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Original Article

Comparison of shear bond strength of a composite resin to resin modified and conventional glass ionomer using different bonding systems

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Abstract

Introduction: Glass ionomers are often used as a base under composite restorations in deep cavities by sandwich technique. The aim of this study was to compare the shear bond strength of composite to resin modified and conventional glass ionomer using total etch , self-etch and universal bonding systems.

Materials & Methods: Ninety glass-ionomer samples were prepared for this research: Fuji II (F II), IonoStar Plus (IS) and Fuji II LC (F II LC).Then the specimens were divided into 9 groups (n=10). The surface of the specimens were prepared with three types of bonding: Adper single bond2 (SB), Clearfil SE bond (SE) and Single bond Universal (SU).Then Z250 composite resin was applied on the glass ionomers. The specimens were incubated in distilled water for 24 hours at 37 ° C and then were tested for shear bond strength. The type of failure was determined by a ×40 stereomicroscope and the results of the study were analyzed by nonparametric statistical analysis and Kruskal Wallis test. $P \leq 0.05$ was considered significant.

Results: The highest shear bond strength was observed in the Fuji II LC + Single bond2 group. There was a statistically significant difference in the shear bond strength of the composite to the two glass ionomers F II and F II LC using SB and SU bonding systems (P=0.033 and P=0.040, respectively).There was no significant difference between the groups regarding the type of failure.

Conclusion: Unlike the Fuji II LC and IonoStar Plus glass ionomers, the shear bond strength of the composite to the Fuji II conventional glass ionomer is affected by the type of bonding system. Total-etch and self-etch bonding systems can be used effectively in sandwich technique. Using a resin modified glass ionomer with total etch bonding can improve the shear bond strength of the composite to the glass ionomer.

Keywords: Dentin bonding agents, Composite resins, Shear strength

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مقایسه استحکام باند برشی یک کامپوزیت رزین به گلاس آینومر نوری و معمولی با استفاده از سیستم های باندینگ مختلف

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چکیده

مقدمه: گلاس آینومرها اغلب به عنوان بیس در زیر ترمیم های کامپوزیتی درحفرات عمیق با تکنیک ساندویچ استفاده می شوند. هدف از این مطالعه مقایسه ی استحکام باند برشی کامپوزیت به گلاس آینومر تغییر یافته با رزین و کانونشنال در حضور باندینگ های توتال اچ و سلف اچ و یونیورسال است.

مواد و روش ها: ۹۰ نمونه گلاس آینومر برای این مطالعه تهیه شد : Fuji II (FII) و Fuji II IonoStar Plus (IS) و Fuji II LC (F II LC) و نمونه ها به ۹ گروه تقسیم شدند (n= 10) سطح نمونه ها با ۳ نوع باندینگ آماده سازی شد : (SB) Adper single bond2 و (SE) Clearfil SE bond و(SU) Single bond Universal سپس رزین کامپوزیت Z250 روی گلاس آینومرها قرار داده شد. نمونه ها به مدت ۲۴ ساعت در آب مقطر و در دمای ۳۷ درجه سانتی گراد در انکوباتور قرار گرفتند و سپس جهت استحکام باند برشی آزمون شدند. نوع شکست توسط استریومیکروسکوپ ۴۰× مشخص و نتایج مطالعه با آنالیز آماری نانپارامتری و آزمون Kruskal Wallis تجزیه و تحلیل شد و $p<0.05$ معنادار تلقی شد.

یافته ها: بیشترین میزان استحکام باند برشی در گروه Fuji II LC + Single bond2 دیده شد. استحکام باند برشی کامپوزیت به دو گلاس آینومر F II و F II LC درحضور باندینگ های SB وSU از نظر آماری تفاوت معناداری داشت (به ترتیب$P = 0.033$ و$P = 0.040$) از نظر نوع شکست در بین گروه ها تفاوت معناداری دیده نشد.

نتیجه گیری: برخلاف گلاس آینومرهای Fuji II LC و IonoStar Plus ، استحکام باند برشی کامپوزیت به گلاس آینومر کانونشنال Fuji II تحت تاثیر نوع سیستم باندینگ قرار گرفت. هر دو سیستم باندینگ توتال اچ و سلف اچ می توانند بطور موثر در تکنیک ساندویچ استفاده شوند. استفاده از گلاس آینومر رزین مدیفاید به همراه باندینگ توتال اچ می تواند استحکام باند برشی کامپوزیت به گلاس آینومر را بهبود بخشد.

واژگان کلیدی: باندینگ های عاجی، رزین کامپوزیت، استحکام برشی

Introduction

Today, tooth colored restorations, including composites, are widely used to enhance the esthetic of the anterior and posterior teeth.[1] But the major disadvantage of the composite is the polymerization shrinkage that causes micro-leakage and secondary caries.[2] Glass ionomers were introduced by Kent and Wilson in 1971 and were less technically sensitive than composites.[2] Some advantages of glass ionomer include the long-term release of fluoride, anti-caries activity, and low thermal expansion coefficient.[1] For this reason, the sandwich technique is used in deep cavities and areas where isolation is questionable.[3-5] In this technique, glass ionomer cement is used as a base or liner under composite restorations to improve the

adhesion and decrease the micro-leakage.[3] In this way, we will have the properties of both composite material (beauty, abrasion resistance) and glass ionomer (ability of bonding to the dentin and long-term release of fluoride).[6,7] Besides, the number of bonded surfaces to the composite and c factor is reduced, then the bond strength is increased and micro-leakage is reduced.[2]

Bond strength is an important factor for the survival of restoration and prevention of micro-leakage and recurrent caries.[6] Both types of conventional and resin modified glass ionomer can be applied in the sandwich technique.[8] But the bond between composite and conventional glass ionomer is micro-mechanical and the bond between the composite and resin modified glass ionomer is chemical.[6] So, for bond improvement, the resin modified type is preferred.[1] Another way to improve bonding is the etching of the glass ionomer surface using phosphoric acid .[1] McLean first used etching for 60 seconds and bonded the glass ionomer to the composite with a resin bonding agent.[8,9]

Etching, by creating pores on the surface of the glass ionomer permits the penetration of resin adhesives into the micro-porosities and improves the bonding.[1] For this reason, etch- and rinse- bonding is widely used in the sandwich technique, but due to problems such as inadequate etching and their multi-step process, self-etch bonding has been suggested.[6] The number of self-etch bonding procedures is less than the etch- and rinse-systems, and since self- etch bondings have acidic and hydrophilic monomers, they do not require separate etching and rinsing process.[6] Self-etch adhesives have lower viscosity and higher wettability than total-etch adhesives.[6]

According to Sadeghi et al. and Panahandeh et al., the shear bond strength of composite to resin-modified glass ionomer using different bonding agents is higher than that of the conventional type.[2,6] Also, some researchers believed that if self-etch adhesives were used in composite and glass ionomer interface, they may produce stronger chemical bond strength than the total-etch system.[3,10,11]

Recently, a new conventional, radio-opaque, fast setting glass ionomer was presented. The manufacturers (Voco, Cuxhaven, Germany) claim that this material has some features like tooth-like fluorescence, low stickiness and perfect marginal adaptation. In addition, it can be packed immediately after placement, cured in 2 minutes and offered high fluoride release. There are some controversies about bond strength of composite resin to this glass ionomer, whereas there are only few studies about this glass ionomer, and our data on bond strength of IonoStar Plus glass ionomer to composite resin using different bonding systems were insufficient; therefore the aim of the current study was to to compare the shear bond strength of composite to Fuji II , Fuji II LC and IonoStar Plus glass ionomers using total-etch , self-etch and universal bonding agents. The null hypothesis of the ongoing study was that the bond strength of various glass ionomers to composite resin with different bonding systems was similar.

Materials & Methods

This study was approved by Ethics Committee of Babol University of Medical Sciences (IR.MUBABOL.HRI.REC.1398.056). In this in vitro study, three glass ionomers of IonoStar Plus (Voco ,Cuxhaven, Germany), GC Fuji II LC (GC ,Tokyo, Japan) and GC Fuji II (GC ,Tokyo, Japan) and 3 bonding systems of Single bond Universal (3M ,Minnesota, USA), Adper single Bond 2 (3M, Minnesota, USA) and Clearfil SE bond (Kuraray,Okayama, Japan) were used with a Filtek Z250 micro-hybrid composite (3M, Minnesota, USA). The materials used in this study are shown in table 1.

Specimen Preparation: First, the square plastic molds were provided in dimensions of 5 × 5 × 2 mm^3. Then, 90 samples of glass ionomer (2 types of conventional glass ionomers and 1 type of resin modified glass ionomer) were prepared and divided into 9 groups (n = 10). The distribution of samples in different groups according to the type of the used bonding and glass ionomer was as follows:

Group 1: GC Fuji II + Single bond Universal + Composite Z250

Group 2: GC Fuji II LC + Single bond Universal + Composite Z250

Group 3: IonoStar plus + Single bond Universal + Composite Z250

Group 4: GC Fuji II + Clearfil SE Bond + Composite Z250

Group 5: IonoStar Plus + Clearfil SE Bond + Composite Z250

Group 6: GC F II LC + Clearfil SE Bond + Composite Z250

Group 7: IonoStar Plus+Adper Single bond 2+Composite Z250

Group 8: GC F II+Adper Single bond 2+Composite Z250

Group 9: GC F II LC+Adper Single bond 2+Composite Z250

Table 1. Materials used in this study

Product	Manufacturer	Code	Composition
Fuji II	GC ,Tokyo , Japan	F II	Powder: fluoro alumino silicate glass Liquid: acrylic acid , maleic acid , water , tartaric acid
Fuji II LC	GC , Tokyo , Japan	F II LC	Powder: fluoro alumino silicate glass Liquid: polyacrilic acid , HEMA , water , maleic acid , comphorquinone , dimethacrylate resins
IonoStar Plus	Voco , Cuxhaven, Germany	IS	Capsule: fluoro alumino silicate glass acrylic acid , maleic acid , water , tartaric acid
Etchant	Pulp dent,Boston, USA	---	Phosphoric acid 37%
Adper single bond 2	3M ESPE , ,Minnesota, USA	SB	Dimethacrylate resins , HEMA , filler , vitrebond copolymer , water , ethanol , initiators
Clearfil SE bond	Kuraray Medical Inc , Okayama , Japan	SE	Primer: HEMA , hydrophilic dimethacrylate , MDP , N-N diethanol, p-toluidine , water , comphorquinone Bond: Bis GMA , HEMA , MDP , hydrophobic dimethacrylate , comphorquinone , N-N diethanol-p-toluidine , silanized colloidal silica
Single bond Universal	3M ESPE , ,Minnesota, USA	SU	MDP , dimethacrylate resins , HEMA , vitrebond copolymer , filler , ethanol , water , silane , initiator
Composite Filtek Z250	3M ESPE , ,Minnesota, USA	---	Matrix: Bis GMA , Bis EMA ,UDMA , TEG DMA Filler: silica , zirconia

HEMA: 2 – Hydroxyethyl mathacrylate / MDP: Methacryloyloxydecyl Dihydrogen Phosphate Bis GMA: Bisphenol A Glycidyl Methacrylate / Bis EMA: Bisphenol A Glycidyl Methacrylate ethoxylated / UDMA: Urethane dimethacrylate / TEG DMA: Triethylene glycol dimethacrylate

According to the manufacturer's instructions, 30 samples of the fast setting and encapsulated IonoStar Plus glass ionomer were prepared: By pressing the capsule, the glass ionomer was activated and immediately mixed in an amalgamator (Duomat3, Kirchlengern, Germany) at 4000 rpm for 10 seconds. Then, each capsule was injected into the 2 molds by AC Applicator type 1 (Voco,Cuxhaven, Germany). The surface of the specimens was smoothed by putting on a Mylar tape and glass slab. The final setting time of this glass ionomer was 2 minutes.

According to the manufacturer's instructions, 30 Fuji II LC resin modified glass ionomer specimens were prepared as follows: one spoonful of powder and two drops of liquid were poured on a glass slab, and the powder was divided into two portions. The first part of the powder was mixed with the liquid during 10-15 seconds, and then the remaining powder was added and placed into the molds. Next, the surface of the specimens was smoothed with Mylar tape and glass slab. It was then cured by a VALO (Ultradent, South Jordan, USA) LED light curing unit for 20 seconds, and the intensity was 800 mW/cm2 measured by radiometer (Kerr, Romulus, USA). The point of the light curing unit was put 1 mm overhead the specimen's surface.

According to the manufacturer's instructions, 30 Fuji II conventional glass-ionomer specimens were prepared as follows: one spoonful of powder and one drop of liquid were poured on a glass slab, and powder was divided into two portions. The first part of the powder was mixed with the liquid during 10-15 seconds, and then the remaining powder was added and placed into the molds. Then, the surface of the specimens was smoothed with Mylar tape and glass slab. The final setting time of this glass ionomer was 2 minutes and 20 seconds.

Bonding procedure: In this study, three types of total-etch, self-etch and Universal bonding systems were used to prepare the glass-ionomer surface. Single bond Universal (self-etch mode): the 8th generation bonding agent was applied on the surface of the glass ionomer for 20 seconds, dried for 5 seconds by an air spray, and then cured for 10 seconds by VALO LED light curing unit. Clearfil SE bond: the 6th generation bonding had two bottles containing primer and bonding. The primer was applied on the surface of the glass ionomer for 10 seconds and was dried by an air spray, and then a bonding layer was placed on it and cured for 10 seconds by VALO LED light curing unit.

Adper single Bond 2: the 5th generation bonding agent was of etch and rinse type. The surface of the glass ionomer was etched for 15 seconds with 37% phosphoric acid (Pulpdent,Boston, USA).Then, it was rinsed and dried for 5 seconds by an air spray. After that, two bonding layers were placed on the glass surface, air-dried and cured for 10 seconds by VALO LED light curing unit. Finally, the A2 color Z250 composite in the plastic tubes with 3 mm inner diameter, and 2 mm height was put on the surface of all specimens and cured by VALO LED light curing unit for 20 seconds. Afterwards,all samples were incubated for 24 hours in distilled water at 37 ° C in an incubator (Sientific LTD,Massachusetts, UK).

Shear bond strength test: for measuring the shear bond strength of composite to glass ionomer, a universal testing machine (KOOPA, Sari, Iran) was used and a force with the speed of 1 mm/min was applied to the composite and glass ionomer interface by Chisel until the failure occurred. The force required to break the specimens was reported by the device (in Newton), and the shear bond strength was obtained through dividing the maximum force by the interface area of composite and glass ionomer (MPa).

Fracture pattern analysis: All specimens were observed under a stereomicroscope (Dewinter, San Francisco, USA) with ×40 magnification to investigate the type of failure. The types of failures were divided into three categories: adhesive (failure in the interface of glass ionomer and composite), cohesive (failure in the material itself) and mixed (combination of both) ones.

Statistical analysis: The mean shear bond strength with the standard deviation was calculated for all groups. Data were analyzed using SPSS. Nonparametric statistical analysis (due to abnormal distribution of data), Chi-square and Kruskal-Wallis tests were used, too. Bonferroni correction for multiple tests was used for pairwise comparison. $P \leq 0.05$ was considered significant.

Results

The study results demonstrated that the highest and lowest values of shear bond strength were related to Group 9 (F II LC-SB) and Group 3 (SU-IS), respectively. Table 2 shows the mean shear bond strength of the composite to glass ionomer (with standard deviation). As illustrated in table 2 , statistically , there is a significant difference between shear bond strength of composite to Fuji II and Fuji II LC glass ionomers using SU and SB bondings (P=0.040 and P=0.033, respectively). Statistically, there is a significant difference between shear bond strength of composite to Fuji II using SB and SE bondings (P=0.050)

Table 2. The Mean±SD of shear bond strength values (Mpa) of composite to glass ionomer using different bonding systems

Glass ionomer Bonding	IS	F II LC	F II
SU	2.28±1.56 ^{Aab}	3.90±1.83 ^{Aa}	2.45±1.16 ^{ABb}
SE	2.85±2.03 ^{Aa}	3.98±2.52 ^{Aa}	3.83±2.09 ^{Aa}
SB	3.55±1.36 ^{Aab}	4.27±1.78 ^{Aa}	2.35±1.63 ^{Bb}

SU = Single bond Universal / SE = Clearfil SE Bond / SB = Adper single bond 2

IS = IonoStar Plus / F II = Fuji II / F II LC = Fuji II LC

- Different Capital letters (A, B) in table represent statistically significant difference in the comparison between glass ionomers in each column

- Different Small letters (a, b) in table represent statistically significant difference in the comparison between bonding systems in each row

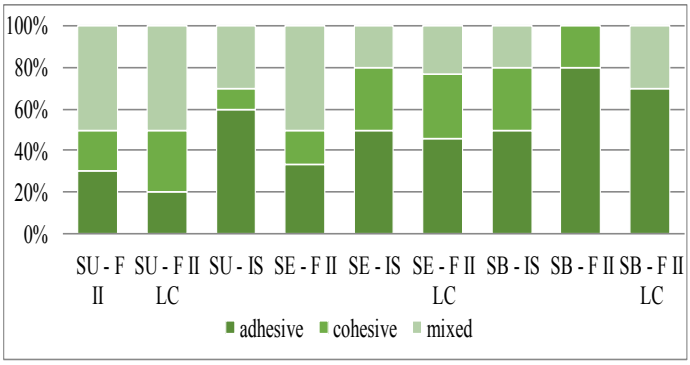

Figure 1. Distribution of failure types in different study groups

The results of the Chi square test for types of failure indicated: There was no significant difference between the failure types in the 9 groups (P=0.273). The failure types were not different in each group, but adhesive failure was statistically significantly higher in the 8th group than other groups (P=0.058). As illustrated in figure 1, In groups 8 and 9, the mixed and cohesive failures were zero, respectively. The adhesive failure showing the closest number to the actual bond strength was the highest (80%) in group 8 and the lowest (20%) in group 2.

Discussion

In this study, the shear bond strength of composite to various glass ionomers using different bonding agents was significantly different except SE Bond. Moreover, the bond strength of composite to Fuji II LC using universal and total etch bonding agents was significantly different from that of Fuji II.

In the current study, the Fuji II conventional and Fuji II LC resin modified glass ionomers were used as gold standard glass ionomers.[6,12] The IonoStar Plus conventional glass ionomer was also applied as a new encapsulated radio-opaque, bulk-fill, fast setting glass ionomer. The manufacturer claimed that the IonoStar Plus had some features such as high level of fluoride release, perfect marginal adaptation, convenient application, tooth-like fluorescence, low stickiness, high compressive strength and abrasion resistance. In the ongoing study, the highest bond strength of IonoStar Plus and Fuji II LC glass ionomers to composite resin was with application of Adper Single Bond 2, but the highest bond strength of composite resin to Fuji II glass ionomer was with using Clearfil SE Bond.

In the present study, the differences and similarities of the total-etch and self-etch systems and their effects on the shear bond strength of composite to glass ionomer were compared by using 3 types of bonding systems named Adper single bond 2 (2 step 5th generation) , Clearfil SE Bond (6th generation) and Single bond Universal (universal bondings). Several studies have used these materials to evaluate the bond strength of composite to glass ionomer.[1,3,8]

The mean shear bond strength of the composite to glass ionomer was highest in group 9 (F II LC - SB), when we used resin-modified glass ionomer with total-etch bonding. This group also had a statistically significant difference with the (F II - SU), (IS - SU), (IS - SE) and (F II - SB) groups. According to studies conducted by Sadeghi et al., Panahandeh et al. and Arora et al., the shear bond strength of composite to resin-modified glass ionomer was more than that of the conventional type, which was in line with the results of this study. This may be due to the existence of unreacted methacrylate molecules inside the resin-modified glass ionomer as well as the presence of an inhibitory oxygen layer on the surface of the glass ionomer, which creates a strong covalent chemical bond with the resin bonding components and increases the bond strength of light cure glass ionomer to the composite.[2,6,11] Additionally, Pamir et al. argued that this may be due to the similarity of the chemical composition of the resin composite and the resin-modified glass ionomer. [8] According to Hinoura et al., the presence of adhesives improved the wetting properties of the glass ionomer surface and strengthened the bond between the composite and the glass ionomers.[13] The bond strength between composite and glass ionomer is an critical factor for increasing retention of restoration and preventing micro-leakage.[8]

Panahandeh et al. suggested that when the surface of glass ionomer was prepared with total-etch bonding, due to surface roughness, stronger shear bond strength and less micro-leakage would be achieved .[6] These findings were similar to the results of this study. However, Sharafeddin, Sheth and Taggart argued that etching the surface of the glass ionomer leads to dissolution of the lower layers of the glass ionomer matrix. As a result, instead of measuring actual bond strength, the cohesive strength of this weakened zone is measured.[14-16]

The mean shear bond strength of the composite to glass ionomer in group 3 (IS - SU) using conventional glass ionomer with universal bonding was the lowest among all groups. Moreover, this group was statistically significantly different from the (F II LC - SU) and (F II - SE) groups. This result was in line with the results of other studies.[2,6,11] However, in contrast to the results of this study, de Oliveira found that with and without adhesive, the shear bond strength of the composite to the Ketac Molar Easymix conventional glass ionomer (7.41 MPa) was higher than that of the Vitrebond resin-modified one (4.08 MPa).[1] The difference may be due to the difference in the chemical composition of the used glass ionomers and time of bonding application on the surface of the glass ionomer. Panahandeh et al. have suggested that the time of bonding application affects the bond strength of the composite to glass ionomer.[6] Hence, bonding must be applied to the surface after the final setting of the glass ionomer.[6,17]

In the current study, the shear bond strength of composite to Fuji II glass ionomer was affected by the type of bonding system. There was a statistically significant difference between SE and SB bonding systems. But the shear bond strength of the composite to Fuji II LC and IonoStar Plus glass ionomers was not affected by the type of bonding system. However, using Adper Single Bond 2 with IonoStar Plus glass ionomer improved the bond strength of composite resin to glass ionomer.

Self-etch bonding systems contain acidic and hydrophilic monomers and do not require separate etching and rinsing steps. This makes the bonding easier to use and technically less sensitive. According to some studies, if self-etch adhesives are used between the glass ionomer and the composite, there will be a stronger chemical bond than the total-etch system, which may be due to the lower viscosity and higher wettability of these bonding systems.[3,10,11,18] Nevertheless, de Oliveira et al. have demonstrated that the effect of single-step self-etch and simplified etch and rinse bonding systems on the surface of resin-modified and conventional glass ionomers is similar.[1,8] The results of two latter studies disagree with those of the present study, and this may be due to the difference in the chemical composition of the used self-etch bonding agent and the etching time of the glass ionomer surface.

In the ongoing study, only in the SE bonding, the bond strength of the composite to conventional and resin-modified glass ionomers was similar. This may be due to the existence of a MDP monomer (Methacryloyloxydecyl Dihydrogen Phosphate) in the SE Bond primer. Phosphate monomer reacts with calcium and aluminum ions on the glass ionomer surface and improves the composite bond to glass ionomer.[19] Of course, this monomer also exists in the Universal bonding system, but it is probably weakened by the presence of other components.[20,21] Besides, the Universal bonding has a higher pH (PH=2.7) than the SE bond (PH=2) leading to less porosity at the glass ionomer surface.[22] This means that in conventional glass ionomers, the bond of the Universal bonding is more MDP-dependent (due to the absence of resin components in conventional glass ionomer and reduction of surface porosity due to high pH) and the use of Universal bonding in light cure resin modified glass ionomers leads to greater bond strength of the composite to the glass ionomer.[23,24]

According to the results of the present study, the effect of various bonding agents on bond strength of composite resin to glass ionomers was different, it seemed that this effect was material-dependent, and it depended on composition of glass ionomers used in this research.

In this study, by using the SE and SU adhesives, all three types of failures (adhesive, cohesive and mixed) were seen in all groups, but by using the SB adhesive, the adhesive failure became dominant in the groups. In the mode of failure study of different groups, less cohesive failure was observed in resin-modified glass ionomer, which is in agreement with the results of the study conducted by Choi et al. [25] Panahandeh et al. has suggested that the bond strength is a function of the cohesive strength of a material. [6] This can be due to the higher cohesive strength of the resin-modified glass ionomer compared to the conventional one.

Conclusion

Unlike the Fuji II LC and IonoStar Plus glass ionomers, the shear bond strength of the composite to the Fuji II conventional glass ionomer is affected by the type of bonding system. Total-etch and self-etch bonding systems can be used effectively in sandwich technique. Using a resin modified glass ionomer with total etch bonding can improve the shear bond strength of the composite to the glass ionomer.

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Authors' Contributions

The study was designed by Effat Khodadadi. The study data were collected by Mahtab Banimostafa. Behnaz Esmaeili edited and reviewed the article, and the results were evaluated and analyzed by Soraya Khafri.

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