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The degree of conversion and class II cavity microleakage of different bulk fill composites placed with different restorative techniques

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ABSTRACT

Objectives: The current study aimed to investigate the degree of conversion and microleakage of bulk fill composites placed using different restorative techniques.
Materials and methods: Four types of resin composites were used: Incrementally-placed Filtek Z350 XT (INC), Filtek Bulk Fill Posterior Restorative (B), Filtek Bulk Fill Flowable (F), 3M ESPE, United States, and SonicFill (SON), Kerr, United States. For the degree of conversion (DC) test, five cylindrical samples were prepared for each group (5 mm diameter and 5 mm depth) (n = 5). Five groups, representing different material-technique combinations, were investigated: Group (INC) in which the incremental technique was used for packing Z350 composite (control), Group (B) in which Filtek Bulk Fill Posterior Restorative was placed as a one 5 mm deep increment, Group (FB-1C) in which Filtek Bulk Fill Flowable was used to fill 2 mm in the base of the mold followed by 3 mm Filtek Bulk Fill Posterior Restorative on top of it then both materials were cured simultaneously, Group (FB-2C) in which 2 mm of Filtek Bulk Fill Flowable was placed at the base of the mold and cured then the rest of the mold was filled with Filtek Bulk Fill Posterior Restorative followed by a final cure, and finally Group (SON) in which SonicFill composite was placed as a one 5 mm increment. The DC of both top and bottom surfaces of each sample was measured using Fourier-transform infrared spectroscopy-Attenuated Total Reflectance (FTIR-ATR). Forty-five extracted human premolars were used for the microleakage assessment. One or two class II slot cavities, with standardized dimensions, were prepared in each tooth. Each of the five investigated groups was represented by 11 cavities (n = 11). The cavities were filled using the same composite material-technique combinations used for the DC test. The restored teeth were thermocycled then immersed in 2% methylene blue solution for 24 h at 37 °C. Dye penetration was assessed by examining longitudinal mesio-distal sections through the restored teeth using a stereomicroscope at 25× magnification. The microleakage was scored using predetermined scoring criteria. The results were statistically analyzed.
Results: The (INC) group showed significantly higher DC for the top surface than all bulk fill groups. No significant difference was found between the (INC), (FB-1C) and (FB-2C) groups regarding the DC of the bottom surface and the three groups had the highest DC while the (SON) group had the lowest DC values. Comparing the top and bottom surfaces of each single group, only the (FB-1C) and (FB-2C) groups showed a significant difference. No significant difference was found between the microleakage scores of the five investigated groups.
Conclusions: Conventional incrementally-placed composite has a higher DC compared to all bulk fill types regardless of the technique used for the bulk fill composite. The sonic-activated composite exhibits lower DC of the bottom composite surface than all other bulk fill composites. Regarding the microleakage, bulk fill composites, used with any of their possible techniques, do not perform any inferior compared to incremental composites.

1. Introduction

Bulk fill composites, which were introduced into the dental market in 2011, are now considered the state of art of restorative dentistry. The development of bulk fill composites mainly aimed to simplify the composite placement process, reduce the chair side time thus decreasing both patient and dentist exhaustion. Using bulk fill composite also eliminates several variables that occur during the conventional incremental packing. However, despite all these advantages, concerns have raised that this simplification in the procedural steps may come at the expense of critical factors that may influence the restoration success [1]. It is feared that compared to conventional incremental packing, bulk placement may result in higher polymerization stresses that can compromise the integrity of the resin composite-tooth interface leading to microleakage. In 1979, microleakage was

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defined by Kidd et al. as a clinically undetectable penetration of bacteria, their metabolites, enzymes, toxins, ions, and other cariogenic factors between the filling and the cavity wall [2]. This penetration leads to marginal discoloration, sensitivity and is considered the forerunner for recurrent caries. Another concern related to bulk fill composite is that the deepest layers of composite may not get adequate light intensity to allow for a sufficient degree of conversion (DC). Inadequately cured composite exhibits lower mechanical properties as well as inferior esthetic quality and color stability [1].

The manufacturers of bulk fill composites emphasize that the new developments in the resin formulations, composite translucency, photo-initiators' light sensitivity and application techniques allow the production of resin composite that can be placed in one large increment without increasing the polymerization stresses or reducing the DC [3]. Proving these claims would make the usefulness of the incremental packing questionable.

According to their viscosity and filler loading, bulk fill composites are available in two forms: sculptable paste-like form (with higher filler volume fraction) and flowable form (with lower filler volume fraction) [4]. Manufacturers adopt different materials and techniques to formulate bulk fill composites. Some manufacturers rely on using high molecular weight monomers that possess a decreased number of reactive groups. This moderates the polymerization shrinkage and the composite stiffness; two factors that significantly influence the polymerization stresses [1]. Other bulk fill products use addition-fragmentation monomers which contain active sites that cleave during polymerization leading to polymer network relaxation with resultant stress relief [5]. Another product uses high viscosity composite together with modifiers that are activated by sonic energy that is delivered by a special handpiece. Once applied, the sonic energy results in a marked reduction in the viscosity (up to 84%) of the composite increment allowing better adaptation to the cavity wall. The viscosity then builds up gradually giving a chance for some internal flow before composite matrix gelation thus alleviating some of the polymerization stresses [6,7]. In addition to these polymerization stresses alleviating strategies, bulk fill composites manufacturers also claim that the filler and matrix translucency was increased and that the photo-initiator efficiency was optimized in order to ensure adequate DC [1].

Different results were reported in literature regarding the DC of bulk fill composites. Alshali et al. found that some brands of bulk fill composite had DC comparable to that of incremental composite while other bulk fill types had significantly lower DC [8]. On the other hand, Kubo et al. compared the DC of bulk fill and conventional composites manufactured by the same producers and found that for some manufacturers, the conventional (incrementally placed composite) had a lower DC than their bulk fill counterparts even at a depth as low as 2 mm [9]. Taubock et al. reported no significant difference between the non-sonic-activated bulk fill and the incremental composite and both groups had lower DC compared to the sonic-activated composite [10].

Diverse results were also reported regarding the microleakage. Campos et al. reported no significant difference between sonic-activated bulk fill composite and incrementally placed composite regarding their microleakage [11]. Conflicting results were found by Ozel et al. who reported that sonic-activated composite exhibited significantly less microleakage than the incremental type [12]. Swapna et al. compared the microleakage of one sonic-activated bulk fill composite with two brands of bulk fill composites that are placed without sonication and reported that the former type exhibited significantly less microleakage than the two latter groups [13]. Orlowski et al. found that the flowable bulk-fill and sonic-activated composite restorations had better marginal sealing compared to the sculptable (paste-like) non-sonicated bulk fill types [14].

Until now, no conclusive evidence is available to support or negate the effectiveness of bulk fill composites. Therefore, the aim of the current study was to compare the DC and microleakage of bulk fill composites placed using different restorative techniques in class II cavities. In order to achieve this, two null-hypotheses were tested. The first null-hypothesis was that using different bulk fill composites with different restorative techniques does not affect the composite's degree of conversion (DC). The second null-hypothesis was that using different bulk fill composites with different techniques does not affect the microleakage.

2. Materials and methods

2.1. Materials

Four types of resin composite materials were used in the current study. The materials are listed in Table 1:

Table 1
Materials used in the study.

Composite products and assigned symbols	Consistency	Composition			Manufacturer
		Inorganic matrix	Fillers		
			Type	Percentage	
Filtek Z350 XT (incrementally placed) (INC)	Sculptable	- Bis-GMA - UDMA - TEGDMA - Bis-EMA - PEGDMA	- Non-aggregated 20 nm silica, 4–11 nm zirconia - Aggregated zirconia/ silica clusters	63.3 vol%	3M ESPE, United States
Filtek Bulk Fill Posterior Restorative (B)	Sculptable	- AUDMA - UDMA - 1, 12-dodecane-DMA	- Non-aggregated 20 nm silica, 11 nm zirconia - Aggregated zirconia/ silica clusters - 100 nm ytterbium trifluoride fillers	58.4 vol%	3M ESPE, United States
Filtek Bulk Fill Flowable (F)	Flowable	- Bis-GMA - UDMA - Bis-EMA - Procrylate resins	- 0.01 to 3.5μ zirconia/ silica particles - 0.1 to 5.0μ ytterbium trifluoride fillers	42.5 vol%	3M ESPE, United States
SonicFill Bulk Fill composite (SON)	Inserted in the cavity as sculptable composite then the viscosity decreases upon sonication	- TMSPMA - Silicon dioxide - Bis-EMA - Bisphenol A bis (2-hydroxy-3-methacryloxypropyl) ether - TEGDMA	Silica, glass	83 vol%	Kerr, United States

Bis-GMA: bisphenol-A-glycidyl dimethacrylate; UDMA: urethane dimethacrylate; TEGDMA: triethylene glycol dimethacrylate; Bis-EMA: ethoxylated bisphenol-A-dimethacrylate; PEGDMA: polyethylene glycol dimethacrylate; TMSPMA: 3-(trimethoxysilyl) propyl methacrylate [5,14–16].

2.2. Methods

2.2.1. Degree of conversion (DC)

The DC of five groups, representing the different material-technique combinations, was investigated (Fig. 1). For each group, five cylindrical samples were prepared (n = 5). A specially designed Teflon mold with a diameter of 5 mm and a depth of 5 mm was used for sample preparation. The detailed steps of sample preparation are explained in Table 2. Bluephase LED curing unit (light intensity of 1200 mW/cm^2), Ivoclar Vivadent AG, Switzerland, was used for sample preparation. The prepared samples were then stored in distilled water for 24 h before testing. Two Fourier-transform infrared spectroscopy (FTIR) spectra were obtained for each sample; one for the top surface and one for the bottom. The spectra were obtained with Vertex 70 FTIR spectrometer, BRUKER, Germany, using attenuated total reflectance (ATR) method in the spectral range of 4000-400 cm^{-1} with resolution of 2 cm^{-1}. Four FTIR spectra were obtained for the four investigated types of composite materials in their uncured state so that their peak intensities would be used as baseline measurements during calculating the DC of the cured samples. The FTIR-ATR mode was used as it collects the light reflected from the surface of the sample directly, whether a solid cured sample or an uncured paste, with no need for sample preparation (i.e. no need to grind the sample into powder or to prepare potassium bromide pellets).

For each sample, the ratio of the intensities of an aliphatic C=C peak (at 1637 cm^{-1}) against a standard aromatic peak (at 1610 cm^{-1}) was determined before and after curing. The degree of conversion (DC) was calculated according to the following equation [10]:

$$DC = \left(1 - \frac{\text{Absorbance}^{\text{Cured}}_{1637\ \text{cm}^{-1}}/\text{Absorbance}^{\text{Cured}}_{1610\ \text{cm}^{-1}}}{\text{Absorbance}^{\text{Uncured}}_{1637\ \text{cm}^{-1}}/\text{Absorbance}^{\text{Uncured}}_{1610\ \text{cm}^{-1}}}\right) \times 100$$

2.2.2. Microleakage

The microleakage of the five groups shown in Fig. 1, representing the different material-technique combinations, was measured using the dye penetration method. Forty-five caries-free upper and lower premolars were used. The teeth were obtained from the outpatient clinic, Surgery Department, Faculty of Oral and Dental Medicine, Cairo University, after taking the patients' consents and the approval of the Ethics Committee. Only teeth with relatively long crowns were used so that upon cavity preparation, the gingival margins would lie on the enamel. Initially, the teeth were hand-scaled to remove any soft tissue residues or hard deposits. The teeth were then disinfected by immersion in formalin for 7 days as recommended in previous research [17].

Before cavity preparation, the teeth were randomly allocated into the five groups. In each premolar, one or two class II slot cavities were

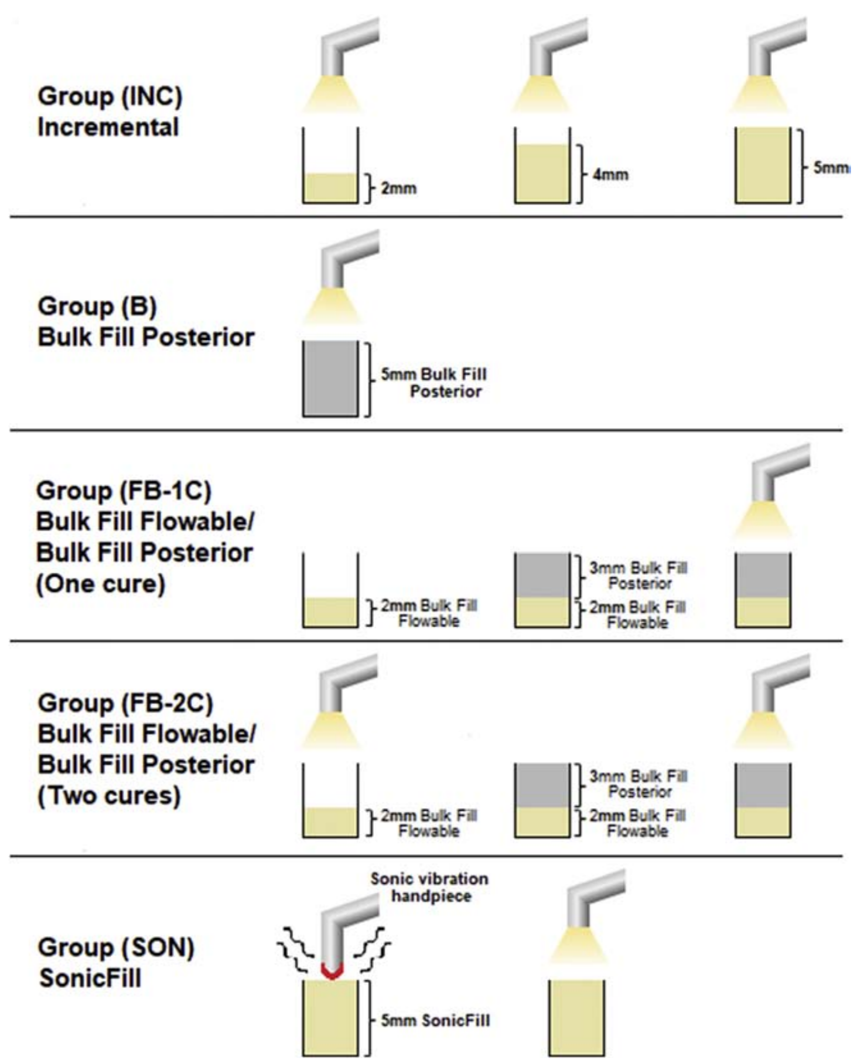

Fig. 1. Schematic illustration of the different material/restorative technique combinations.

Table 2
The materials and restorative technique steps used for sample preparation for the different groups of both tests.

Group name	The used composite	Technique*
(INC) (Control)	Filtek Z350	The mold (or cavity) was filled with Filtek Z350 XT using the incremental technique: - The first increment (2 mm) was placed into the bottom of the mold, cured for 20 s. - The second increment (2 mm) was placed and cured for 20 s. - Finally, the last increment (1 mm) was placed and cured for 20 s.
(B)	3M Bulk Fill Posterior Restorative	The mold (or cavity) was completely filled with 3M Bulk Fill Posterior Restorative composite as one increment then cured for 40 s.
(FB-1C)	- 3M Bulk Fill Flowable Restorative - 3M Bulk Fill Posterior Restorative	- The base of the mold (or cavity) was lined with 2 mm increment of 3M Bulk Fill Flowable Restorative. - The rest of the mold (or cavity) (3 mm) was filled by 3M Bulk Fill Posterior Restorative. - The two composite increments were simultaneously cured with a single cure for 40 s.
(FB-2C)	- 3M Bulk Fill Flowable Restorative - 3M Bulk Fill Posterior Restorative	- The base of the mold (or cavity) was lined with 2 mm increment of 3M Bulk Fill Flowable Restorative then cured for 40 s. - The rest of the mold (or cavity) (3 mm) was filled by 3M Bulk Fill Posterior Restorative then cured for 20 s.
(SON)	SonicFill	The mold (or cavity) was completely filled with SonicFill composite as one increment, the increment was sonic-activated then cured for 20 s.

*: All curing times were determined according to the manufacturers' instructions. For the four bulk fill groups, after demolding the samples or removing the matrix, two extra curing cycles (10 s each) were provided from the buccal and lingual directions as recommended by the manufacturers for class II cavities.

prepared depending on the size of the tooth. Each slot cavity had a depth of 5 mm, buccolingual width of 3 mm and gingival seat thickness of 2 mm. In order to ensure cavity standardization, all cavities were prepared by one operator and the dimensions were checked during and after cavity preparation using a periodontal probe (Hu-Friedy, United States). The same bonding agent, Clearfil 3S Bond Plus, Kuraray Dental, United States, and the same bonding procedure were used for all cavities and the filling process was performed by just one operator to eliminate any source of variation. The selective etching approach was used where only the enamel was etched using Scotchbond Universal Etchant gel, 3M ESPE, United States, for 10 s then washed and dried before the self-etch adhesive was applied to the entire cavity wall. The adhesive was applied to the cavity, rubbed against the walls using a brush for 10 s, gently dried for 5 s then finally cured for 10 s. The cavities were filled using the different material-restorative technique combinations explained in Table 2. Each group was represented by 11 cavities (n = 11). A metallic matrix was used to ensure a proper restoration contour. The restored teeth were stored in distilled water for 24 h then subjected to thermocycling where they were alternately immersed in 5 °C and 60 °C water baths for 1000 cycles with a dwell time of 30 s. Before immersion in the dye, the apical foramen of each tooth was blocked using sticky wax. Then, each tooth was painted with two coats of transparent nail polish that covered all tooth surface as well as the restoration surface except for 1 mm above and 1 mm below the gingival margin of the restored cavity. The teeth were then immersed in 2% methylene blue solution for 24 h at 37 °C then were longitudinally sectioned in a mesiodistal direction using a diamond disk under copious water spray (Horico, Diaflex, Berlin, Germany). The longitudinal sections were examined using stereomicroscope (Leica, Leica Microsystem, Germany) with 25× magnification and the gingival microleakage of each cavity was quantified by determining the extent of penetration of the dye into the tooth-composite interface. The microleakage was scored according to the criteria shown in Fig. 2. The investigator who assessed the microleakage was blinded to the group names where the teeth were given numerical codes, unknown to the investigator, and were only decoded after the microleakage was scored.

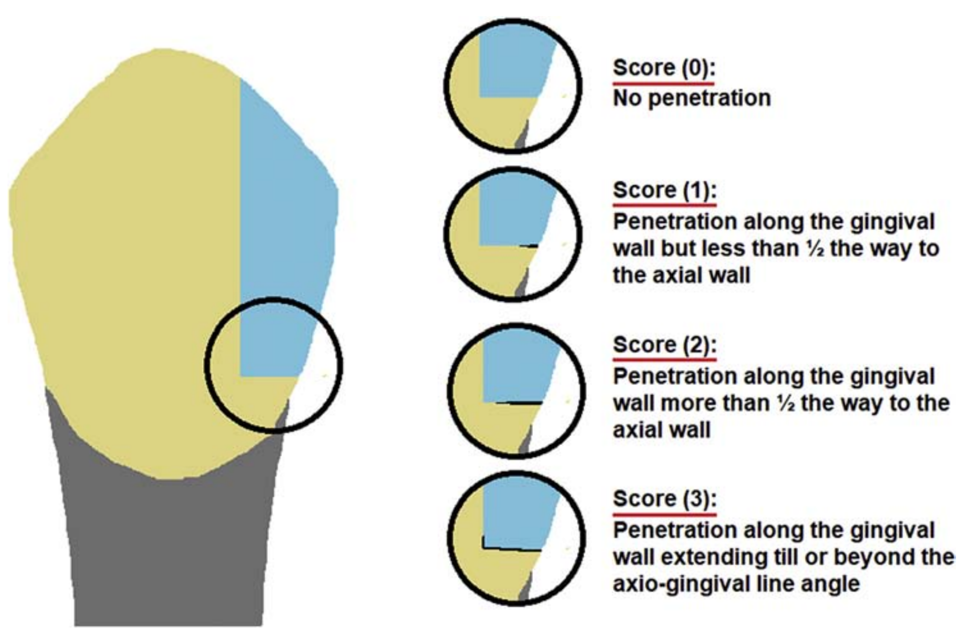

Fig. 2. Schematic representation of the criteria used for microleakage scoring.

2.2.3. Statistical analysis

The data were presented as means and standard deviation values. Data were explored for normality using the Shapiro-Wilk test. The one-way ANOVA test was used to compare between the DCs of the different groups while the Tukey's HSD post-hoc test was used for pairwise comparison. The paired *t*-test group was used to compare between the top and bottom surfaces of each group. The Chi-square test was used to compare the frequency distribution of the microleakage scores among the different groups. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

3. Results

3.1. Degree of conversion (DC)

Comparing the DC of the top surfaces of the five groups, the one-way ANOVA and Tukey's HSD test results revealed that the incremental group (INC) had the significantly highest DC while no significant difference was found among the other four groups (Fig. 3A). Regarding the bottom surface, no significant difference was found among the (INC), (FB-1C) and (FB-2C) groups. These three groups had the significantly highest DC followed by the (B) group while the (SON) group had the lowest DC among all groups (Fig. 3B).

When comparing the DCs of the top and bottom surfaces within each single group, each one of the (INC), (B) and (SON) groups had no significant difference between the top and bottom surfaces. On the other hand, for both the (FB-1C) and (FB-2C) groups, the bottom surfaces had significantly higher DC compared to the top surfaces (Fig. 4).

3.2. Microleakage

The Chi-square test results revealed no significant difference between the five investigated groups (Fig. 5). Representative stereomicroscopic images of the different microleakage scores are shown in Fig. 6.

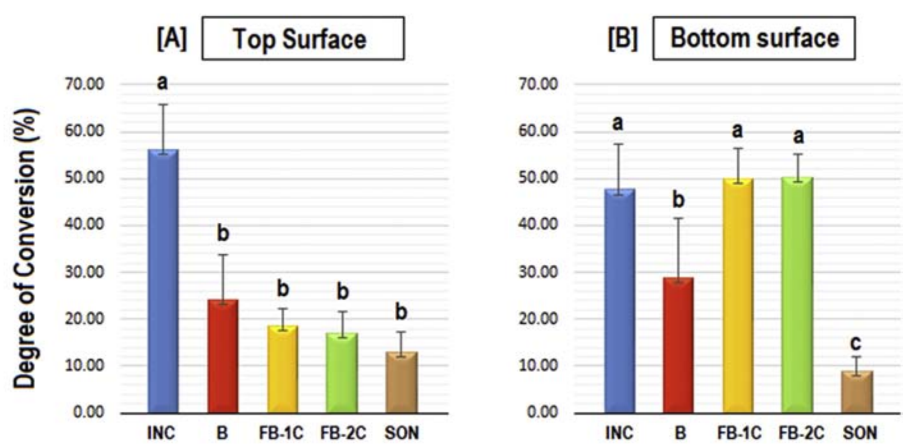

Fig. 3. Comparison of the DC of the top surfaces [A] and the bottom surfaces [B] among the five groups.

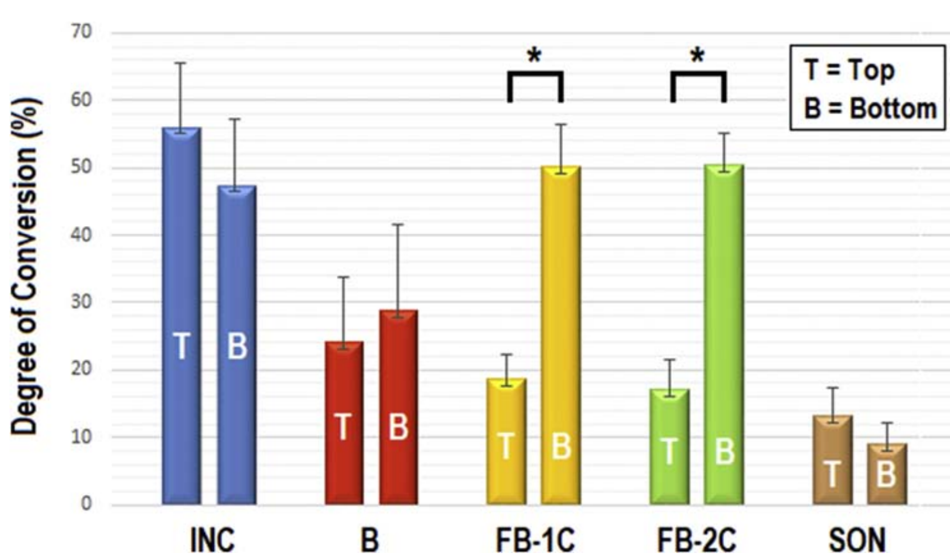

Fig. 4. Comparison between the DC of the top and bottom surfaces of each single group.

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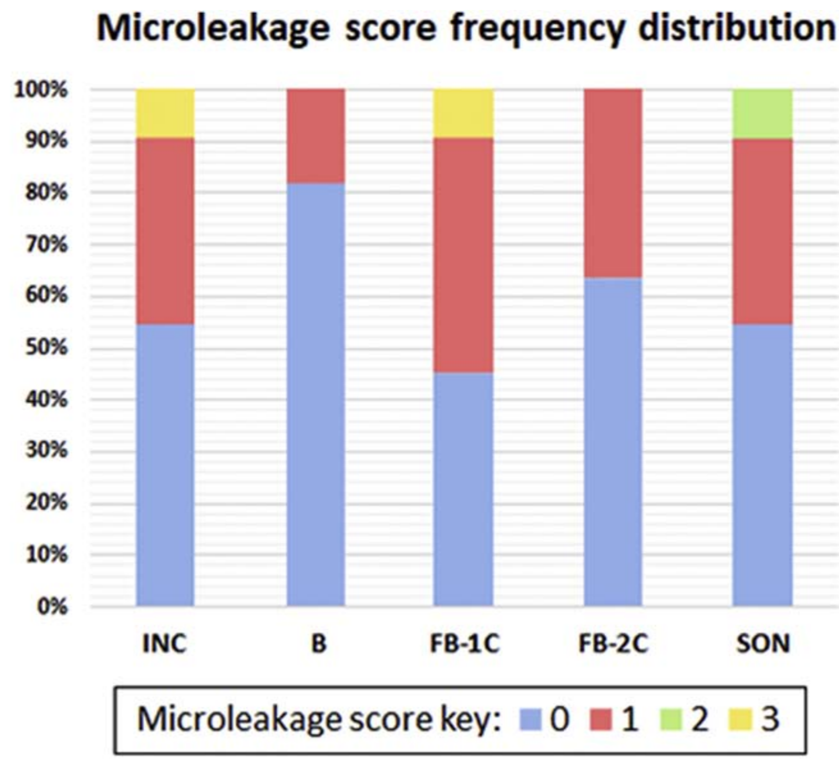

Fig. 5. Frequency distribution of the gingival microleakage scores of the different groups.

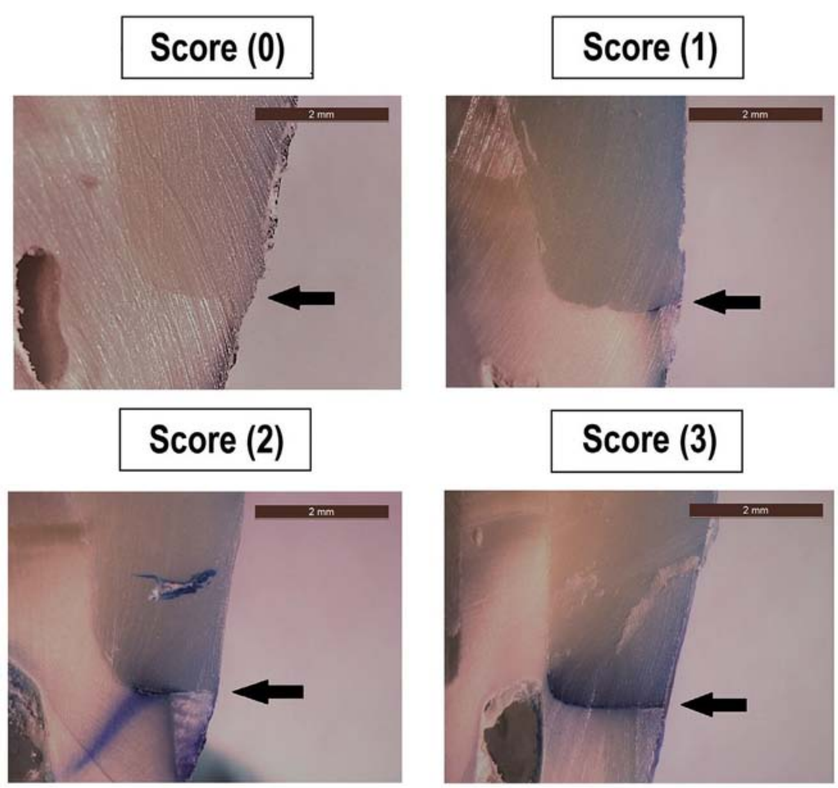

Fig. 6. Representative stereomicroscopic images of the different gingival microleakage scores (x25). It was noticed that in some specimens, once the dye reached the dentino-enamel junction, it flared into the adjacent dentinal tubules.

4. Discussion

Despite the clinical advantages offered by the bulk fill composites, in terms of the simplicity of their application, their use triggered some concerns related to their curing efficiency, polymerization shrinkage and possible microleakage [1]. To investigate the validity of these concerns, the current study compared the degree of conversion (DC) and microleakage of bulk fill composites placed with different restorative techniques. It must be highlighted that comparing the different restorative techniques can only be accomplished through investigating different types of bulk fill composites because each technique has specific requirements that dictate using particular types of bulk fill materials. In the present study, the traditional incrementally-placed composite was used as a control as it is considered the gold standard.

The DC is a critical factor that greatly influences several properties related to the composite restoration longevity such as the solubility, color stability, mechanical properties and even biocompatibility. In the present study, the DC was measured using the FTIR which represents a simple convenient method whose results are consistent with the results of other more complicated techniques [18].

Based on the DC results of the present study, the first null-hypothesis was rejected. It was found that the incremental composite had significantly higher DC on the top surface than all bulk fill composite groups (Fig. 3A). Understanding the chemical composition of the different tested composites is essential for interpreting these results. The polymeric matrix of the Z350 composite used in the incremental group (INC) is based on a combination of Bis-GMA, UDMA and TEGDMA while the Filtek Bulk Fill Posterior composite, which forms the top surfaces of the (B), (FB-1C) and (FB-2C) groups, is based mainly on UDMA [5,16]. The TEGDMA is a low molecular weight polymer that is used to decrease the viscosity and improve the flow properties of the composite [19]. The viscosity of the composite is one of the factors that greatly influence the DC. A low viscosity allows free migration of the reactive species that are responsible for the initiation and propagation of the polymerization reaction. On the contrary, a high viscosity restricts the mobility of the free radicals and limits the extent of polymerization even when the reactants are not yet depleted [3]. Although it is well-accepted that the UDMA has a low viscosity [20], yet it seems that the absence of TEGDMA in the formulation of the Filtek Bulk Fill Posterior composite [used in the (B), (FB-1C) and (FB-2C) groups] and its presence in the Z350 composite [used in the (INC) group] may have allowed the latter group to attain a higher DC.

In addition to this viscosity-mediated effect, it has been previously proven that combining TEGDMA and Bis-GMA in the composite formulation, as in the (INC) group composite, allows a synergistic effect that increases the DC. This is attributed to the uniquely flexible structure of the TEGDMA molecule, caused by the presence of ether linkages in its backbone, which allows for a higher crosslinking density [21].

Apart from the difference in the chemical composition, the volume of the increment of composite may also play a role. Unlike the 5 mm thickness used with bulk fill composites, the 2 mm increment in case of the (INC) group may allow easier energy transfer where the reactive species have to span only a short distance to reach their intended reaction sites. This may help attaining a higher DC.

Interestingly, only the (FB-1C) and (FB-2C) groups, among all bulk fill composites, had relatively high DC of their bottom surfaces that did not differ significantly from that of the (INC) group but was significantly higher than the (B) and (SON) groups (Fig. 3B). What makes the (FB-1C) and (FB-2C) unique among the bulk fill composite groups is that their bottom surfaces are composed of flowable bulk fill composite. Compared to the sculptable bulk fill composites, flowable composites have a lower filler volume fraction. It has already been established that composites with lower filler volume fractions can attain higher DC values compared to composites with higher filler content if all other composition variables are standardized [22]. This is mediated by two effects: first; the lower filler content contributes to more translucency which in turn allows more light penetration within the matrix with subsequent higher DC [22]. Second, flowable composites have relatively low viscosity which allows more effective curing and higher DC as previously explained [3,22].

The (SON) group had the lowest DC among all groups regarding the bottom surface (Fig. 3B). This may be attributed to the difference in the chemical constitution of the resin matrix or the photo-initiator system compared to the other groups. In addition, the sonic-activated composite had the highest filler volume fraction among all investigated composites which may have contributed to this relatively low DC. This may be the reason why the manufacturer of the sonic-activated composite emphasizes that the clinician should provide additional curing for 10 s directed from the lingual and buccal sides after removal of the matrix during placing the composite in class II cavities. It should be noted that this recommendation was meticulously followed during sample preparation.

Regarding the microleakage, no significant difference was found between the five groups indicating that the bulk fill composites, regardless of the implemented restorative techniques, did not perform any less efficiently compared to incremental composite (Fig. 5). Based on these findings, the authors fail to reject the second null-hypothesis. These results are in agreement with those reported by Campos et al. [11] and Mosharrafian et al. [23]. However, contradicting results were reported by Ozol et al. who found that sonic-activated composites had less microleakage compared to the incremental type [12]. This difference in results may be attributed to the difference in the depth of the prepared proximal cavity where a depth of 3.5–4 mm was used in the former study while the cavity depth in the present study was 5 mm.

It is noteworthy that the absence of significant difference in microleakage between the groups despite the differences in the DC indicates that the microleakage is a multifactorial phenomenon that is not only influenced by the DC. Other factors may also play an important role such as the amount of polymerization shrinkage, the direction of the polymerization stresses as well as the flow properties of the uncured composite that affect its ability to attain efficient wetting of the cavity walls. For example, both (B) and (INC) groups showed no significant difference in microleakage although group (B) had significantly lower DC than the incremental group (INC) for both top and bottom surfaces. This can be explained by the fact that each of the two groups has certain factors that contribute to low microleakage. For the (INC) group, the incremental placement technique decreases the polymerization stresses and allows each increment to compensate for the shrinkage of the previous one [24]. On the other hand, the Filtek Bulk Fill Posterior composite used in group (B) contains addition-fragmentation monomer that alleviates the stresses that result from the polymerization shrinkage. In addition, the Filtek Bulk Fill Posterior composite is mainly based on UDMA while the incremental Z350 composite contains BisGMA in addition to the UDMA. The UDMA is known to have a higher molecular weight compared to BisGMA [19,20]. This relatively high molecular may have decreased the overall polymerization shrinkage in group (B) thus decreased the interfacial stresses and the microleakage. Having stresses-reducing factors in the favor of each of the two groups may account for the insignificant difference between them.

The microleakage of the sonic-activated (SON) also did not differ from the incremental (INC) group. Although the incremental packing decreases the interfacial polymerization stresses which may favor the sealing ability of the (INC) group, the sonic activation used in the (SON) group may also have a comparable effect. The sonication may improve the sealing ability by a twofold mechanism; a direct mechanism in which the vibration-induced low viscosity improves the composite's adaptation to the cavity wall, and an indirect mechanism in which the low viscosity alleviates the polymerization stresses thus maintains the integrity of the tooth-composite interface [12]. In addition, the sonic-activated composite used in the present study has a higher filler volume fraction compared to the control which may have decreased the overall polymerization shrinkage and the resultant stresses thus decreased the microleakage potential.

Finally, these results may dispel the clinicians' concerns about the performance of bulk fill composites. In addition, the fact that there was no significant difference in microleakage between the group that used the sculptable bulk fill composite alone (B) and the two groups that used it in combination with flowable bulk fill (FB-1C and FB-2C) is considered promising. It's important to emphasize that having to make extra clinical steps, such as lining the cavity with flowable composite, to ensure adequate curing and avoid microleakage would have negated the main advantage that characterized bulk fill composites, which is their restorative procedure simplicity.

5. Conclusions

Based on the results of the current study, the following conclusions can be drawn:

1. The sculptable bulk fill composites, used with any restorative technique, exhibit a lower DC compared to the incrementally placed type.
2. The flowable bulk fill composites exhibit comparable DC to incrementally placed composites while the sonic-activated type has the lowest DC among all bulk fill composite types.
3. For the incrementally placed, the sculptable bulk fill and the sonic-activated bulk fill composites, the DC at a 5 mm depth is comparable to the DC at the top surface.
4. The restorative technique used with bulk fill composites does not affect the microleakage potential which is comparable to that of incrementally placed composite.

Conflicts of interest

The authors have no conflict of interest to disclose.

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