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# MICROLEAKAGE OF THREE CONTEMPORARY BULK FILL RESIN COMPOSITES; THERMOVISCOUS PREHEATED, SONIC FILL AND FLOWABLE BULK FILL IN CLASS I CAVITIES: IN VITRO STUDY

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*ABSTRACT*

**Objective:** The aim was to compare the microleakage of three different types of bulk fill composites in class I cavities.

**Materials and methods:** Fifteen freshly extracted molars were selected for this study. Standardized occlusal cavities measuring 5X4X4 mm were prepared. The cavities were distributed among the three tested groups according to the type of resin composite; whereas; Group A: Viscalor thermoviscous preheated bulk fill, group B: Sonic fill bulk fill composite and group C: SUREFIL SDR™ flowable bulk fill. The restored molars were subjected to artificial aging, then teeth were immersed in 2% methylene blue dye solution for 24 hours at 37°C. Each tooth was then sectioned into 2 halves and the specimens were examined under a stereomicroscope. All the specimens' images were subjected to image analysis to determine the depth of dye penetration in Mm. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

**Results:** A statistically significant difference was found between group B and each of group A and group C where ($p$=0.018) and (p<0.001) respectively. No statistically difference was found between group A and group C where ($p$=0.332). The highest mean value of dye penetration was found in group B, while the least mean value was found in group C.

**Conclusions:** None of the tested composites could completely eliminate microleakage along the tooth restoration interface in class I cavities. Flowable bulk fill composites and preheated composites showed less microleakage in comparison to the sonic fill composite.

**KEYWORDS**: Bulk fill composite, preheating, sonic activated, microleakage.

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## INTRODUCTION

Resin composite is the most frequently used direct restorative material for posterior restoration, because of the increase in patients' esthetics demands and the merits of tooth structure preservation. Despite the continuous improvements of the materials and techniques, polymerization shrinkage of resin composite is still considered the main problem. The generated shrinkage stresses result in microleakage at the restoration tooth interfaces[1].

Microleakage is characterized by the invasion of microorganisms and their products, ions, and chemicals at the tooth restoration interface with subsequent consequences such as; postoperative sensitivity, marginal staining, recurrent decay, and eventually failure of restoration[2].

Different attempts have been proposed to minimize the influence of polymerization shrinkage such as; increasing the filler load, modifying the monomer matrix, using different curing protocols, and incremental packing techniques[3]. Although, Incremental packing has been proven to minimize the overall volumetric shrinkage of resin composite especially in cavities with high C-factor. It showed many adverse effects such as void incorporating, contamination between the subsequent layers as well as prolonged application times[4].

In an attempt to simplify the packing technique and to shorten the chairside time, bulk fill composites were introduced[5]. Bulk-fill composites have gained widespread clinical use thanks to their improved curing properties, better control of polymerization shrinkage stresses, and reduction of cuspal deflection[6,7]. Nowadays it is considered an acceptable alternative to conventional resin composites as proved by the systematic review and meta-analysis published by Mai Akah et al., in 2016[8]. Many types of bulk-fill composites were introduced having different insertion techniques. The technique by which the composite is introduced into the cavity affects the physical and mechanical properties of the restorative material. Unfortunately, internal voids are inevitable at the tooth restoration interface, the amount of which can be affected by the material type and the insertion technique.

Thermal energy increases the mobility of the molecular chains of the resin monomer and considerably enhances the flowability of paste-like composites. Also, ultrasonic energy yields a more random and looser configuration that results in the decreased viscosity of the composite upon extrusion[9].

Many studies have evaluated the internal gap formation of dental resin composites[10,11]. However, little data is available regarding the effects of different insertion techniques of the contemporary bulk fill composites on the microleakage and internal gap formation to cavity walls and margins.

Therefore, the purpose of this investigation was to compare the microleakage of three different types of bulk fill composites with different insertion techniques; Viscalor (thermoviscous preheated), sonic fill (sonic activated), and SUREFIL SDR™ (Smart Dentin Replacement flowable bulk) in class I cavities assessed with dye penetration. The null hypothesis was that there would be no difference in the microleakage between the tested composites.

## MATERIALS AND METHODS

### Tooth selection, grouping and cavity preparation

Fifteen freshly extracted, caries-free human molars were selected for this study. The molars were randomly distributed among the three tested groups according to the type of resin composite (n=5 molars); whereas; Group A: Viscalor thermoviscous preheated bulk fill, group B: sonic fill bulk fill composite, and group C: SUREFIL SDR™ flowable bulk fill composite.

Standardized occlusal cavity measuring 5 mm in mesiodistal diameter, 4mm in buccolingual diameter, and 4 mm in depth was prepared in each tooth. Cavities were prepared using diamond tips (SF-31SC, Mani, INC, Japan) attached to a high-speed air turbine under water cooling. The bur was replaced after every five preparations. The cavity dimensions were verified with a periodontal probe **(figure 1)**.

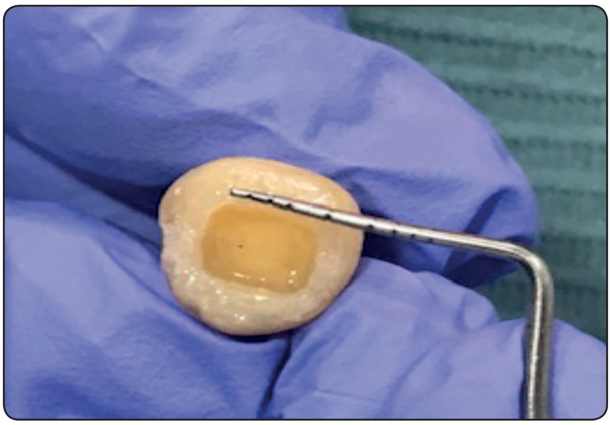

Fig. (1): The cavity dimensions were verified with a periodontal probe.

### Bonding procedure

The bonding procedure was done for all the cavities using the universal adhesive; All bond universal (Bisco, Schaumburg, IL, USA) following the selective enamel etching technique. Whereas; the cavity enamel margins were etched for 30 seconds, thoroughly rinsed for 20 seconds, and dried. Then the bonding agent was applied into the cavity walls in two consecutive coats with 15 seconds of air blowing for each, and light-cured once for 20 seconds. The light cure device used in this study was the Bluephase light-curing unit (Ivoclar Vivadent, Schaan, Liechtenstein).

### Restorative procedures

For group A: The viscalor composite compule (A2) was loaded into the Viscalor dispenser and heated on mode 1 for 30 seconds heating time to a temperature of 65°C. After the preheating time, the heating device stopped indicating that the compule reached the required temperature. The dispenser light flushed, indicating the start of the packing time (2.5 minutes) as per the manufacturer's instructions. And the composite was then packed into the cavity in a single increment of 4mm depth and light-cured for 20 seconds **(figure 2)**.


Fig. (2): Viscalor dispenser and composite compule.

For group B: The sonic fill composite compule (A2) was uncapped and loaded into the sonic fill 2 handpiece and attached to the dental air turbine and the sonic energy level was adjusted to 3. The resin composite was then inserted into the cavity in a single increment of 4 mm depth, and light-cured for 20 seconds **(figure 3)**.

Fig. (3): Sonic fill composite application.

For group C: The flowable bulk fill composite SureFil SDR was injected in a 3 mm bulk increment to fill the dentinal part of the cavity, then light-cured for 20 seconds. As per the manufacturer's instructions, the top one mm of the cavity was restored using the nanoceramic composite Ceram X Mono (A2) that was also light-cured for 20 seconds **(figure 4)**. The teeth were stored in distilled water at temperature 37°C for 24 hours before the artificial aging.

The material types, insertion techniques, composition, and manufacturers are presented in table 1.

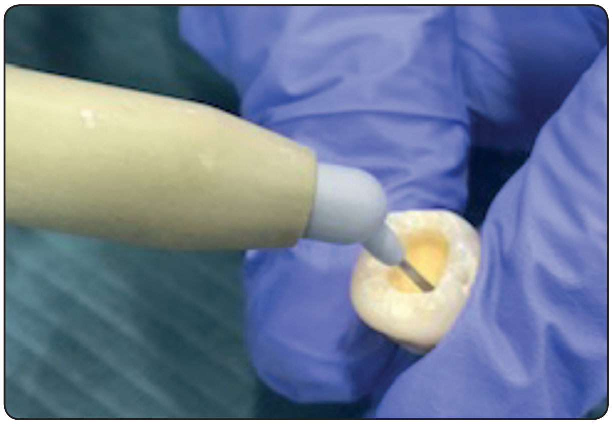

Fig. (4): SureFil SDR composite application.

TABLE (1): Types, insertion technique, composition and manufacturers of the materials used in this study

| Product | Material type | Insertion technique | Shade | Matrix composition | Filler % by weight | Manufacturer |
|---|---|---|---|---|---|---|
| Viscalor | Thermoviscous bulk fill paste like resin composite | Heated | A2 | Bis-GMA, aliphatic dimethacrylate, inorganic fillers | 83 | VOCO, Cuxhaven, Germany www.voco.dental.com |
| Sonic fill 2 | Bulk-fill paste-like resin composite | Sonic activated | A2 | Poly(oxy-1,2- ethanediyl), α,α´-[(1- methylethylidene) di-4, 1-phenylene] bis[ω- [(2- methyl-1- oxo-2- propen-1-yl)oxy], 2,2´- ethylenedioxydiethyl dimethacrylate | 81.3 | Kerr, CA, Orange, USA www.kerrdental.com |
| SUREFIL SDR™ | Flowable bulk fill resin composite | Injectable | A2 | Barium and strontium alumino-fluoro-silicate glass, TEGDMA, modified UDMA, DMA, EBPADMA, pigment, photoinitiator | 68 | Dentsply Caulk, Milford, DE, USA/ www.dentsplysirona.com |
| Ceram.X Mono | Nano-ceramic composite | Packable | A2 | Methacrylate modified polysiloxane, DMA, barium-aluminum-borosilicate glass, methacrylate functionalized silicon dioxide nanofillers | 76 | |
| Scotchbond universal etchant | 35% phosphoric acid gel | NA | NA | NA | NA | 3M, St Paul, MN, USA www.3M.com |
| All Bond Universal | Universal light cure adhesive system | NA | NA | MDP, Bis-GMA, HEMA, ethanol, and water. | - | Bisco, Schaumburg, IL, USA www.bisco.com |

***Abbreviations: Bis-GMA; bisphenol-A diglycidyl ether dimethacrylate; TEGDMA; triethylene glycol dimethacrylate, UDMA; urethane dimethacrylate, DMA; dimethacrylate, EBPADMA; ethoxylated bisphenol A dimethacrylate, MDP; 10-methacryloyloxydecyl dihydrogen phosphate, HEMA; hydroxyethyl methacrylate.***

### Artificial aging, dye Penetration, and specimen preparation

The restored molars were subjected to artificial aging by thermocycling for 1000 cycles between temperatures of 5°C and 55°C, with a dwell time of 30 seconds in each bath and a transfer time of 10 seconds[12] in the 100 SD Mechatronic thermocycler, Germany.

Double coats of nail varnish were applied on the tooth surfaces, except for 1 mm away from the restoration margins. Afterward, the teeth were immersed in 2% methylene blue dye solution (Imperial Chemical Industries, London, England) for 24 hours at 37°C, and then thoroughly rinsed for five minutes[13]. Each tooth was then sectioned mesio-distally into 2 halves with a micro slicing machine (IsoMet 4000; Buelher, USA) to result in ten specimens per group (n=10) **(figure 5)**.

### Interface examination and Microleakage measurement (image analysis):

The specimens were then examined under a stereomicroscope (Nikon MA 100, Japan) at a magnification of X50 to determine the extent of dye penetration along with the tooth restoration interface. All the specimens' images were subjected to image analysis to determine the depth of dye penetration in Mm using the image analysis software (Omnimet, Buehler, Germany) **(figure 6)**.

### Statistical analysis:

The mean and standard deviation values for the dye penetration depth were calculated for each group. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests and showed parametric (normal) distribution. One-way ANOVA followed by Tukey post hoc test was used to compare between more than two groups in non-related samples. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

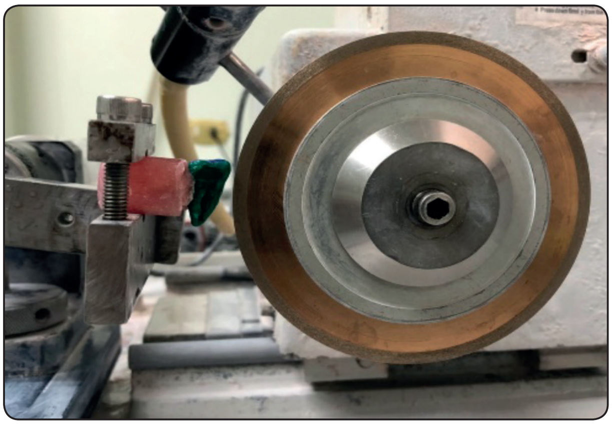

Fig. (5): Tooth sectioning into two halves using a micro slicing machine.

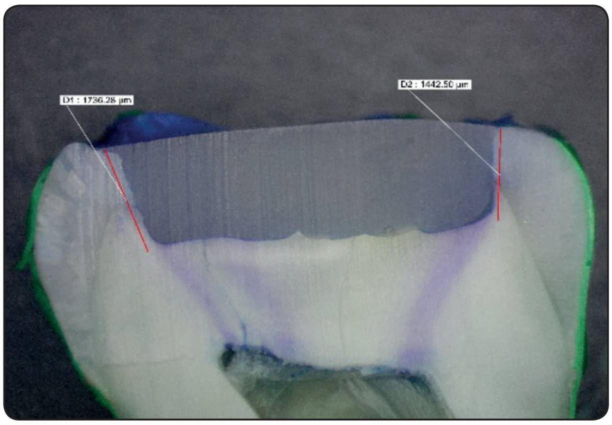


Fig. (6): Determining the depth of dye penetration using the image analysis software.

## RESULTS

The means and standard deviations of the dye penetration depth along with the tooth restoration interface for the three tested composites are presented in table 2 and figure 7. There was a statistically significant difference between group A, group B, and group C ($p$=0.001). A statistically significant difference was found between group B and each of groups A and group C, where ($p$=0.018) and ($p$<0.001), respectively. No statistically significant difference was found between group A and group C where ($p$=0.332). The highest mean value for dye penetration was found in group B, while the least mean value was found in group C.

TABLE (2): The mean, standard deviation (SD) values of penetration depth of different groups.

| Variables | Penetration depth | |
|---|---|---|
| | **Mean** | **SD** |
| **Group A Viscalor thermoviscous** | 1572.79 [b] | 209.16 |
| **Group B Sonic fill 2** | 1795.95 [a] | 66.32 |
| **Group C SDR flowable bulk fill** | 1462.87 [b] | 195.89 |
| ***p-value*** | **<0.001*** | |

***; significant (p<0.05) ns; non-significant (p>0.05)***

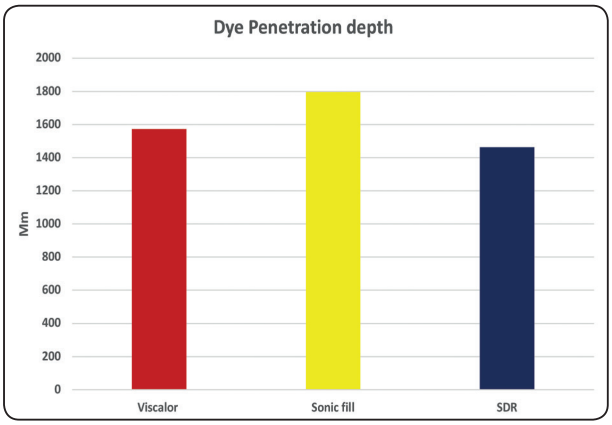


Fig. (7): Bar chart representing the dye penetration depth in Mm for the three tested composites.

## DISCUSSION

The study aimed to compare the effect of different insertion techniques of three types of bulk fill resin composites on the microleakage in class I cavities after artificial aging using the dye penetration technique. The results showed a significant difference in the microleakage degrees amongst the three tested bulk fill composites. Every resin composite type has a different insertion technique, emphasizing that the material type and placement technique influence the internal adaptation to cavity walls and margins. Thus, the null hypothesis was rejected.

Bulk fill composites can fill the cavity in a single layer making the procedure less technique sensitive[8]. Additionally, Bulk fill formulations allow for modulation of the polymerization reaction by using stress-relieving monomers and fillers and the incorporation of reactive photo-initiators. Furthermore, bulk placement reduces void incorporation and contamination between composite layers, leading to more durable restorations[14,15].

Similar to conventional composites, filler types and contents, matrix compositions and manufacturing process of bulk fill resin composites are quite different between the different categories either; preheated, sonic activated or flowable bulk fill composites[16,17,18].

Moreover, the viscosity of the composite material affects the adaptability and hence the gap formation incidence between the composite and the cavity walls and margins. Such gaps severely affect the mechanical properties of the composite material, particularly under aging conditions, since they could act as stress raisers, and lead to clinical failures of the restorations[19,20,21].

Composite preheating is an alternative method to the conventional placement of resin composites. Composite heating reduces the material viscosity without affecting the composition and physicochemical properties, which allows for improving composite to cavity wall adaptation with the subsequent reducing internal voids. [22,23]. The Viscalor dispenser is a newly introduced heating device to be used in combination with Viscalor bulk fill composite compules. The manufacturer claims that the dispenser application gives the material a lower viscosity, allowing it to flow optimally into the cavity margins and undercuts, minimizing the chance for air bubbles entrapment and the risk of marginal gaps. The device mode 1 is heating to a temperature of 65°C for 30 seconds pre-warming time and 2.5 minutes working time.[24]

The sonic activated sonic fill composite resin has a depth of cure of 5 mm. It has a specific handpiece that provides sonic energy at different intensities. As the sonic energy is generated through the handpiece, the built-in modifier causes the viscosity to decrease up to 87%[25].

Also, Flowable bulk fill composites are an alternative option used to fill the deeper aspects of the cavity with its flowable consistency enhancing the material adaptation and self-leveling within the cavity confinement. It can fill up to 4-6 mm depth with the addition of a conventional resin composite occlusally[26].

Class I cavity design was selected in this study, so that, it was possible to assess the degree of leakage under such challenging stresses generated at the highest C-factor in comparison to any compound or complex cavity designs[27]. A single type of universal adhesive system was selected to bond all the resin composite types, to standardize the impact of the adhesive system and adhesion protocol on the microleakage of the three tested composites.

The dye penetration technique is one of the most commonly used methods for microleakage assessment in vitro[28]. This technique is highly feasible with no radiation hazards. In addition, the dye has a contrasting color to both the tooth and the restoration, without any chemical interactions with the specimens. Thermal cycling was applied to the samples, simulating the degradation of the bond interface that occurs in the oral cavity[29,30]. The results of the current study revealed a statistical difference between the sonic fill technique and each of the Viscalor and the SDR, with more leakage reported in the sonic fill group. This result was in an agreement with Eunice et al., 2012, who found no effect for the sonic application in minimizing the microleakage to cavity walls[31]. Also, Julio et al., 2020, who showed higher interfacial stress and lower bond strength for sonic fill composite with dentin in comparison to Tetric N-Ceram and Tetric N-Ceram bulk fill. Their result could be attributed to the low modulus of elasticity together with the higher tensile and compressive strength of sonic fill composite (8.6 GPa). Despite this interaction of mechanical properties reduced the internal stresses inside the material, it raised the interfacial stresses at the cavity walls and margins[26].

The results were also following Gulbike et al., 2020, who observed increasing void percentage for sonic fill packing compared to conventional and preheated composites[32]. This result was attributed to the sonic vibration, which resulted in more air intake into the restoration. Furthermore, sonication may lead to the gathering of smaller and isolated bubbles already present in the resin into larger void sizes. It was also found that when the sonicated composite returns to its original rheological properties, the air trapped in the material becomes more pronounced and could severely affect the restoration properties[33].

In addition, the restorative procedure using the sonic fill system is more difficult, and it requires a trained operator for better control over the ultrasonic device[34].

Regarding the increased leakage in the sonic fill group in comparison to the other types, this could be attributed to the degree and the rate of viscosity decrease. As previously mentioned, sonication decreased the viscosity up to 87% during the composite insertion and when the sonic energy is interrupted, the composite resin returns to a more viscous consistency, suitable for sculpturing. This is not happening with the flowable bulk fills which retain their low viscosity and hence keep the adaptation to cavity walls and margins[26]. The superior adaptation of Viscalor preheated composite is justified in literature by the thermal energy that forces the composite monomers apart, allowing them to slide by each other more readily improving the material adaptation. Additionally, the rate of cooling of the Viscalor composite which is about 3 minutes is a relatively long period permitting suitable adaptation to cavity walls together with better stress release if compared to the sonic fill resin composite[24,35]. Another study emphasized the effect of composite heating on material viscosity by testing the viscosity of bulk fill composites at different temperatures. The results revealed a viscosity of 0.05±0.00 kPa s at 25°C and 0.03±0.01 kPa s at 37°C; which was about 48.7% reduction in viscosity with heating[36]. The results of this study could be correlated to another study done by Yang et al., in 2019, which evaluated the composite extrusion force. They found that the extrusion force required for the preheated Viscalor compule was 66.49±14.16 N, while, 153.62±1.56 N force was required to extrude the unheated compule[37], indicating a pronounced decrease in the material's viscosity with the Viscalor heating.

SDR flowable bulk fill showed the least microleakage levels in comparison to the other types. This result was in agreement with another study that tested the marginal sealing ability of flowable bulk fill composite versus conventional composite to enamel and dentin. Although no difference was found for the enamel, bulk fill resins showed better marginal seal with dentin[38]. This was explained by the intimate union between the flowable bulk fill composite with the cavity floor and walls. Moreover, flowable bulk acted as a flexible intermediate layer that helped in the release of shrinkage stresses. Also, the increased translucency of SDR allows for deeper light transmission as well as the incorporation of modified UDMA in the composite matrix are considered the causes behind the stress releasing property of the SDR. The SDR technology also comprises the unique polymerization modulator which is embedded at the center of the resin. Those modulators resulted in a higher depth of cure and decreased interfacial gap together with the self-leveling property[39,40]. In addition to the inherent properties of the SDR flowable bulk fill composite, the dye penetration might be decreased because of the sealability of the overlying nanoceramic composite. This top coating layer might help to prevent the dye from penetrating deeper along with the underneath SDR- dentin interface.

Possible limitations of the study are the use of a single energy level in the sonic fill handpiece (Level 3) and a single heating temperature (65°C). Different sonic frequencies, as well as different temperatures, might have different effects on the physical and rheological properties of bulk fill composites and hence on their microleakage. Moreover, further studies are required to validate the clinical performance of these bulk fill resins in vivo.

## CONCLUSIONS

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

- None of the evaluated composite categories could completely prevent microleakage along with the tooth restoration interface in class I cavities.
- Flowable bulk fill composites and preheated composites showed better adaptation to the cavity walls in comparison to the sonic fill composite.
- Sonic fill composite packing is a less predictable technique requiring training and experience in comparison to the other tested techniques.


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