COMPARISON OF DEGREE OF CONVERSION AND MICROLEAKAGE IN BULKFILL FLOWABLE COMPOSITE AND CONVENTIONAL FLOWABLE COMPOSITE (AN IN VITRO STUDY)

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ABSTRACT

INTRODUCTION: Composite restorative materials represent one of the many successes of modern biomaterials research, since they replace biological tissue in both appearance and function. Several aspects during selection of composite restorative materials should be considered, among which are the degree of conversion and microleakage.

OBJECTIVE: The objective of this study is to compare the degree of conversion and microleakage in bulkfill flowable and conventional flowable composite.

MATERIALS AND METHODS: Bulk-fill flowable composites (SDR, Dentsply), (Filtek Bulkfill flowable, 3M ESPE) and conventional flowable composite (X-Flow, Dentsply), (Filtekz350xt flowable, 3M ESPE) were tested. 28 cylindrical specimens were prepared from each material in Teflon mold. Degree of conversion (DC) was determined using Fourier transform infrared spectroscopy (FTIR) test. 44 non-carious molars were selected and Class V cavities were made and filled with composite in bulk increment then immersed in a basic fuschine dye. Samples were sectioned in the center of the restoration and observed with a 40x stereomicroscope; extent of dye penetration was measured. Statistical analysis of the results was performed using ANOVA and Post Hoc for DC, Kruskall-Wallis and Mann Whitney test for microleakage.

RESULTS: A statistically significant difference was recorded for the degree of conversion test between the groups with p (<0.001). Microleakage test showed no statistically significant difference between the four groups at occlusal margins with $p=0.563$, nor at the cervical margins with $p=0.243$.

CONCLUSIONS: Within the limitations of the current study, it was concluded that the bulkfill flowable composite (SDR) had better DC in comparison to the other three flowable composites used in the study. It was also concluded that it had the best marginal seal in both occlusal and cervical margin among all the groups.

KEY WORDS: Degree of Conversion, leakage, bulkfill flowable composite, conventional flowable composite.

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INTRODUCTION

Composite resins are nowadays considered materials of choice in restorative dentistry because of the increasing demand for high-quality esthetic materials in everyday practice. Recent types of dental composite are expected to have mechanical properties comparable to those of tooth enamel and dentin and provide a long life of service. Nevertheless, several factors limit the performance of composites, of which degree of conversion (DC) (1-7).

Despite the continuous evolution of these resins, problems such as polymerization shrinkage and marginal microleakage still occur. Furthermore, with high-viscosity composite resin, it is difficult to obtain perfect adaptation to the internal cavity surface and proper marginal seal of the cavity (1,2,8,9).

Recently, a new class of resin-based composite, the so-called “bulk-fill” composites have been introduced into the dental market with the purpose of time savings. The unique advantage of this new material class is stated that it can be placed in a 4 mm thickness bulks to be cured in one step instead of the current incremental placement technique, without adverse effect on polymerization shrinkage or degree of conversion. Manufacturers stated that the polymerization shrinkage of those materials is even less than that of commonly used flowable and conventional resin-based composites. Consequently, problems arise from polymerization shrinkage could be reduced (2,10-12).

Therefore, it would be of interest to compare the degree of conversion and microleakage in two bulkfill flowable composites and two conventional flowable composites. The first null hypothesis of the present study was that there was no difference in the degree of conversion between bulkfill and conventional flowable composites. The second null hypothesis was that there was no difference in the sealing ability of the two types of flowable composites.

MATERIALS AND METHODS

The composites employed in the current study were two bulkfill flowable composites; SDR (Dentsply) and Filtek Bulkfill flowable (3M ESPE), in addition to two conventional flowable composites; X-Flow (Dentsply) and Filtek Z350 XT flowable (3M ESPE). Moreover, two single-step self etch adhesives; Xeno V (Dentsply) and Single Bond Universal (3M ESPE) were also employed in the study (table 1).

1. Degree of conversion test

Twenty eight cylindrical shaped specimens (6mm diameter × 4 mm thickness) of each tested material were prepared in a Teflon mold. They were applied inside the mold so that the bulkfill flowable composites were placed in a single increment of 4mm thickness, and the conventional flowable composites were applied in two increments of 2mm thickness each. Mylar strip was placed over the composite resin and glass slide was slightly compressed to extrude excess material. Photo-activation was performed by positioning the light guide tip in contact with the glass slide on the top surface of the specimen. Each specimen was irradiated according to the manufacturer instructions for 20 s with light emitting diode (LED) curing unit (Elipar S10; 3MESPE, st paul, MN, USA) with a light intensity of 1200 mW/cm2, and with curing time of 10 or 20s according to the manufacturers(table 1). Standardization of the distance between light source and specimen was obtained by the thickness of the glass slide and mylar strips which gave smooth surfaces for the specimens.

Fourier transform infra-red spectroscopy [FTIR] (Shimadzu Ft/IR-8400-Spectrophotometer, Japan) was used to evaluate the degree of conversion. Each of the polymerized specimens (n=7) of each composite was milled into a fine powder with a mortar and pestle. 50 mg of the powder was mixed with 5 mg of potassium bromide powder and pressed to produce a thin disc, which was placed in a specimen holder and transferred to the spectrophotometer. The absorbance peaks were recorded using the diffuse-reflection mode of FTIR under the following conditions: 32 scans, over a wave length of 400–4000 cm^{-1}.

Unpolymerized specimens (n=7) of each composite resin were smeared onto thin potassium bromide discs, placed into a cell holder, and then a spectrum was obtained with the same parameters as for the polymerized specimens.

Degree of conversion was determined by estimating the changes in peak height ratio of the absorbance intensities of aliphatic C$=$C peak at 1638 cm^{-1} and that of an internal standard peak of aromatic C$=$C at 1608 cm^{-1} during polymerization, in relation to the uncured material. DC % for each specimen was calculated using the following equation:

$$DC\% = \left\{1 - \frac{(1638\ cm^{-1}/1608\ cm^{-1})\ cured}{(1638\ cm^{-1}/1608\ cm^{-1})\ uncured}\right\} \times 100$$

2. Microleakage test

Sample preparation

44 sound molars, freshly extracted free of caries, cracks, restorations and dental anomalies were collected from out patients' clinic surgery department, faculty of dentistry; Alexandria University. These teeth were recently extracted for periodontal reasons and selected for this in vitro study. Each tooth underwent scaling and root planing with an ultrasonic device to remove residual organic tissue. The teeth stored in 0.5% Chloramine T aqueous solution at 4°C till for disinfection and stored in a saline solution weekly changed for two months till being experimented.

Using diamond stone under air-water cooling, an experienced operatorprepared cuboidal cavities (height × width × length = 2 mm × 4 mm × 4mm), the margins of the cavities were butt-joint 1mm above the CEJ. Cavity dimensions are measured by a periodontal probe, plain fissure with a cutting tip of length 4mm was used to verify the dimensions of the cavity.

4 composites were used in this study (Filtek Bulkfill flowable, Filtek Z350xt flowable 3M ESPE) with their adhesive system single bond universal (3M ESPE) and (SDR, X-Flow Dentsply) with their adhesive system XenoV^{+} (Dentsply) presented in table(1). As it is recommended by the manufactures to use the composite with its adhesive system .

All prepared samples were randomly divided into four groups of 11 teeth each according to the restoration material used: Group 1, SDR (Dentsply); Group 2, X-Flow (Dentsply); Group 3: Filtek Bulkfill flowable (3M ESPE); Group 4, Filtek Z350xt flowable (3M ESPE). Two coats of the adhesive XenoV^{+} (Dentsply) were applied to the cavity walls in group1 and 2; they were then lightly air dried and light cured for 20 seconds. Two coats of the single bond universal (3M) were applied to the cavity walls in group3 and 4; they were then lightly air dried and light cured for 20 seconds according to manufacture instructions presented in table (1).

Flowable composites were applied and cured by a light emitting diode (LED) curing unit (Elipar S10; 3M ESPE, St. Paul, MN, USA) with a light intensity of 1200 mW/cm^2, and the curing time was according to the manufacturers (table 1).

Composites were applied so that the bulkfill flowable composites were placed in a single increment of 4mm thickness, and the conventional flowable composites were applied in two increments of 2mm thickness each.

After 24 h, the restorations were finished with fine-grit diamond stone, polished with a graded series of flexible discs (Sof-Lex, 3M ESPE, St. Paul, MN, USA) and stored in distilled water at 37°C. Samples were completely sealed with two layers of nail polish, leaving 1-mm window around the cavity margins. The samples in each group were subjected to 500 thermal cycles of 5 ± 2°C to 55 ± 2°C with dwell time of 60 s.

Samples were immediately immersed in basic fuchsin dye for 24 hours. The teeth were removed from the dye, brushed under tap water for 1 min. The samples were sectioned longitudinally in the middle of the composite restoration, using a microtome under water cooling at low speed. Two sections were obtained for each tooth. For all sections, pictures of the restoration interface were taken under × 40 stereomicroscope (Nikon-Japan)) to assess the extent of dye penetration.

Statistical analysis of the results was performed using ANOVA and post Hoc test for DC. Kruskall-Wallis and Mann Whitney test used for microleakage analysis.

Table 1: Materials Composition and Application procedures.

Materials	Composition	Application procedures
1- Filtek™ bulk fill flowable composite (Bulk fill flowable composite) (3M ESPE)	Matrix: Bis GMA, UDMA, bisEMA and Procrylate resins. Filler: Zirconia and silica.01-3.5μ with average particle size is 0.6 μ,ytterbium trifluoride0.1-5.0μ Filler content (wt%/ vol%):64.5%/42.5%	Apply in an increment of 4mm thickness and light cured for 20s
2- Filtek™ Z350 XT (conventional flowable composite) (3M ESPE)	Matrix: BisGMA, TEGDMA and Procrylate resins Filler: Ytterbium trifluoride 0.1-5.0 microns, non-agglomerated/ non-aggregated surface modified 75nm silica filler, non-agglomerated/ non-aggregated surface modified 20nm silica filler, surface modified aggregated zirconia/silica cluster filler (20nm silica and 4-11nm zirconia). The aggregate has average cluster particle 0.6-10 microns. Filler content (wt%/ vol%):65%/46%	Apply in an increment of 2mm thickness and light cured for 20s
3- Single bond universal (Total-Etch and Self- Etch) (3M ESPE)	MDP phosphate monomer HEMA. Dimethacrylate resin. Silane. Vitre bond copolymer. Filler. Ethanol. Water. Initiator.	Apply two coats with scrubbing motion for each 20s, then air dry for 5s,then light cured for s
4- Smart dentine replacement (SDR)™ (Bulk fill flowable composite) (Dentsply)	Matrix SDR™ patented urethane di-methacrylate resin Di-methacrylate resin Di-functional diluents Filler: Barium and Strontium alumino-fluoro-silicate glasses. Photoinitiating System, average filler size:4.2 μm Filler content (wt%/ vol%):68%/45%	Apply in an increment of 4mm thickness and light cured for20s .
5- X-Flow (conventional flowable composite) (Dentsply)	Matrix Di- and multifunctional acrylate and methacrylate resins Diethylene glycol dimethacrylate (DGDMA). Di- and multifunctional acrylate and methacrylate resins Diethylene glycol dimethacrylate (DGDMA) Fillers: Strontium alumino sodium fluoro phosphor silicate glass Filler content (wt%/ vol%):60%/38%	Apply in an increment of 2mm thickness and light cured for20s .
6- XenoV+ (Self etch approach) (Dentsply)	Bifunctional acrylate. Acidic acrylate. Functionalized phosphoric acid ester. Acrylic acid. Water. Tertiary butanol. Initiator. Stabilizer.	Apply two coats with scrubbing motion for 20seach, then air dry for 5s,then light curedfor 20s.

RESULTS

Degree of conversion (DC)

Results of the degree of conversion test are presented in table2 and figure 1. ANOVA revealed a statistically significant difference in DC among the four groups of composites tested (P < 0.05). SDR (Bulk Fill flowable composite) showed the highest DC with mean value 57.97 in comparison to the other three composites Filtek Bulkfill flowable (bulkfill flowable composite) 49.0, X-Flow 40.21 and Filtek Z350 xt (conventional flowable) showed the lowest DC with mean value 38.89.

Table 2: Comparison between the different studied groups according to degree of conversion.

	Filtek bulk fill (n = 7)	Filtek Z350xt (n = 7)	SDR (n = 7)	X-Flow (n = 7)	F	P
Degree of conversion						
Min. – Max.	45.0 - 53.0	30.20 – 45.0	51.0 – 64.0	38.0 – 42.0		
Mean ± SD.	49.0 ± 2.65	38.89 ± 6.21	57.97 ± 4.59	40.21 ± 1.52	31.877*	<0.001*
Median	49	42.0	58.0	40.0		
Sig. bet. grps	p_1= 0.001*, p_2= 0.002*, p_3= 0.003*, p_4 <0.001*, p_5= 0.931, p_6<0.001*					

F: F test (ANOVA)
p_1: p value for Post Hoc test (Tukey) for comparing between Filtek bulk fill and Filtek Z350xt
p_2: p value for Post Hoc test (Tukey) for comparing between Filtek bulk fill and SDR
p_3: p value for Post Hoc test (Tukey) for comparing between Filtek bulk fill and X-Flow
p_4: p value for Post Hoc test (Tukey) for comparing between Filtek Z350xt and SDR
p_5: p value for Post Hoc test (Tukey) for comparing between Filtek Z350xt and X-Flow
p_6: p value for Post Hoc test (Tukey) for comparing between SDR and X-Flow
*: Statistically significant at $p \leq 0.05$

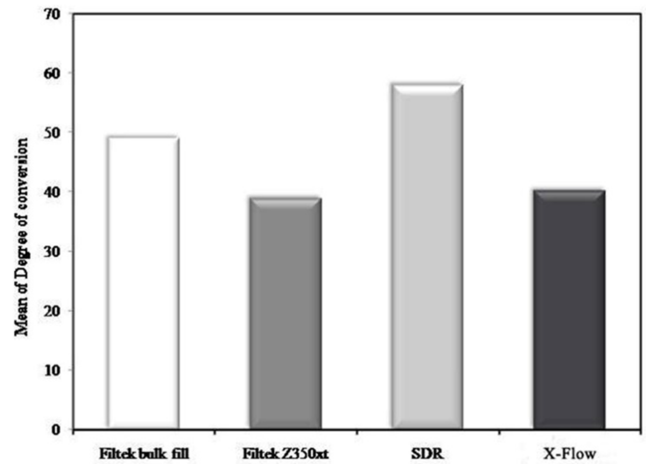


Figure 1: Comparison between the different studied groups according to degree of conversion.

Microleakage

The degree of leakage which has occurred at the occlusal and gingival margins at the tooth and restorations interface was given a score from 0-3 in an ascending pattern as follows (13):

0- no leakage.
1- leakage up to one-half of the cavity walls.
2- leakage along the full length of the cavity walls.
3- leakage along the full length of the cavity and including the axial surface.

The mean values for dye penetration through the composite-tooth interface at the occlusal margins are shown in table (3) and represented graphically in figure (2). It was shown that the bulkfill flowable composite (SDR) in Group 1 recorded the lowest mean value of microleakage scores among the four groups (mean=0.18), whereas the conventional flowable composite (X-Flow) in Group 2 showed the highest mean value (0.45). Kruskall-Wallis test proved no statistically significant difference in the microleakage scores among the four
groups (p=0.563).

Regarding dye penetration through the composite-tooth interface at the gingival margins, results are shown in table (3), and represented graphically in figure (3). It was shown that SDR flowable composite in Group 1 recorded the lowest mean value of microleakage scores among the four groups (mean=0.36), while Filtek Z350 flowable composite in Group 4 showed the highest mean value (1.18). Kruskall-Wallis test proved no statistically significant difference in the microleakage scores among the four groups (p=0.243).

Table 3: Comparison between the different studied groups according to degree ofconversion

	Filtek bulk fill (n = 11)		Filtek Z350XT (n = 11)		SDR (n = 11)		X-Flow (n = 11)		KW	P
	No.	%	No.	%	No.	%	No.	%		
Occlusal margin										
0	8	72.7	7	63.6	9	81.8	6	54.5		
1	3	27.3	4	36.4	2	18.2	5	45.5		
Min. – Max.	0.0 – 1.0		0.0 – 1.0		0.0 – 1.0		0.0 – 1.0		2.048	0.563
Mean ± SD.	0.27 ± 0.47		0.36 ± 0.50		0.18 ± 0.40		0.45 ± 0.52			
Median	0.0		0.0		0.0		0.0			
Sig. bet. Grps	p_1=0.655 , p_2=0.619, p_3=0.386, p_4=0.350 , p_5= 0.672, p_6 = 0.180									
Gingival margin										
0	6	54.5	4	36.4	7	63.6	4	36.4		
1	3	27.3	3	27.3	4	36.4	4	36.4		
2	2	18.2	2	18.2	0	0.0	3	27.3		
3	0	0.0	2	18.2	0	0.0	0	0.0	4.175	0.243
Min. – Max.	0.0 – 2.0		0.0 – 3.0		0.0 – 1.0		0.0 – 2.0			
Mean ± SD.	0.64 ± 0.81		1.18 ± 1.17		0.36 ± 0.50		0.91 ± 0.83			
Median	0.0		1.0		0.0		1.0			
Sig. bet. Grps	P_7= 0.263, p_8=0.475, p_9= 0.417, p_{10}= 0.080, p_{11}= 0.654, p_{12}= 0.104									

KW: Kruskal Wallis test and sig. bet. Grops. Using Mann Whitney test
p_1: p value for comparing between Filtek bulk fill and Filtek Z350xt
p_2: p value for comparing between Filtek bulk fill and SDR
p_3: p value for comparing between Filtek bulk fill and X-Flow
p_4: p value for comparing between Filtek Z350xt and SDR
p_5: p value for comparing between Filtek Z350xt and X-Flow
p_6: p value for comparing between SDR and X-Flow
P_7: p value for comparing between Filtek bulk fill and Filtek Z350xt
P_8: p value for comparing between Filtek bulk fill and SDR
P_9: p value for comparing between Filtek bulk fill and X-Flow
P_{10}: p value for comparing between Filtek Z350xt and SDR
P_{11}: p value for comparing between Filtek Z350xt and X-Flow
P_{12}: p value for comparing between SDR and X-Flow

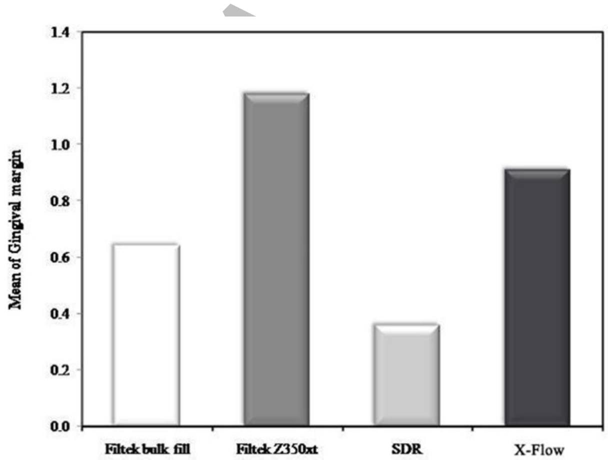
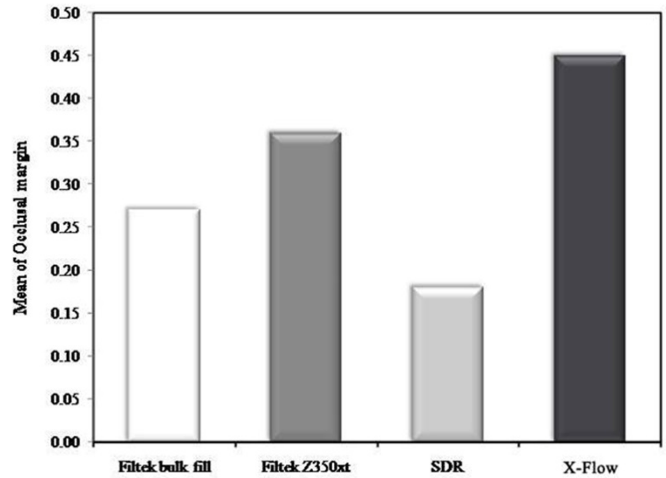


Figure 3: Comparison between the four groups according to microleakage scale of gingival margin.



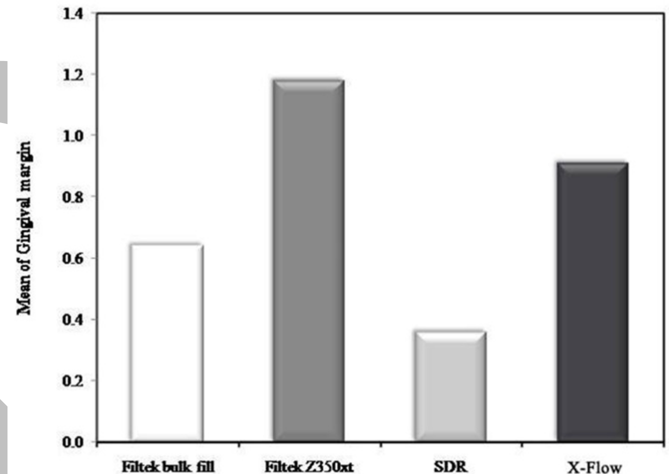


Figure 2: Comparison between the four groups according to microleakage scale of occlusal margin.

DISCUSSION

Adequate light curing and hence polymerization of the composite resin restorations is one of the main important factors influencing their clinical success. The degree of conversion is an important tool to estimate the physical, mechanical and biological properties of composite resin restorations (2,4,14).

Inadequate polymerization might lead to marginal microleakage, and decreased bonding strength of resin composite restorations. A lower degree of conversion might, also result in increase in the amount of released un reacted monomer, leading to less biocompatible restorations. In addition, uncured functional groups can act as plasticizers, producing restorations with inferior mechanical properties (2).

Bulk Fill flowable resins with improved mechanical and chemical characteristics have recently been introduced with significant flow and low polymerization shrinkage. Clinical recommendations suggested that they have greater depth of cure and can be placed in a 4-mm bulk increment and will have adequate polymerization (1,15).

1- Degree of Conversion

In the current study DC of the composites was assessed using FTIR spectroscopy. FTIR measures changes in the mechanical performance of the material by detecting the amount of un reacted C=C in the resin matrix and the C=C stretching vibrations directly before and after curing of the composite resins (1).

The differences in the DC of the materials could be attributed to variations in the chemistry of their resin matrix. Since polymerization conditions were kept standardize the main two features of a monomer that affect the degree of conversion and reactivity are the initial monomer viscosity and flexibility of its chemical structure. The ultimate degree of conversion of different monomer system increase in the following order: Bis-GMA<Bis-EMA<UDMA<TEGDMA (16).

Several Bis-GMA based resin composites exhibited considerable un reacted monomers in the final restorations, with DC of 52-75% (2).

Another contributing factor that might affect the DC of resin composite is the filler particles size. DC decreased in composites whose filler particles size closer to the wavelength of the activating light. This is due to the scattering effect of small fillers which reduce the amount of light transmitted through the resin. In this study SDR showed higher degree of conversion than other groups and this may be due to unique combinations of fillers and large filler size in comparison to the other groups (2).

There was significant difference between bulkfill flowable composite and conventional flowable composite with p=0.001.

SDR and Filtek bulkfill (bulkfill flowable composite) showed higher degree of conversion than conventional flowable composite, this could be attributed to the lower filler volume fraction in bulkfill composite compared to the low viscosity conventional flowable composite (17).

Filtek bulkfill showed higher DC than FiltekZ350xt and this could be attributed to the presence of 4 high molecular weight monomers Bis-GMA, Bis-EMA, UDMA and procrylate in Filtek bulkfill. Procrylate is a high molecular weight monomer with low viscosity similar to Bis-GMA but with a lower viscosity, the difference between Bis-GMA and Procrylate is the lack of pendant hydroxyl groups.

The lack of hydroxyl group reduces the viscosity of this monomer due to decreased hydrogen bonding potential. Also Bis-EMA and UDMA are high molecular weight monomers with low viscosity so the manufacture adjust the proportions of the 4 high molecular monomers to decrease viscosity and create hard cross link network (18).

SDR showed the highest DC and this could be attributed to the presence of UDMA based monomer which is a viscous monomer with weak hydrogen bond intramolecular interaction between its imino (-NH-) and carbonyl group(-C=O).This weak bond has been responsible for characteristic chain transfer reactions that provide an alternative path for the continuation of polymerization. On the other hand (FBF, filtekZ350 and X-Flow) contains Bis- GMA which is a more viscous and a less flexible monomer due to strong intramolecular hydrogen bonding via its pendant hydroxyl group and the presence of rigid aromatic nuclei in its structure (19).

In the present study DC% of bulk fill was higher than conventional flowable composite, which comes in agreement with Zorzin et al (2015) (17). This finding may be related to the lower filler volume fraction in bulkfill composite (42.5% for filtek bulk fill and 45% for SDR) when compared to the higher fraction of conventional flowable composite (46% for filtek Z350), where it has been demonstrated that increasing the filler-to-matrix ratio might progressively decrease the degree of conversion (20).

These results were also in agreement with Li x et al(2015) (21), they found that most of the bulkfill could be cured up to at least 4mm depth because SDR provide greater depth of polymerization due to its high translucency, which enhance the transmission of light and the presence of photoactive group embedded in the urethane based methacrylate monomer. This group is claimed to interact with CQ, thereby boosting the polymerization process.

2- Microleakage

The most important aims of cavity restorations are to establish predictable marginal seal in order to prevent microleakage and its clinical consequences. Microleakage is an important property used to assess the success of restorative material (1).

In the present study the preparations of class v cavities were made (4mm wide mesiodistally, 2mm occluso-cervical height and 4mm depth),as it was assumed by the manfactures that bulkfill flowable composites were applied in a4mm depth, this study was made in order to examine the material in 4mm depth.

Teeth were selected from older patients, over40 years with recessed pulp chambers, and that any specimen with exposure was excluded from the study.

The type of adhesive resin did not seem to make a significant difference in the microleakage scores among groups.

In the present study thermocycling was used in which all the specimens were thermocycled for 500 cycles, thermally induced stresses, which may lead to gap formation and microleakage (1).

In this study all the teeth were immersed in 0, 5% aqueous basic fuchsin dye for 24 hours at 37C. Dye penetration test is known to be valid tools for the determination of marginal gaps in vitro studies (22).

Polymerization shrinkage generates stress at the tooth-restoration interface, resulting in debonding of the restoration. One mechanism to decrease shrinkage stress is to delay the gel point. The gel point shows the increase of viscosity when network is forming in the pregel phase the formed polymer chains are very flexible, the viscosity of polymer is still low. In general the higher the monomer content and the more flowable the composite is the higher the shrinkage and faster the conversion rate in to the gel phase (23, 24).

Restorative composites have a relatively high modulus of elasticity, high stiffness and consequently increased contraction stress during polymerization. This can lead to either bond failure or fracture of the tooth structure, resulting in microleakage (25). On the contrary, the low elastic modulus and high wettability of flowable composites make this kind of material absorb the shrinkage stress during the polymerization, and thus can act as a stressbreaker. Furthermore, their low modulus of elasticity considerably increases their ability to flex with a tooth than stiffer materials, making them suitable to be used with class Class V restorations (26).

The results of the current study indicated that the bulkfill flowable composite (Filtek bulk fill flowable) showed less microleakage scores compared to conventional flowable composite (Filtek Z350xt) on both occlusal and gingival margins.

These results match with JR et al (2015) (23), who recorded less leakage for Filtek bulk fill flowable than the conventional flowable composite (Z350F). They related their results to the presence of Bis-EMA monomer in Filtek bulk fill that usually exhibits higher DC and lower polymerization shrinkage than the typical Bis-GMA/TEGDMA combination present in Filtek Z350 flowable (27). The current study also coincides with the findings of Zorzin et al (2015) (17), who found that FBF (Filtek bulkfill flowable) showed less shrinkage than FSF (Filtek supreme XTE flowable) and explained that the presence of larger amount of TEGDMA in FSF (5-10 wt%) when compared to that in FBF (<1wt%) might have reduced the viscosity of resin composites and increased polymerization shrinkage.

The results of the current study indicated that the bulkfill flowable composite (SDR) showed less microleakage scores compared to conventional flowable composite (X-flow) on both occlusal and gingival margins.

Jang J-H et al (2015) (28), compared SDR (bulkfill flowable composite) with X-flow (conventional flowable composite). They found SDR showed lower polymerization shrinkage than conventional flowable composite and these results were in agreement with our results, this could be attributed to the presence of modified polymer chains in SDR, which are very flexible in the pregel phase, this highly stress-relieving internal monomer might delay the gel point, which could allow more time to compensate for the shrinkage; consequently polymerization shrinkage would be reduced. Also the research by Ilie and Hickel (29) implies that the flowable composite materials based on SDR technology showed a lower shrinkage compared with other flowable materials such as X-Flow and Filtek Supreme.

Nonetheless, the results of the current study were in disagreement with Arslan S et al (2013) (30), concluded that microleakage is not affected by the application of either conventional flowable or SDR (bulkfill flowable) and this could be attributed to the difference in the methodology used, as they used SDR as intermediate material not as a restorative material. Also it was proved first that, X-Flow had lower modulus of elasticity than SDR .Since stress is determined by volumetric shrinkage and elastic modulus of the material according to Hooke's law, low elastic modulus of X-Flow might compete with stress development helping to maintain the marginal seal of the restoration.

Second, according to, Burgess et al the chemistry of SDR is designed to slow the polymerization rate, thereby reducing polymerization shrinkage stress without affecting polymerization shrinkage level (30).

The results of the current study indicated that the bulkfill flowable composite (SDR) showed less microleakage scores compared to bulkfill flowable composite (Filtek bulk fill flowable) on both occlusal and gingival margins.

These results were in agreement with JR et al (2015) (23), who found that SDR showed less leakage than Filtek bulkfill flowable and this could be explained by the lowest level of shrinkage stress of SDR, the longest pregel phase, and lowest shrinkage rate. Koltisko et al (31), found that the polymerization stress of SDR were lower than other flowable composites. In SDR the increase of polymerization stress is reduced with time due to SDR patened urethand dimethacrylate structure. Urethane with incorporated photo active group is able to control the polymerization kinetics. While the incorporation of activated resin results in 60-70% less shrinkage stress when compared to conventional methacrylate –based resins (30).

Activated resin in SDR has demonstrated a relatively slow radical polymerization rate, suggesting that the photo initiator incorporated into the resin affects the polymerization process.SDR contains polymerization modulator that interacts with camphoroquinone to reduce the contraction modulus and increase the number of linear bonds (30). However these results were in disagreement with Zorzin et al (2015) they found that SDR and Filtek bulk fill showed the same polymerization shrinkage and this could be explained by the high translucency of bulk fill composite (17).

The results of the current study indicated that the conventional flowable composite (Filtek Z350) showed less microleakage scores than conventional flowable composite (X-Flow) on occlusal margins and conventional flowable composite (X-Flow) showed less microleakage scores than conventional flowable composite (Filtek Z350) on gingival margins.

This can be explained by the following (Filtek Z350) conventional flowable composite with 65% filler percent showed better leakage than (X-Flow) conventional flowable composite with 60% filler percent. The results were in agreement with Awliya WY (2008) (32) that compared leakage pathway of different flowable composites and found high volumetric shrinkage and leakage in flowable composite with lower filler loading than higher one.

In the present study microleakage scores at the occlusal margins showed lower leakage level than the gingival margins in all groups. All the evidence of various leakage patterns correlates with the results of the present study. The greater thickness of enamel at occlusal margins than gingival margins provide better penetration of adhesive system, thus forming strong bond with composite resin (33, 34)

Another reason for the increased microleakage at the gingival margins of Class V restorations would be the frequent occurrence of prismless enamel at the gingival margins of permanent teeth. The extent of resin penetration into prismless enamel is limited, this may not provide effective barrier to dye penetration (33).

Another important result in this study is that SDR showed the best marginal seal in both occlusal and gingival margins. These results were in agreement with Scotti et al (2014) (1), who found that the bulk fill flowable composite (SDR) provided better marginal seal in the gingival margins than the conventional flowable composite. This could be attributed to the lower stresses of SDR and its lower wettability that could provide better marginal adaptation to the cavity walls. The lowest leakage scores obtained by SDR may be related to its relatively higher filler content (68%wt) when compared to Filtek bulkfill (64.5 %wt), Z350 F (65%wt) and X-Flow (60%wt). In addition, SDR contains patented modified UDMA (849 g/mol) that has higher molecular weight than other monomers, and therefore could have reduced shrinkage by decreasing the number of reactive sites per unit volume (23).

It was not the intent of this work to measure volumetric shrinkage of conventional flowable or bulkfill flowable composites. However polymerization shrinkage frequently manifests as resin pulling away from dentin, leading to gap formation and leakage (32, 35).

In conventional composite polymerization shrinkage is related directly to the degree of conversion, as the higher the degree of conversion, the higher is the composite's final shrinkage (36).

However in the present study bulkfill flowable composites (SDR and Filtek bulkfill) showed higher degree of conversion and lower shrinkage than conventional flowable (X-Flow and FiltekZ350) .This in agreement with Zorzin et al (2015) (17), who also recorded higher degree of conversion for the bulkfill flowable composite (Filtek bulkfill) with 42.5% filler volume than the conventional flowable composite (Filtek Supreme XTE flowable) with 46% filler volume may be due to less filler volume. However Filtek bulkfill flowable showed less leakage than Filtek Supreme XTE flowable, this could be attributed to the presence of TEGDMA in Filtek bulkfill flowable with <1wt% and in Filtek Supreme XTE flowable With 5-10 wt %, this low molecular weight monomer (TEGDMA) reduces the visciosity of resin composites and enhances volumetric polymerization shrinkage.

Furthermore Marovic et al (2014) (37), they compared bulkfill flowable composite (SDR) with conventional flowable composite (X-Flow) in degree of conversion and polymerization shrinkage, their results were in agreement with this study and this could be explained by the presence of (polymerization modulator) incorporated in the high molecular weight urethane dimethacrylate resin. The modulator is supposed to increase monomer flexibility and contribute to polymer matrix relaxation and decrease polymerization shrinkage, the polymerization process was shown to occur at slower rate when compared with conventional flowable composite, thus delaying gelation and relieves polymerization shrinkage force. Manufactures of SDR took advantage of enlarged filler size (average filler size of SDR is 4.2μm and X-Flow is 0.85-0.9μm) that increase light propagation due to reduced filler- matrix interface area, which decrease light scattering and increase degree of conversion.

CONCLUSION

Bulkfill flowable composite demonstrated better DC and marginal seal than conventional flowable composite. SDR showed the most DC performance and provide the best marginal seal in occlusal and cervical margins.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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