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In Vitro Microleakage of Bulk Fill and Conventional Composites and a Hybrid Glass Ion-omer in Primary Molars

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Objectives The main disadvantage of composite resins is their polymerization shrinkage, which can lead to microleakage. The purpose of this in vitro study was to evaluate the microleakage of bulk fill and conventional composites and a new hybrid glass ionomer (GI) in class II restorations of primary molar teeth.
Methods In this in vitro study, 51 primary molar teeth were randomly divided into three groups. Standard class II cavities were then prepared. In group 1 the cavities were restored with Filtek bulk fill composite; in group 2, the cavities were incrementally filled with Z250 conventional composite and in group 3, EQUIA Forte hybrid GI resin was used to fill the cavities. The teeth were subjected to thermal and then mechanical thermocycling. Afterwards, the teeth were immersed in 1% methylene blue solution. The teeth were then mesiodistally sectioned, and microleakage was evaluated at the occlusal and gingival margins under a stereomicroscope and a scanning electron microscope (SEM). The Shapiro-Wilk and Kruskal-Wallis tests were used to statistically analyze the data.
Results There was no statistically significant difference in the mean microleakage of bulk fill and conventional composites and hybrid GI in the occlusal (P=0.495) or gingival (P=0.293) margins. The gingival microleakage was significantly higher than occlusal microleakage in all three groups (P<0.05).
Conclusion Based on the results of the present study, microleakage of Filtek bulk fill composite is the same as that of Z250 conventional composite and EQUIA Forte hybrid GI.
Keywords Dental Leakage; Composite Resins; Tooth, Deciduous; Molar

Introduction

Nowadays, resin restorations are commonly used in dental treatments due to their optimal esthetic properties and the existing concerns regarding the adverse biological effects of amalgam restorations.[1, 2] As all other restorative materials, dental resin restorations have their own weaknesses. Low resistance to abrasion, polymerization shrinkage (2.6-7.1%)[3], difficulty in creating the proper contour and contact, stainability, and need for isolation are some of their weaknesses pointed out in different studies.[4-6] If polymerization shrinkage exceeds the bond strength of composite resin, marginal leakage may pursue.[7,8] Polymerization shrinkage can cause debonding of composite from the cavity walls and result in microleakage of fluids, molecules and ions.[9] Continuation of microleakage through the restoration margins, especially at the gingival margin of class II cavities leads to tooth hyper-sensitivity, marginal discoloration, and secondary caries.[10,11]

Microleakage is defined as the passage of bacteria, fluids, molecules, and ions through the interface of cavity wall and restorative material, which cannot be clinically detected.[12-14] Microleakage negatively affects the restoration durability[14] and increases tooth hyper-sensitivity, caries recurrence, and pulp sensitivity.[15] The main reason of microleakage is the weak adaptation between the restorative material and cavity wall. The secondary reason is the volumetric change in restorative material due to cohesive shrinkage as the result of thermal alterations in the oral cavity. Such thermal alterations create gap between the restorative material and tooth structure, which results in microleakage. To seal the restoration margins and increase the durability of restoration, a hermetic seal at the tooth-restoration interface is imperative[16] Gingival margin is at high risk of microleakage.[15] Decreased polymerization shrinkage decreases the microleakage and can be achieved by incremental application of composite, using various methods of polymerization[17], application of resin liner beneath the restoration[18], and increasing the amount of filler.[19] Although incremental application of composite is a common method, it has some weaknesses such as risk of void formation and contamination, bond failure between layers, difficult application of composite in conservative cavities, and longer composite application time.[20] Attempts to decrease the microleakage and shorten the working time resulted in introduction of bulk fill composites, which have less filler content, larger filler size, and higher translucency than the conventional composites.[21, 22] The advantages of bulk fill composites include lower polymerization shrinkage[23], decreased cuspal flexure in class II cavities[24], and optimal bond strength irrespective of the cavity form and method of filling.[25] Moreover, they are suitable for use in uncooperative children due to their reportedly shorter

application time.[26]
Recent hybrid glass ionomers (GIs) consist of ultrafine reactive glass particles scattered in a con-ventional GI matrix with a molecular weight higher than that of acrylic acid. They have optimal characteristics such as bulk filling of cavities, easy and fast application, lacking technical sensi-tivity, lacking polymerization shrinkage or shrinkage stress, having proper marginal seal which prevents microleakage and discoloration in long-term, releasing fluoride, and resistance against abrasion and erosion.[27] Due to the small number of studies on bulk fill composite restorations of primary teeth[28-30], and absence of any study comparing bulk fill composites with hybrid GIs in primary teeth, we decided to assess the microleakage of a bulk fill composite in comparison with a conventional composite and a hybrid GI.

Materials and Methods

Sample Selection:

Fifty-one primary molar teeth were selected for this in vitro experimental study. The study was approved by the ethics committee of our university (IR.IAU.DENTAL.REC.1399.118). The teeth were debrided by a prophylaxis brush and low-speed handpiece. Afterwards, the teeth were examined under a stereomicroscope (Olympus, Tokyo, Japan) at ×2 magnification. The teeth with sound proximal surfaces without any caries, cracks, or fracture and no root resorption were selected for the study. The teeth were stored in saline until the experiment. One week before the study, they were placed in 0.5% chloramine T solution at 4°C for one week and then they were returned to saline again.[28]

Preparation of class II cavities:

Class II cavities were prepared in proximal surfaces (mesial or distal) with divergent walls from the gingival towards the occlusal surface using a fissure bur (L010 No 837; Tizkavan, Tehran, Iran) and high-speed handpiece with water coolant. The dimensions of the cavities were 2.5 mm buccolingually, 1.5 mm mesiodistally, and 4 mm occluso-gingivally with 1.5 mm isthmus width.[31] The cervical margin of the cavity was 1 mm above the cementoenamel junction with 90° cavosurface margin.[29] The cavity dimensions were ensured by a universal Probe (Joya, Tehran, Iran).

Restoration of cavities:

After cavity preparation, the teeth were mounted in self-cure acrylic resin (Figure 1). Afterwards, the teeth were randomly divided into three groups (each containing 17 teeth) based on the dental materials used. A LED curing unit (Kerr, CA, USA) with a minimum light intensity of 450 mW/cm^2 was used for curing in all groups. T-Band matrix was applied on the teeth in each group by a postgraduate student of pediatric dentistry before restoration of teeth.

In group 1, enamel and dentin were etched with 35% phosphoric acid (Ultra-Etch; Ultradent, South Jordan, UT, USA) for 20 and 15 s, respectively and were finally rinsed with water for 15 s. The cavities were then dried with air spray, and two layers of Single Bond 2 (3M ESPE; St. Paul, MN, USA) were applied on surfaces. Then, air spray was applied for 3-5 s from 20 cm distance, and curing was done from the occlusal surface for 20 s. the cavities were filled with Filtek bulk fill composite (3M ESPE, St. Paul, MN, USA) and it was cured from the occlusal surface. The matrix band was then removed and the restoration was cured for another 15 s from the buccal and lingual surfaces. The restoration surface was then polished with Sof-Lex polishing discs (3M ESPE; St. Paul, MN, USA).[32]

In group 2, all the procedures were the same as those in group 1 except for the type of composite. In this group, Z250 conventional composite (3M ESPE, St. Paul, MN, USA) was used. Cavity preparation, etching and bonding were performed the same as those in group 1. Z250 conven-tional composite was applied incrementally in 2 mm thickness.[29]

In group 3, after etching the cavity for 10 s, cavity conditioner (GC Corporation, Tokyo, Japan) was applied and was then washed and dried. EQUIA Forte hybrid resin capsule (GC Corpora-tion, Tokyo, Japan) was mixed in an amalgamator at a speed of 400 rpm for 10 s, and applied in the cavity with a special GC gun. The final finishing was done by egg diamond bur (No 018 L14; Tizkavan, Tehran, Iran) under water coolant. Next, EQUIA coating was applied and cured.[27]

Figure 1- Mounted samples in self-cure acrylic resin

Measuring the microleakage:

Tooth surfaces were then covered with two layers of nail varnish 1 mm around the restoration margin. Apices were sealed with wax. The teeth were then subjected to artificial aging by thermal cycles. All the teeth were immersed in water bath at 5-55°C for 5000 cycles with a dwell time of 30 s in each bath and transfer time of 10 s. Afterwards, the teeth were exposed to occlusal force of maximally 90 N with 2 Hz frequency for 100,000 cycles in a cyclic load test machine (Nemo, Tehran, Iran). Next, the samples were immersed in 1% methylene blue dye for 24 h. They were then washed and dried, and were sectioned vertically at the restoration center in mesiodistal direction by a diamond saw (Mecatome T201A; Presi, Paris, France). Each slice was examined under a stereomicroscope (EZ4D Leica; Olympus, Tokyo, Japan) at x10 magnification.[29] Two other samples from each group were examined under a scanning electron microscope (SEM) at x2000 magnification.[29] Microleakage at the occlusal and gingival margins was ranked using a 0-4 ranking scale based on dye penetration depth as follows [30]:

0: No dye penetration
1: Dye penetration limited to the enamel
2: Dye penetration extending to the outer 2/3 of the floor
3: Dye penetration not reaching the axial wall
4: Dye penetration reaching the axial wall

Data analysis:

The Wilcoxon and Kruskal-Wallis tests were used for data analysis via SPSS version 25 at 5% level of significance.

Results

The Kruskal-Wallis test showed no significant difference in microleakage among the three restorative materials at the occlusal or gingival margins (P>0.05).

Comparison of microleakage at the occlusal and gingival margins showed that the microleakage at the gingival margin was significantly higher than that at the occlusal margin for all three restorative materials (P< 0.001).

Figures 2 and 3 show the frequency distribution of microleakage scores at the occlusal and gin-gival margins of the three groups. At the occlusal margin, score 2 microleakage had the highest frequency in bulk fill composite; while, score 1 had the highest frequency in the conventional composite and hybrid GI. At the gingival margin, score 2 had the highest frequency in all three groups.

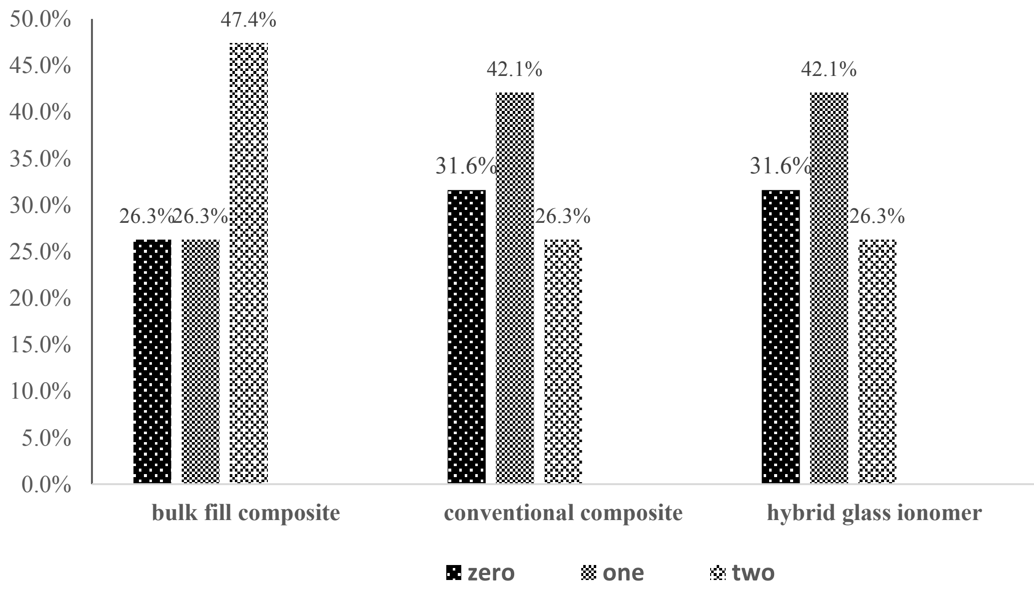

Figure-2- Distribution of microleakage scores at the occlusal margin of the study groups

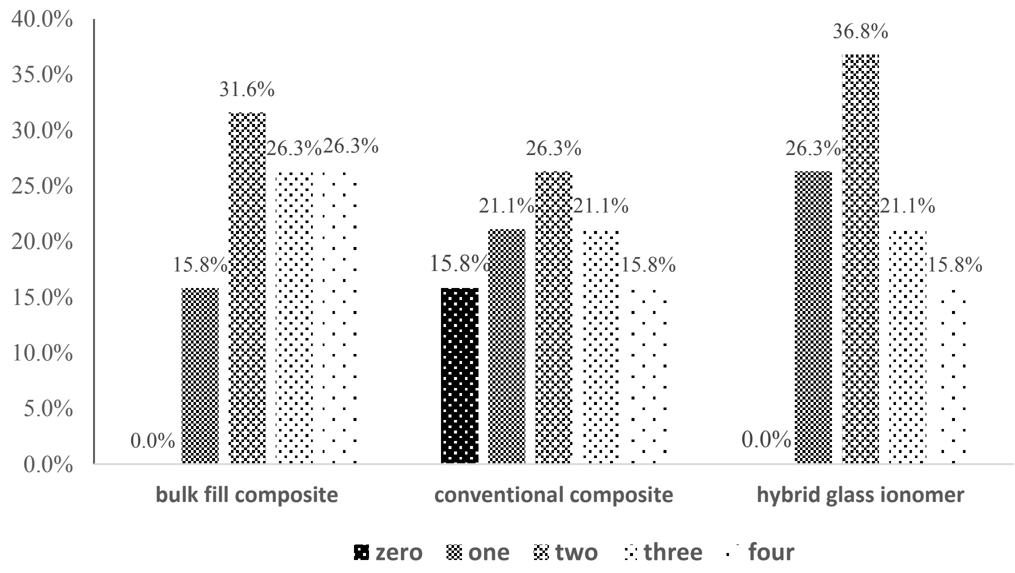

Figure 3- Distribution of microleakage scores at the gingival margin of the study groups

SEM micrographs of the groups are presented in Figure 4. As shown, the restoration-tooth interface in Z250 conventional composite was narrower than that in the other two groups. SEM micrographs confirmed the abovementioned findings.

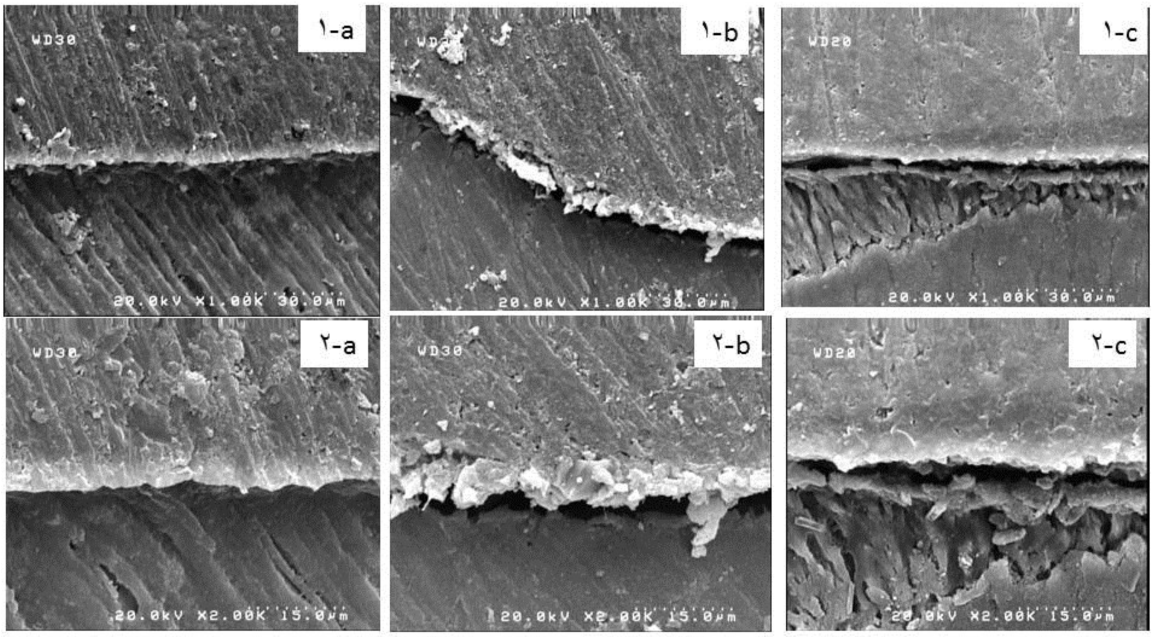

Figure 4- SEM micrographs: (a-1) gingival margin restored with Z250 conventional composite at x1000 magnification; (a-2) gingival margin restored with Z250 conventional composite at x2000 magnification; (b-1) gingival margin restored with Equia hybrid GI at x1000 magnification; (b-2) gingival margin restored by Equia hybrid GI at x2000 magnification; (c-1) gingival margin restored with bulk fill composite at x1000 magnification; (c-2) gingival margin restored with bulk fill composite at x2000 magnification

Discussion

The findings of the present study showed that the mean microleakage at the occlusal and gingival margins in bulk fill composite, conventional composite and hybrid GI groups had no statistically significant difference (P >0.05). Moreover, the findings revealed that the mean microleakage in all three groups was significantly higher at the gingival margin than the occlusal margin (P<0.001). This finding could be attributed to the greater amount of enamel at the occlusal mar-gin. According to higher mineralization rate of enamel compared with cementum and dentin, dye leakage into this part was less; therefore, the microleakage score was lower in the occlusal than the gingival margin.

Microleakage is an important parameter used to assess the success of restorative materials. It leads to tooth hypersensitivity and can result in development of secondary caries and pulpal in-flammation. Efforts to decrease microleakage and application time led to introduction of bulk fill composites with lower filler content, larger filler particles, and higher translucency than conven-tional composites.[21, 29] The main advantage of bulk fill composites is higher curing depth.[33] Furthermore, bulk placement prevents void formation and contamination between composite layers, leading to more compact restorations. The manufacturers claim that these composites enable restoration build-up with up to 4 mm thick layers with less polymerization shrinkage than the conventional composite resins.[31] Therefore, they are suitable for uncooperative children due to their shorter application time.[26]

Garcia Mari et al.[34] showed that the mean microleakage at the cervical margin of conventional composite was less than that in high-viscosity bulk fill composites; however, this difference was not statistically significant. Their results were in line with the findings of our study. However, the main difference of the present study and their study was that the samples underwent thermal and mechanical cycles in our study in order to simulate the oral conditions; while, in their study the samples only underwent thermocycling. Also, they evaluated permanent teeth while we studied primary teeth. Enamel of primary teeth contains less calcium and phosphorus than permanent teeth; moreover, primary teeth have more delicate enamel rods with higher density. The number of dentinal tubules in primary teeth are more than permanent teeth.[35] All of these factors can cause higher microleakage score in primary compared with permanent teeth.

Eltoum et al.[30] found no significant difference in microleakage at the occlusal and gingival margins in use of bulk fill and nano-hybrid composites. Their findings regarding no significant difference between bulk fill and nano-hybrid composites confirmed our results; however, they found no significant difference between the occlusal and cervical microleakage, which was different from our results. This difference can be due to the conduction of mechanical and thermal cycles in our study. Similar to our study, Mosharafian et al.[29] found no significant difference in microleakage at the occlusal and gingival margins of the samples restored with bulk fill and conventional composite resins. Moreover, they revealed that the amount of microleakage at the occlusal margin was significantly lower than that at the gingival margin for all three types of restorative materials, due to more amount of enamel in the occlusal margin. Due to higher mineralization of enamel in comparison with cementum and dentin, dye penetrates less into it; therefore, less microleakage was detected at the occlusal margin. However, the microleakage in bulk fill composite was less than that in the conventional composite. The reason for different findings between the two studies may be due to the method of assessment of microleakage. They only performed thermocycling and assessed the microleakage by use of silver nitrate. Different size of silver nitrate and methylene blue particles and applying mechanical thermocycling are responsible for the difference in the results of the two studies.

Gopinath[28] showed that the conventional GIs and bulk resin composite had significantly lower microleakage than resin-modified GIs. Their results were not in agreement with those of the present study probably due to the fact that they did not perform mechanical thermocycling.

Khoroushi et al.[36] compared the microleakage of resin-modified GI with composite resin and reported the least microleakage at both dentin and enamel margins of resin-modified GI group; whereas, in our study, the least microleakage at the occlusal margin was noted in hybrid GI group. Microleakage at the gingival margin of conventional composite was lower than that in other groups in our study. However, the microleakage difference between the hybrid GI and conventional composite was not statistically significant in our study. Difference in the results could be due to the type of GI used, the number of cycles in thermocycling, and microleakage assessment method.

One limitation of this study that should be mentioned is the fact that the study was conducted in vitro. It is likely that these results predict the performance of composite restorations but they cannot account for all the potential influences of the oral environment in vivo. Therefore, future studies can further contribute to better understanding of clinical performance, longevity, and ef-ficacy of bulk fill restorations.

The findings of this study predict the microleakage of composite restorations; however the microleakage might differ in vivo. Therefore, we suggest further studies to focus on clinical application of bulk fill composites.

Conclusion

Based on the present study results, it can be concluded that microleakage of bulk fill composite was more than that of conventional composite and hybrid GI; however the difference was not statistically significant. Therefore, easier and faster application technique of bulk fill composite is extremely valuable for pediatric dentistry.

Conflict of Interest

None Declared ■

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