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MICROLEAKAGE EVALUATION OF DIFFERENT TYPES OF BULK-FILL COMPOSITES ON ENAMEL AND CEMENT

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ABSTRACT

Background and Aim: The aim of this in vitro study was to compare the microleakage of slot Class II restorations restored with, a high viscosity/full body bulk-fill, a flowable bulk-fill and a fiber bulk-fill base, and a conventional nanohybrid composite.

Materials and Methods: Standardized slot Class II cavities at the mesial and distal surfaces were prepared in forty-eight extracted non-caries human molars with one having the gingival wall below, one above the cemento-enamel junction (CEJ). The prepared teeth were randomly divided into four groups and restored with: Group I- high viscosity/full body bulk-fill composite-Tetric EvoCeram Bulk Fill; Group II- a flowable bulk-fill composite+nano-ceramic composite-SureFil SDR Flow+Ceram.X Mono; Group III- fiber bulk-fill base composite+microhybrid composite-GC everX Posterior+G-ænial Posterior; Group IV- a nanohybrid composite-Filtek Supreme (n=12). Each restorative material was used with its respective adhesive system. After the restorative procedures, the samples were subjected to thermocycle (1000 cycles, 5°C-55°C), then immersed in 0.5% basic fuchsin dye for 24h. The teeth were sectioned and evaluated for dye penetration. Results were analyzed using the Kruskal-Wallis and Mann-Whitney U tests. The comparison between enamel and cement scores within each group was performed using Wilcoxon test ($p<0.05$).

Results: There was no significant difference in microleakage among the restorative materials either on enamel or on cement ($p>0.05$). Within each group, enamel and cement leakage scores differed only in SureFil SDR Flow+Ceram.X Mono group ($p<0.05$).

Conclusion: None of the tested restorative systems was able to eliminate leakage. The nanohybrid composite showed similar microleakage to bulk-fill composites.

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Keywords: Fiber Bulk-Fill Base, Flowable Bulk-Fill, High Viscosity Bulk-Fill, Microleakage

CLINICAL DENTISTRY AND RESEARCH 2019; 43(3): 100-109 Orijinal Araştırma

FARKLI TİPTE BULK-FİLL KOMPOZİTLERİN MİNE VE SEMENTTEKİ MİKROSIZINTISININ DEĞERLENDİRİLMESİ

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ÖZ

Amaç: Bu in vitro çalışmanın amacı yüksek viskoziteli/tam bulk-fill, akışkan bulk-fill ve fiber bulk-fill kaide ve geleneksel nanohibrit kompozitlerin slot Sınıf II restorasyonlarda mikrosızıntısını karşılaştırmaktır.

Gereç ve Yöntemler: Çekilmiş çürüksüz 48 insan molar dişin mezial ve distal yüzeylerine gingival duvarlarının biri sement-mine birleşiminin (CEJ) üzerinde, diğeri altında olacak şekilde standardize edilmiş slot Sınıf II kaviteler prepare edildi. Prepare edilen dişler rastgele 4 gruba ayrıldı ve restore edildi; Grup I- yüksek viskoziteli/tam bulk-fill kompozit- Tetric EvoCeram Bulk Fill; Grup II- akışkan bulk-fill kompozit+nano-seramik kompozit- SureFil SDR Flow+Ceram.X Mono; Grup III- fiber bulk-fill kaide kompozit + mikro-hibrit kompozit-GC everX Posterior+G-ænial Posterior; Grup IV-nanohibrit kompozit-Filtek Supreme (n=12). Her restoratif materyal kendi adeziv sistemi ile uygulandı. Restoratif işlemlerin ardından örnekler termal siklusa (1000 siklus, 5°C ve 55°C) tabi tutuldu, sonra %0,5 bazik fuksin boyasına 24 saat batırıldı. Dişlerden boya penetrasyonunun değerlendirilmesi için kesitler elde edildi. Bulgular Kruskal-Wallis ve Mann-Whitney U testleri kullanılarak analiz edildi. Her grup içinde mine ve sement skorları arasındaki karşılaştırma Wilcoxon testi kullanılarak yapıldı ($p<0.05$).

Bulgular: Restoratif materyaller arasında hem mine hem de sementte mikrosızıntı açısından anlamlı fark bulunmadı ($p>0.05$). Her bir grup içinde mine ve sement sızıntı skorları sadece SureFil SDR Flow+Ceram.X Mono grubunda farklıydı ($p<0.05$).

Sonuç: Test edilen hiçbir restoratif sistem sızıntıyı engelleyemedi. Nanohibrit kompozit bulk-fill kompozitler ile benzer mikrosızıntı gösterdi.

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Anahtar Kelimeler: Fiber Bulk-Fill Kaide, Akışkan Bulk-Fill, Yüksek Viskoziteli Bulk-Fill, Mikrosızıntı

INTRODUCTION

Resin composites are the most frequently used direct restorative materials for restoring posterior teeth, because of the increase in patients' claim for esthetics and importance on preservation of tooth structure. Placement of resin composite restorations is technique sensitive and continues to be complex procedure for clinicians. Despite the developments in technology, the polymerization shrinkage of resin composites is an unsolved problem, although several approaches have been introduced to reduce the shrinkage stress.[1-4] Polymerization shrinkage generally results gap formation between restoration and tooth structure that leads to microleakage. Microleakage is characterized by the invasion of oral microorganisms and their products, ions, and chemical materials between restoration and tooth structure that might cause formation of recurrent caries, pulpal inflammation or necrosis, postoperative sensitivity, and eventually failure of restoration.[5] Therefore, it is one of the important contributing factors in the survival of composite restorations. It is vital to maintain the marginal integrity of the composite-tooth with perfect sealing to achieve successful and long-lasting posterior direct composite restorations.[6,7] Different strategies have been proposed to lessen the effects of polymerization shrinkage such as; increasing the filler load or changing the monomer matrix, using different curing protocols and placement of resin composite in increments.[8-10] The incremental technique, no thicker than 2 mm to ensure proper monomer to polymer conversion at the bottom of the increment, a widely accepted and common technique for conventional composites.[11-13] This is even more critical at the bottom of a proximal box of a large Class II restoration, where light access is often compromised.[7] On the other hand, there are various disadvantages associated with incremental placement technique, such as incorporating voids or contamination between composite layers, failures in bonding between layers, placement difficulty owing to limited access in small cavities and an extended treatment time for placement of layers and their polymerization.[14]

In an attempt to simplify this incremental layering technique and to shorten the chair time, a new generation of resin composites has been launched, known as "bulk-fill" composites.[15,16] These composites are indicated in medium to deep posterior cavities, can be light cured up to 4–5 mm thickness.[17-19] The major advantages of bulk-fill composites are increased depth of cure; the percentage of fillers, the translucent shades, the use of some specific photo-initiators and monomers. Additionally, their increased depth of cure reduces the clinical application time compared to conventional resin composites.[20-24] These bulk-fill composites are classified as flowable bulk-fill, fiber bulk-fill base, and high viscosity/full body bulk-fill.[7,13] Flowable bulk-fill composites are used to fill the deeper aspects of the cavity up to 4 mm depth with the addition of a conventional resin composite occlusally. They should not be in occlusal contact with the opposing tooth structure because of their low percentage of fillers, low wear resistance and poor mechanical properties.[25] For fiber reinforced bulk-fill bases, there are two commercially available materials (flowable or packable), which cannot be placed in open contact areas such as occlusally or inter-proximally as fibers need to be protected by a conventional composite.[13] The other type of bulk-fill composites is the high viscosity/full body resins that are heavily filled and used to fill a cavity up to 4-5 mm deep. Due to their improved physical and mechanical properties, no capping material is required.

An ideal indication for posterior composite restoration is to have preparation surrounded by enamel. However, in many cases tooth preparation usually extents below the cemento-enamel junction (CEJ). It is known that the most critical area of the restorations is the gingival floor, where detachments and microleakage are more frequent. Due to the complexity of the tissue structure, the tooth-resin adhesion generally becomes weaker that impairs the quality of the marginal integrity.[26,27]

Although there have been many in vitro investigations to determine the mechanical properties of bulk-fill composites,[25,28,29] the literature still lacks data regarding their microleakage. As the application of bulk-fill restoratives has recently experienced a significant increase and there is a widespread use of bulk-fill composites in daily practice, it seems relevant to assess their leakage. Therefore, the aim of the current study was to compare microleakage of bulk-fill composites (a flowable bulk-fill, a fiber bulk-fill base, and a high viscosity/full body bulk-fill) and a conventional composite (a nanohybrid composite) in slot Class II restorations with enamel and cement margins. The null hypothesis of the study was that there would be no significant difference in microleakage scores of the composites tested.

MATERIALS AND METHODS

A total of 48 freshly extracted caries-free sound human molars were used in the study. The molars were extracted

for periodontal or orthodontic reasons and were included in the study according to the following criteria: intact crown, caries-free, hypoplastic defect-free, restoration-free, and crack-free. All calculus deposits and remaining connective tissue were removed by scaling (hand instrumentation and ultrasonic scaling) and the teeth were stored in 0.1% thymol solution for up to 4 months after extraction, at room temperature, until the study was carried out.

Cavity preparation

A single operator prepared 96 slot Class II cavities using cylindric diamond burs (Diatech, Heerbrugg, Switzerland) at high-speed handpiece with plenty of water spray.[30] A new bur was used for every ten preparations in order to maintain cutting efficiency. In each tooth, two standardized slot cavities (on mesial and on distal surfaces) were prepared. The overall dimensions of the cavities were standardized as follows: the buccolingual width of the cavities was 1/3 of intercuspal distance; axiopulpal extension of the cavities was 3 mm; the gingival wall was located 1 mm above the CEJ in enamel or 1 mm beyond the CEJ in cement/dentin.[31] The internal angles were rounded and cavosurface margins were sharp without bevel. The dimensions of the cavities were verified with a periodontal probe and digital caliper. The teeth were stored in physiological solution until the restorative procedure.

Restorative procedure

The prepared teeth were randomly divided into four groups of twelve teeth (24 cavities) and each group receiving a different restorative material. All restoratives were used with their respective adhesive according to the manufacturers' instructions and all restorations were placed by one operator. Table 1 lists materials, batch numbers and their respective manufacturers.

A contoured matrix band was placed around the teeth for restorative procedures and was held by finger pressure against the gingival margin of the cavity. The cavities were restored as follows: Group I (high viscosity/full body bulk-fill composite): The enamel surfaces were etched with 37% phosphoric acid (Super Etch, SDI, Bayswater, VIC, Australia) for 30 seconds and the dentin surfaces for 15 seconds, rinsed for 10 seconds and blot dried with a gentle blow of air for at least 5 seconds. A two-step etch-and-rinse adhesive, ExciTE F (IvoclarVivadent, Schaan, Liechtenstein) was applied to all enamel/dentin surfaces for 10 seconds followed by gentle air-drying and light curing with a LED curing unit (Radii Plus, SDI, Victoria, Australia) for 10 seconds. A high viscosity/full body bulk-fill composite, Tetric EvoCeram Bulk Fill (IvoclarVivadent, Schaan, Liechtenstein) was placed in bulk up to 4 mm thickness and light cured for 20 seconds with the same curing unit.

Table 1. Materials tested in the study.

Material	Type	Manufacturer/Batch #	Composition
Tetric EvoCeram Bulk Fill	high viscosity/ full body bulk-fill composite	IvoclarVivadent, Schaan, Liechtenstein/R77065	Bis-GMA, UDMA, Bis-EMA, barium alumina silicate glass filler, ytterbium fluoride, spherical mixed oxide
SureFil SDR Flow	flowable bulk-fill composite	Dentsply Caulk, Milford, DE, USA/1207205	Barium and strontium alumino-fluoro-silicate glass, TEGDMA, modified UDMA, DMA, EBPADMA, pigment, photoinitiator
Ceram.X Mono	nano-ceramic composite	Dentsply Caulk, Milford, DE, USA/1203000406	Methacrylate modified polysiloxane, DMA, barium-aluminum-borosilicate glass, methacrylate functionalized silicon dioxide nanofillers
GC everX Posterior	fiber bulk-fill base composite	GC Corp., Tokyo, Japan/1309121	Bis-GMA, TEGDMA, PMMA, glass fillers and inorganic granular fillers
G-ænial Posterior	microhybrid composite	GC Corp., Tokyo, Japan/1211192	Methacrylate monomers, UDMA, DMA comonomers, prepolymerized fillers, camphorquinone and amine, fluoroaluminosilicate, fumed silica
Filtek Supreme	nanohybrid composite	3M ESPE, Deutschland GmbH, Neuss, Germany/N447764	Bis-GMA, UDMA, Bis-EMA, TEGDMA, Nano silica and zirconia/silica, nanoclusters
Bis-GMA; bisphenol-A glycidyl methacrylate, UDMA; urethane dimethacrylate, TEGDMA; triethylene glycol dimethacrylate, Bis-EMA/EBPADMA; Ethoxylated bisphenol A diglycidly dimethacryrlate, PMMA; Polymethyl methacrylate, DMA; dimethacrylate			

Group II (flowable bulk-fill composite + nano-ceramic composite): The cavities were etched as previously described in Group I. A two-step etch-and-rinse adhesive, Prime&Bond NT (Dentsply DeTrey, Konstanz, Germany) was applied to all cavity surfaces and light cured for 10 seconds. The flowable bulk-fill composite, SureFil SDR™ Flow (Dentsply Caulk, Mildford, DE, USA) was placed in a 4 mm bulk increment in the dentinal part, then light cured for 20 seconds and followed by a covering layer of the nanohybrid composite, Ceram.X Mono (Dentsply/DeTrey) that was light cured for 20 seconds.

Group III (fiber bulk-fill base composite + microhybrid composite): The enamel surfaces were etched with 37% phosphoric acid for 10 seconds then rinsed and dried with an air/water syringe for at least 5 seconds. Self-etch adhesive, G-ænial Bond (GC Corp., Tokyo, Japan) was applied to all cavity surfaces and light cured for 10 seconds. Mesial or distal proximal walls were built with 1 mm thickness using microhybrid composite, G-ænial Posterior (GC Corp.), then light cured for 20 seconds. The fiber bulk-fill base composite, everX Posterior (GC Corp.) was placed into the cavity in 4 mm thickness. The last two mm thickness layer of the cavity was restored using the G-ænial Posterior as an overlay layer.

Group IV (nanohybrid composite): The cavities were etched as described in Groups I and II. Two coats of etch-and-rinse adhesive, Adper Single Bond 2 (3M ESPE, St. Paul, MN, USA) was applied to all enamel and dentin surfaces. The adhesive was gently dried for 5 seconds, then light cured for 10 seconds. The cavities were restored with a nanohybrid composite, Filtek Supreme (3M ESPE), using an incremental technique, each increment being no thicker than 2 mm. All increments were light cured for 20 seconds.

After the restorative procedures, all teeth were stored in distilled water for 24 hours at 37°C in an incubator. The restorations were finished with fine grain diamond burs (Diatech), and polishing was accomplished with Sof-Lex aluminum oxide disks (3M ESPE) of decreasing abrasiveness and rubber points (Kerr Corp, Orange, CA, USA).

Thermocycling

The restored teeth were subjected to the thermocycle (MTE 101 Thermocycling Machine, Esetron, Ankara, Turkey). All teeth were immersed alternately in cold water baths at a temperature of 5°C and hot water at a temperature of 55°C with a dwell time of 30 s in each bath for 1000 cycles.

Dye penetration of the samples

All the root apices of the samples were sealed with a composite (TPH Spectrum, Dentsply), and all tooth surfaces were coated with two layers of nail varnish up to 1 mm from the restoration margins to prevent dye penetration into the tooth except at the resin-tooth interface. The specimens were soaked in a 0.5% basic fuchsin dye at room temperature (22°C) for 24 hours and subsequently rinsed for 5 minutes under running water, then dried and embedded in epoxy resin (Struers, Copenhagen, Denmark). The samples were sectioned mid-sagittally in the mesiodistal plane using a cutting diamond disc with a low-speed water-cooled diamond saw (Isomet Buehler Ltd, Chicago, IL, USA) and two longitudinal sections were made through the center of both restorations in a mesio-distal direction.

Table 2. Frequency of gingival wall microleakage scores (percentages) for enamel and cement margins among the different groups tested.

GROUPS	Gingival wall microleakage scores									
	Enamel					Cement				
	0	1	2	3	4	0	1	2	3	4
Group I Tetric EvoCeram Bulk Fill	10 (83%)	0	2 (17%)	0	0	6 (50%)	0	2 (17%)	3 (25%)	1 (8%)
Group II SDR + Ceram.X Mono	7 (59%)	3 (25%)	1 (8%)	0	1 (8%)	4 (33%)	2 (17%)	1 (8%)	3 (25%)	2 (17%)
Group III GC everX + G-ænial Posterior	5 (42%)	3 (25%)	4 (33%)	0	0	5 (42%)	0	5 (42%)	1 (8%)	1 (8%)
Group IV Filtek Ultimate	10 (83%)	0	2 (17%)	0	0	6 (50%)	1 (8%)	3 (26%)	1 (8%)	1 (8%)

Microleakage analysis

The dye penetration of samples was analyzed by two calibrated evaluators under magnification x20 in a stereomicroscope (Olympus SZX7, Hamburg, Germany) and standardized digital images were obtained. The observers, previously calibrated in accordance with microleakage score criteria, scored each section independently; consensus was reached by reevaluating.

The extent of gingival wall microleakage at enamel/cement was recorded following the score system:[32] score 0= no dye penetration; score 1= dye penetration less than half length of the gingival wall; score 2= dye penetration greater than half length of the gingival floor but limited to 2/3 of the gingival wall length; score 3= dye penetration at the whole length of the gingival wall up to the axial wall; score 4= dye penetration along the axial wall. In all cases, the highest gingival wall dye penetration value of each section was considered as the value of the restoration.

Statistical analysis

The obtained results were statistically analyzed using the statistical software IBM SPSS for Windows version 22.0 software package (IBM SPSS, New York, ABD) with the significance level set at 0.05. The microleakage data was subjected to statistical analysis using the Kruskal-Wallis test. Wilcoxon signed rank test was used to compare gingival wall microleakage scores at enamel and cement within each group.

RESULTS

The gingival wall microleakage scores for enamel and cement margins are presented in Table 2 and illustrated in Figures 1 and 2.

The results demonstrated no significant differences among microleakage scores of all groups either on enamel or cement margins ($p>0.05$). Although, the most common enamel microleakage score was '0' for all groups, none of the restorative materials could eliminate the microleakage completely even on enamel.

When comparing enamel and cement microleakage scores within each restorative material, significant difference was only observed in Group II (SDR + Ceram.X Mono) ($p<0.05$).

Representative stereomicroscopic photographs of microleakage from different groups in enamel and cement margins are displayed in Figures 3-5.

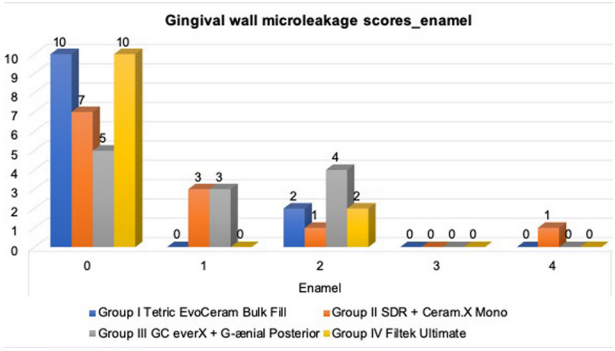


Figure 1. Distribution of gingival wall microleakage scores of the different groups for enamel margins.

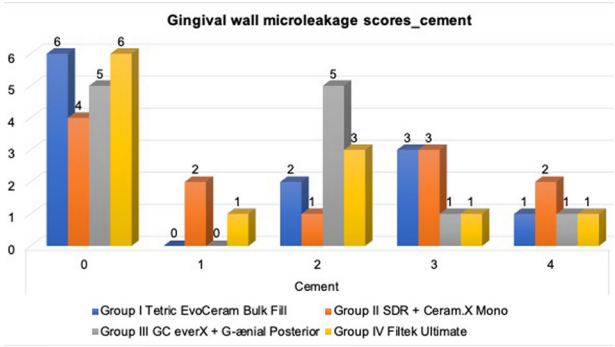


Figure 2. Distribution of gingival wall microleakage scores of the different groups for cement margins.

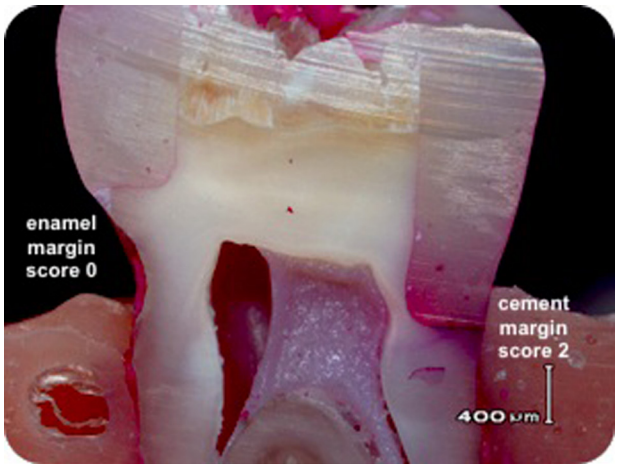


Figure 3. Representative stereomicroscopic photographs (x20) of microleakage in Group 1, in enamel margin scored with 0 and in cement margin scored with 2.

DISCUSSION

One of the best ways to assess the sealing efficiency of a restorative material is the microleakage test.[33] In the current study, the microleakage of different types of bulk-fill composites were investigated and compared

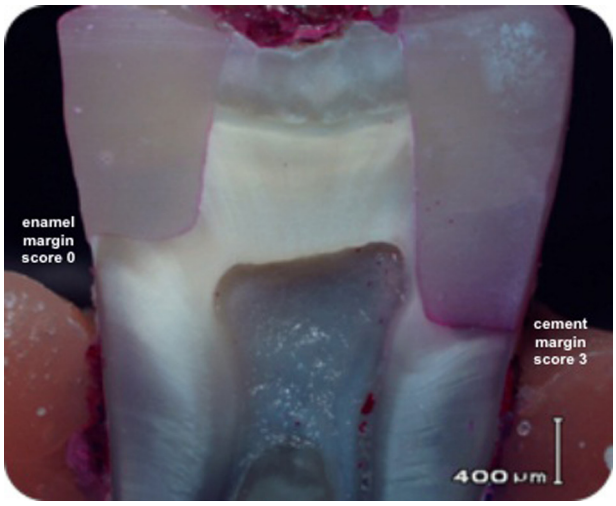


Figure 4. Representative stereomicroscopic photographs (x20) of microleakage in Group 4, in enamel margin scored with 0 and in cement margin scored with 3.



Figure 5. Representative stereomicroscopic photographs (x20) of microleakage in Group 2, in enamel margin scored with 4 and in cement margin scored with 4.

with conventional resin composite and no difference was observed between the tested resin composites. Therefore, the null hypothesis of the study has been accepted.

A previous study that evaluated the cuspal deflection and cervical microleakage of Class II cavities incrementally filled with a conventional resin composite or flowable bulk-fill composite-SDR, no difference was observed between SDR and conventional composite in terms of cervical microleakage scores.[34] In a similar study the enamel and dentin marginal sealing ability of a flowable bulk-fill composite was compared with a nanohybrid composite. While similar leakage values were obtained on enamel margins, bulk-fill resins showed better marginal seal on dentin.[35] In another study the microleakage of two bulk fill restorative materials, X-tra Base and everX Posterior used as a base material was compared with incrementally placed resin composite, G-ænial posterior in endodontically-treated Class II cavities.[36] Similar to our findings no difference was observed among the groups. This assumption was confirmed in an in vitro study that evaluated the gaps between the cavity and restoration margins that were restored with two bulk fill, one flowable bulk-fill, Sonicfill and a conventional incrementally placed composite. The bulk-fill composite restorative materials resulted in similar gap-free margins as the use of a conventional composite.[9] Roggendorf et al.[15] evaluated marginal gaps of posterior resin composite restorations with and without 4 mm flowable base-SDR, using SEM. As a dentin replacement material, the use of SDR with a 4 mm thickness did not affect the results negatively and showed good performance. Concur with these findings, another study reported that bulk-fill restorative materials and incrementally layered composite resulted in a similar proportion of gap-free, marginal interface in enamel even in dentin except for one bulk-fill composite.[37] They attributed this result to the high viscosity of the tested bulk-fill restorative material that influenced the proportion of gap-free marginal interface and the internal adaptation.

Garoushi et al.[38] reported that restorations made from short fiber-reinforced base material (everX Posterior) with conventional composite have similar leakage percentages with the teeth that were incrementally restored with conventional composite (Tetric N-Ceram). On the other hand, contrary to our findings, these groups had a significantly lower microleakage percentage than cavities that were restored with only bulk-fill composite (Tetric EvoCeram Bulk Fill). They reported that the best combination was achieved when short fiber-reinforced composite was used as a base and a conventional composite as a surface layer. However, they used a multi-mode self-etch adhesive resin (G-ænial Bond) for all tested groups and the margins were located above the CEJ. Although the same adhesive, G-ænial Bond was used only in one group (Group III) in our study, it was applied in selective etch mode. The diversity of the obtained results might be related with the margin location of the restoration. Moreover, in our study Tetric EvoCeram Bulk-fill material was used with its respective adhesive system, Adper Single Bond 2. The reason why no difference

was observed between everX and Tetric EvoCeram Bulk-fill resin composites might be related with the used adhesive system. In our study each restorative was used with their respective adhesive. Orlowski et al.[39] compared marginal sealing of four different bulk-fill composites for restorations of class II cavities with dye penetration method. They found that flowable bulk-fill composites showed better marginal sealing with less leakage than bulk-fill composites. They explained their result due to flow consistency of flowable bulk-fill composites during application. Although it has been reported that the fluidity of material effects the marginal adaptation to cavity walls,[40] in the present study no difference was detected between bulk-fill and flowable bulk-fill restorations in terms of microleakage. This might be related with the use of the low viscosity of Surefil SDR flow. Van Ende et al.[41] reported that the filling method and the composition of resin composite (type, size and percentage of filler content, structure of organic matrix, etc.) might have a great contribution role on the adhesion of the composite. In the present study, observing no difference between the tested restoratives in terms of leakage could be associated with the similar properties such as filler volume (between 57-62%) and polymerization shrinkage rate (between the range of 2.25-3.57).[18,19,42,43] It has been reported that there is a direct correlation between filler content and volumetric polymerization shrinkage of resin restorative materials.[44] The polymerization shrinkage of resin composites plays an important role on the breakdown of the tooth/restoration interface, consequently increasing the microleakage.[40] Depth of cure has also a critical importance in the success of restoration. Improper polymerized resin might give rise to gap formation that results with subsequent leakage.[45] Zarzin et al.[46] evaluated the performance of bulk-fill resins in terms of Vickers hardness, degree of conversion, polymerization volume shrinkage and polymerization shrinkage stress. They observed sufficient polymerization properties at 4 mm. In the current study the investigated bulk-fill restoratives had some specific properties that affects their curing depth. With the content of a new dibenzoyl germanium compound (Ivocerin), Tetric EvoCeram Bulk fill, has a higher photocuring activity than camphorquinone (CQ).[28,47] This property with the higher depth of cure leads to decrease gap formation. Moreover, incorporation of some pre-polymerized filler particles and stress relievers in this restorative might have helped to control shrinkage stress.[18,48]

With regards to SDR, the increased translucency of this material ensures adequate mechanical properties owing to the transmission of light through the material much easier. Additionally, in its monomer composition, there is a patented modified UDMA that is responsible to relieve polymerization shrinkage and stress. The SDR technology also comprises the unique combination of such a large molecular structure with a chemical moiety called a "Polymerization Modulator" which is chemically embedded in the center of the polymerizable resin backbone of the SDR.[19] Of the bulk-fill resins tested in the current study, everX Posterior contains E-glass fibers that conduct and scatter the light enables adequate polymerization depth and has CQ and DMAEMA (N, N-dimethyaminoethy methacrylate) as photo-initiator. Another reason why no differences were observed between the restorative materials' microleakage scores might be explained by their adequate depth of cure and special compositions mentioned above.

Despite the notable advances in adhesive systems and restorative materials, resin composite restorations having margins partially or totally located in dentin is still an inevitable problem. Due to factors such as the tubular pattern, high water and low mineral content that is to say non-homogenous structure, dentin still remains a challenging substrate for bonding. However, in the present study, leakage at cement margins was significantly higher than at enamel margin only for SDR + Ceram.X Mono. For the rest of the tested restorative materials, enamel leakage scores were statistically similar to cement scores. In the present study, the tested bulk-fill restoratives were found to be comparable to incrementally placed resin composite with respect to marginal leakage. However, this study was conducted under in vitro conditions and the tested restoratives were only compared with only one type of conventional resin. Therefore, further studies are required to validate real performance of these bulk-fill resins in vivo.

CONCLUSION

Based on these findings, and within the limitations of an in vitro study the following conclusions can be made:

- None of the materials tested could completely eliminated microleakage either on enamel or cement gingival margins of the restorations.
- All tested restorative materials showed similar performance in terms of microleakage.

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