblasting group (n=20) | sandblasting & etching (n=20) | p-value |
|---|---|---|---|---|
| Mean ± SD | 4.07±0.23 | 4.75±0.15 | 6.17±0.303 | <0.001* |

*significant p<0.05

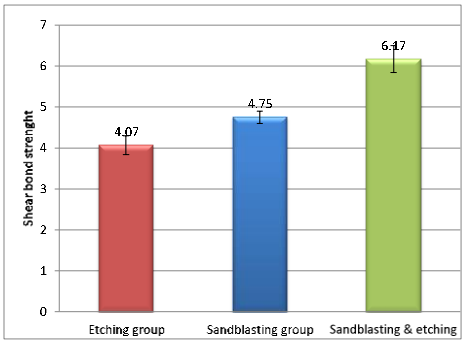


**Figure 1.** Mean of shear bond strength values (Mpa) for studied groups.

Table 3. Mode of failure and the number of occurrences.

| Groups | Adhesive | Cohesive | Mixed | p-value |
|---|---|---|---|---|
| **Group 1** | 4 (40%) | 1 (10%) | 5 (50%) | 0.173 |
| **Group 2** | 2 (20%) | 3 (30%) | 5 (50%) | |
| **Group 3** | 1 (10%) | 6 (60%) | 3 (30%) | |

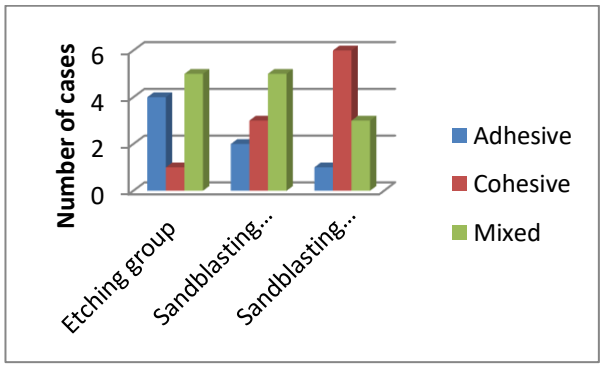


Figure 2. Mode of failures among studied groups.

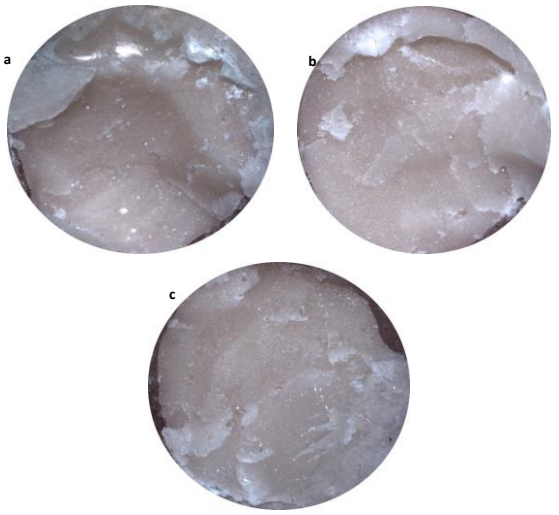


**Figure 3.** Representative images by Stereomicroscope (mag. X 1.2) representing the type of failure; (a) Group I: represented mixed failure with dominant adhesive failure in GICs; (b) Group II: represented mixed failure with dominant cohesive failure in GICs; (c) Group III: showed cohesive failure in GICs.

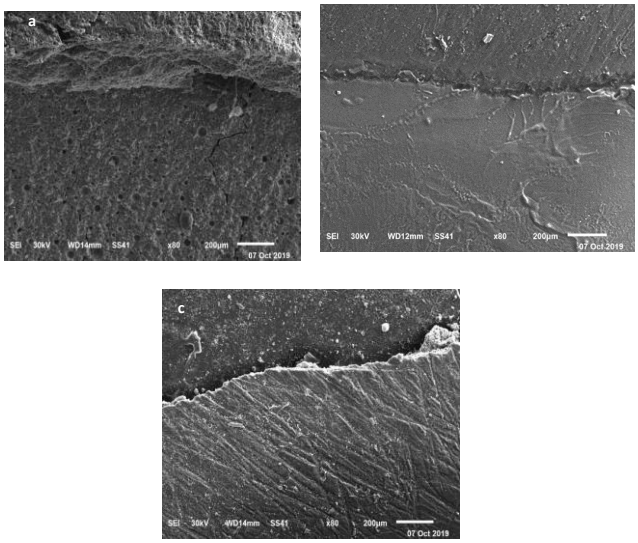


**Figure 4.** SEM micrographs (mag. X 80) of the examined specimen: (a) Group I: showed mixed failure with dominant adhesive failure in GICs; (b) Group II: showed mixed failure with dominant cohesive failure in GICs; (c) Group III: showed cohesive failure in GICs.

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