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Clinical Outcomes of Bulk-Fill versus Layered Resin Composite Restorations

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Abstract:
Objectives: This study was conducted to evaluate and compare the clinical performance of class II restored with Tetric EvoCeram bulk-fill, Filtek bulk-fill resin composite, and layered Filtek Z250 resin composite restorations.
Materials and Methods: Thirty class II cavities were prepared. The cavities were randomly divided into three groups (n=10) according to the restorative material used (Tetric Evoceram Bulk fill, Filtek bulk-fill and Filtek Z250). The patients were recalled at 6 months and restorations were evaluated using Modified United State Public Health Criteria (USPHS).
Results: No statistically significant difference between all the tested restorative materials.
Conclusions: Bulk fill restorative materials (Tetric Evoceram bulk fill & Filtek bulk-fill) showed clinical outcomes like that of conventional resin based composite.

Keywords: *Bulk Fill, Clinical Evaluation, Incremental.*

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I. Introduction

There is great interest in the beauty since the earliest civilizations; composite resins have become a part of this quest to enhance the esthetics of the teeth and mouth. It is now one of the most commonly used direct restorative materials for anterior and posterior teeth. But one of the inevitable drawbacks of dental composites is its shrinkage during free radical polymerization, which may be as high as 3% by volume.[1-5]

During resin polymerization, monomer molecules convert into a highly cross-linked polymer resulting in a decrease in the distance between the monomer molecules due to the formation of short covalent bond between those molecules. Therefore, decreasing the overall free volume within the monomer molecules creates volumetric shrinkage.[6,7]

When shrinkage occurs while the resin composite materials are inside the cavity and bonded to the cavity surfaces, stresses develop transferred to the tooth restoration interface. If the bond strength is smaller than these stresses, de-bonding might occur resulting in postoperative sensitivity, marginal discoloration, marginal gap formation and recurrent caries.[8] However if these stresses are smaller than the bond strength no de-bonding occurs, but the restoration will maintain internal stresses that pull the cusps together, decreasing the inter-cuspal distance width causing cuspal deformation which might cause micro cracks and/or cusp fracture.[9,10]

Many clinical methods have been proposed to reduce the shrinkage stress, such as the control of the curing light intensity,[11,12] flowable resin liner application,[13]indirect resin restoration,[14] and incremental layering techniques.[15] However, no method has been shown to be totally effective in abating the effects of polymerization shrinkage.

Despite the controversy over the advantages of incremental build-up of composites (through which the material is gradually placed in layers of 2 mm or less) this technique has been broadly recommended in direct resin composite restoration, because it is expected to decrease the C-factor (the ratio of bonded surface to unbonded free surface), allowing a certain amount of flow to partially dissipate the shrinkage stress.[16] However, in addition to these advantages, incremental technique has number of disadvantages such as; entrapment of voids between the increments, bond failure between the increments and the time taken to complete the procedure long time is required to place and polymerize each increment.[17-19]

In order to overcome many of the downsides associated with the incremental approach to place resins, new restorative materials have emerged that are marketed as bulk-fill composites. However, dentists who have

become accustomed to the incremental cure philosophy when placing light-cured composites quite rightly question what specifically has changed to make these bulk-fill composites a viable alternative.[20]

Bulk-fill resin-based composites are tooth-colored restorative materials with increased polymerization depth, decreased polymerization shrinkage stresses and decreased cuspal deflection rates.They can be applied into the prepared cavities in layers up to 4or 5 mm thick.[21]

According to some researchers these bulk-fill composites offer a number of advantages for restoring preparations such as simplifying the restorative process and saving time.Furthermore, bulk-fill composites eliminate many of the drawbacks that are associated with incremental layering techniques, such as the risk of contamination and voids forming between the increments.[22-24]

The general practitioner, however, is rather confused with the variety of different materials on the market and the way they are promoted. The most common method to promote and market these products is by presenting data gained from laboratory tests. Yet, neither dentists nor laboratory researchers have a clue as to what these tests say on the possible clinical outcome in terms of predictability and longevity. Continuing research into practical advances and successful clinical evaluations of composite restoratives are critical to oral care, esthetics, and functional restoration.[25] The present study was intended to evaluate the clinical performance of two different bulk-fill composite resins in class II cavities over the course of 6 months. A conventional posterior micro-hybrid composite resin was used as a control. The null hypothesis was that bulk-fill composite resins exhibit the same clinical outcome as conventional composite resins that were applied using the incremental technique.

II. Materials & Methods

Two high viscosity bulk fill resin-based composite materials (TetricEvoCeram and Filtek bulk-fill), and one conventional universal composite (Filtek Z250) were investigated in this study (Table1). Each restorative material was used with its proprietary adhesive system. A well controlled light emitting diode (LED) (Blue Phase meter, Ivoclar/Vivadent AG, Schaan, Liechtenstein) curing unit with light intensity of 800mW/cm^2 was used for polymerization.

Table1: Materials used in this study.

Restorative system	Manufacturer	Resin	Filler	Filler size
Filtek Bulk Fill (Nanohybrid)	3MESPE	Bis–GMA, TEGDMA, EBpDMA	Zirconia/silica particles ,Mixed oxide prepolymer	Unreported
Single Bond(two-step etch-and rinse	3MESPE	Bis-GMA,HEMA,DMA,polyalkenoicacidcopolymer,initiator,water,ethanol.		
TetricEvo Ceram Bulk Fill(nanohybrid)	IvoclarVivadent	UDMA, Bis-GMA	Barium glass, Ytterbium trifluoride, Mixed oxide prepolymer	550nmavarege Range(40 -3000nm)
Excite F(two-step etch-and-rinse	IvoclarVivadent	Etchant:73%phosphoricacidwithcolloidalsilica Adhesive:HEMA,DMA,phosphoricacidacrylate,silicondioxide,initiator,stabilizersinanalcoholsolution.		
FiltekZ250(microhybrid)	3MESPE Konstanz,Germany	Bis-GMABis-EMA,TEGDMA ,UDMA.	Zirconia/silica particles	0.01-3.5µm Average:0.6µm

Thirty patients were selected from the Dental Clinic at College of Dentistry, Prince Sattam Bin Abdull-aziz University. Patients were asked to participate in the follow up (Pregnant or nursing female were excluded). The enrolled patients were required to have good oral hygiene as well as, complete and normal occlusion and to provide written informed consent according to the regulations of our institution's ethics committee. Reasons for placement of the resin composite restorations were primary carious lesion. A total of 30 class II cavities were prepared and restored in premolar and molar teeth (10 with each resin composite restorative system.

Clinical Procedures

Periapical radiographs of the teeth to be restored were taken before restorative procedures, Vitality tests cores of the teeth were recorded with a vitality tester.

Cavity Preparation

Local anesthesia was applied to prevent patient discomfort during the restorative procedures. Round diamond and fissure burs at high speed with water cooling were used to prepare the cavities. Slow-speed tungsten carbide burs and hand instruments were used to remove the deep caries. Assessments of the excavated preparation floor were mainly conducted by probing with a sharp explorer and by means of the color of the

underlying dentin. Conservative preparation design was used according to the principles of minimally invasive dentistry.

The common characteristics of this preparation design were as follow:1) none of the cavity preparations involved one or more cusps; 2) all of the gingival margins included sound enamel were placed above the gingival sulcus; and 3) no beveling were applied to the preparation walls and margins. The buccolingual width of the preparations did not exceed one-third of the intercuspal distance.

Restorative procedures

After cavity preparation and shade selection, the operative field were isolated with rubber dam. Calcium hydroxide-based material were used only in deep preparations and were applied directly over the deep portion of the preparation and then sealed with a glass ionomer cement lining.

For all Class II cavities a thin metallic matrix (Zeroband Ivoclar/Vivadent) were used and carefully wedging were performed. The cavities were cleaned by a thorough full rinsing with water. In order to make an intra- individual comparison possible, all patients received three restorations. Cavities were randomly distributed to be restored with either the bulk-fill TetricEvoCeram resin composite, Filtek bulk-fill resin composite or the control restoration with conventional layered Filtek Z250.

Each resin composite restorative system were applied and cured according to manufacturer's instructions. Contouring and finishing of the restorations were performed at the same appointment using a water-cooled, fine-grit diamond finishing instrument. Articulating paper was used to establish appropriate occlusal morphology and contact. Flame shaped finishing burs were used to obtain smooth surfaces.[26]

Multiple-use polishing system (Politip Ivoclar/Vivadent).; the system composed of grey politip-F finisher and green politip-p polishers) was used to smooth contours and margins. Finishing was made by using Politip-F finisher and polishing was performed using politip-P. The quality of the interproximal contacts were checked with dental floss (Figure1a-c).

Figure 1;a. Case with multiple carious lesions.

Figure 1;b. Cavity was prepared in lower premolars and first molar teeth.

Figure 1;c. Teeth restored and the restorations were finished polished and occlusal adjusted.

Evaluations

Each restoration were evaluated according to slightly Modified United State Puplic Health service (USPHS) criteria for the following characteristics: anatomical form, marginal adaptation, color match, marginal discoloration, surface roughness, and secondary caries (Table2).[27] The restorations were evaluated at a baseline, and then blindly at 6 months by two independent examiners.

Examiners were not involved in the filling procedures. To detect secondary caries, the presence of softness, opacity, etching, or white spots are considered as evidence of undermining or demineralization in areas where the explorer catches or resists removal after insertion. A magnifying aid was used for examination of marginal adaptation. Retention loss, severe marginal defects, discoloration that needed repair or replacement, and the occurrence of caries along the restoration margins were considered to represent clinical failure.

Table 2. Modified USPH criteria (Abbreviations A, Alpha; B, Bravo; C, Charlie; D, Delta)

Category and rating		**Criteria**
Retention	A	Restoration is present.
	D	Restoration is partially or totally missing.
Color match	A	The restoration matches the adjacent tooth tissue in color, shade or translucency
	B	There is a slight mismatch in color, shade or translucency but within the normal range of adjacent tooth structure.
	C	There is a slight mismatch in color, shape or translucency but outside of the normal range of adjacent tooth structure
Marginal discoloration	A	There is discoloration anywhere along the margin between the restoration and the adjacent tooth structures
	B	Discoloration is present but has not penetrated along the margin in a pulpal direction.
	C	Discoloration has penetrated along the margin in a pulpal direction.
Secondary caries	A	No caries is present at margin of the restoration, as evidenced by softness, opacity, or etching at the margin.
	B	There is evidence of caries at margin of the restoration
Surface roughness	A	The restoration surface is as smooth as surrounding enamel.
	B	The restoration surface is rougher than the surrounding enamel.
	C	There is a crevice and fracture on the restoration.
Marginal adaptation	A	There is no visible evidence of a crevice along the margin into which the explorer penetrates.
	B	There is visible evidence of a crevice along the margin into which the explorer penetrates or catches.
	C	The explorer penetrates the crevice, and dentin or base is exposed.
	D	The restoration is mobile, or missing, either in part or total
Postoperative sensitivity	A	Normal reaction to cold spray compared to non -restored teeth
	B	Increased cold sensitivity
	C	Spontaneous pain
	D	Non-vital
Interproximal contact	A	Interproximal contact is clinically sufficient; floss passes through against strong resistance.
	B	Interproximal contact is clinically acceptable: loose, but no complaints no food impactions or trauma of the papilla.
	C	Interproximal contact is clinically not acceptable: loose contact with food impactions, and/or trauma of the papilla.

Statistical Analysis

All the collected data were subjected to statistical analysis using the statistical package for Social Science (SPSS Inc, Chicago, IL, US). For clinical evaluation trial, since the assessment of the restorations yielded clearly ordinal structural data, only non parametric procedures were used. The changes in the parameters during the 6-months evaluation period were analyzed using the Friedman test, which is a non parametric analysis of variance ($p<0.05$).

III. Results

All restorations showed no statistically significant differences detected between their performance regarding the retention, marginal discoloration, recurrent caries, marginal adaptation and interproximal contact at base line and after6-months recall.

Table 3: Results of Friedman test comparison of the clinical performance of the tested composites (Z250,TEBF and F) at base line and 6 months recall ($P\leq0.05$).

Materials	TestValues	Retention	Marginaldiscoloration	Secondary caries	Marginaladaptation	Post-operativesensitivity	Inter-proximalcontact	Colormatch
Z250	ChiSquare	0.000	4.714	0.000	9.000	18.000	8.760	12.000
	PValue	1.000	0.194	1.000	0.029	0.000	0.033	0.007
TEBF	Chisquare	0.000	6.000	0.000	6.000	12.000	6.000	6.000
	PValue	1.000	0.112	1.000	0.112	0.007	0.112	0.112
F	ChiSquare	0.000	3.000	0.000	3.000	15.000	3.000	3.000
	PValue	1.000	0.392	1.000	0.392	0.002	0.392	0.392

F: Filtek bulk-fill composite resin. TEBF: Bulk Fill composite resin. Z250:Filtek Z250 composite resin.

Retention

For all groups there was no significant difference between the restorative materials concerning retention at 6 months recall visits ($P>0.05$).

Secondary Caries

There was no secondary caries observed after 6-months of clinical service for all groups.

Marginal Discoloration

Regarding marginal discoloration criteria, the majority of scores were Alpha, while Bravo scores were only recorded at the 6 months of evaluation in two restorations restored with Z250 composite (Figure 2). There was no statistically significant difference found regarding marginal discoloration ($p>0.05$).

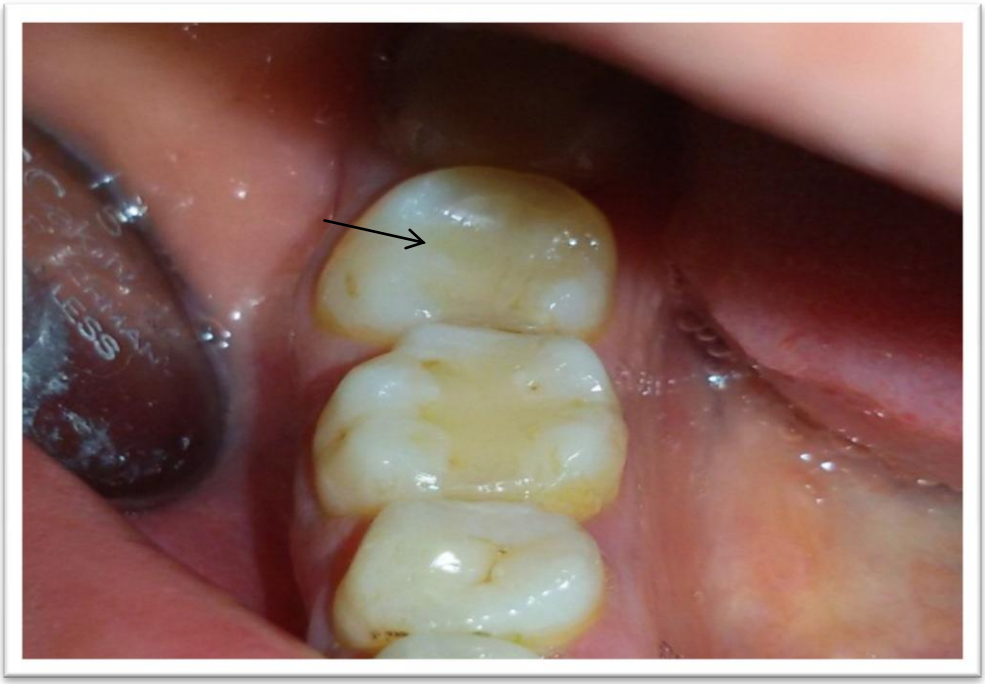

Figure 2. A photograph showing lower right second molar restored with Z250 after 6 months and scored bravo for marginal discoloration.

Marginal Adaptation

At base line and at 6-months recall, for all restorations, there were no marginal defects recorded at the margins. No significant difference was found between the tested restorative systems ($p>0.05$).

Inter-proximal Contact

There was no significant difference between the tested restorations regarding the inter-proximal contact.

Postoperative Sensitivity

At base line there were two restorations for TetricEvoCeram bulk-fill, one restoration for Filtek bulk-fill and one restoration for Filtek z250. Restorations were sensitive to air and tactile contact, all was relieved after a short time. There was no statistically significant difference between the tested groups ($P<0.05$).

IV. Discussion

Composite success story has been driven, not only by the patient demand for esthetic universal filling materials, but also by continued industry-led product development and improvement of physical, mechanical, esthetic and handling properties of both adhesives and composites. Despite the great improvements and the wide use in restoring posterior cavities, composite restorations still represent some short-comings as polymerization contraction and obtaining a tight contact point.

During an incremental layering technique, the composite resin material is gradually placed in layers of 2 mm or less. This approach has a number of advantages; such as, it results in better light penetration and better polymerization of the composite resin, reduction of the cavity configuration factor, cuspal deflection, polymerization shrinkage stresses; and ensure that the resin adheres better to cavity walls. However, in addition to these advantages, there are a number of disadvantages associated with the use of incremental approach to apply resins in the cavity; for example, voids can be trapped between the increments,[10] bonding failure could occur between the increments, it can be difficult to place composite after conservative cavity preparation, and the time taken to complete the procedure is more lengthy due to the time required to place and polymerize each increment.[28]

Dentists have always been looking for a fast and reliable filling technique. Bulk-fill composites are resin-based, tooth-colored restorative materials that can be inserted into prepared cavities in layers that are up to 4 or 5 mm thick and characterized by increased polymerization depth, decreased polymerization shrinkage stresses, and cuspal deflection rates.[29]

Bulk fill RBC materials have been developed to enable dentists to reduce placement time and work more efficiently. Little information is available about the performance of this new bulk fill RBC, therefore, the current study was conducted to evaluate clinical performance of two bulk fill RBC over 6 months follow up period.

Laboratory tests might provide useful information about the potential performance of a filling material and its' handling, but such tests cannot adequately evaluate the clinical performance of a material or clinical handling characteristics. *Invitro* studies cannot answer questions about *in vivo* durability of these tooth colored restorations. The complexity of some intraoral environmental condition variables such as occlusal stress, temperature changes, bacterial flora and pH alterations makes reproduction of oral physiology difficult. So, only the clinical environment may be determinant in assessing dental materials or restorative techniques.[30]

Clinical evaluations require objective, reliable and relevant criteria to assess the performance of resin based composite restorations. Composite restorations were evaluated using a system of clinical parameters; developed by Gunnar Ryge and known as (USPHS) criteria or Ryge criteria or direct evaluation criteria.[27]

Although resin-based composites have been used extensively in restoring posterior teeth, it is recommended to be used in small to medium sized cavities, not extensive restorations, to reduce direct occlusal contacts. On the basis of this concept, the clinical cases were selected to be ranged between small to medium sized cavities. Butt-joint, clean-cut non-beveled preparations in the occlusal cavities were preferred. All the restorations were performed under rubber dam isolation to prevent salivary contamination.

Retention

There was no loss of retention reported over 6-months follow up in the present study, indicating that the bond strength at the restoration/ tooth structure interface is satisfactory in all the tested groups. The stresses generated by polymerization contraction might be less than the bond strength at the tooth restoration interface. For incrementally placed conventional composite, the technique may allow flow of the resin through the unbounded surfaces. For bulk-fill placed composites, low polymerization shrinkage stresses were due to the highly filled nature and the presence of stress breaker fillers that acts as cushion.

Marginal discoloration

Regarding marginal discoloration criteria all the tested composite materials were clinically accepted with no Charlie score all over the recall periods. Marginal discoloration usually caused by defects that exist between the composite restoration and the cavity margins. These defects could be caused by inadequate restoration placement or finishing procedures, unsatisfactory bonding, and/or by subsequent stress fatigue.[31] For Filtek Z250 the accepted results might be due to the use of incremental layering. It is widely accepted that the use of the incremental technique with a maximum of 2 mm in each layer is likely to reduce the incidence of marginal discoloration. In the current study, bulk-fill composite was placed at a 4-mm thickness increment in a cavity. A very slight degree of marginal discoloration was observed after 12 month in the bulk-fill resins. This may be due to the nanofillers which allow excellent polish-ability that diminish any surface roughness and minimize surface discoloration. Also the filler loading of both bulk-filled resins is significantly increased on the expense of resin matrix, which decreased the possibility of discoloration due to degradation of uncured resin.

Recurrent caries

Biofilm formation on a dental tissues or restoration surface is a complex phenomenon. Bacterial accumulation in dental biofilms is highly dependent on the surface characteristics of the material. Bacterial accumulation on the surfaces of restorative materials may provide the bacterial source leading to the development of secondary caries and periodontal diseases. Composite resin restoration do not show a static state in the biological intra oral environment being constantly modified by environmental influences that could change the profile of bacterial accumulation.[32]

In the present study, there was no secondary caries, all restorations scored alpha in this regard. This may be due to good oral hygiene of the patients, adequate restorative technique and good adhesive systems. Also absence of recurrent caries in the present study could be indicative of good marginal seal of the tested groups.

Marginal adaptation

At base line and at 6-months recall there was no evidence of crevice along the margins of all restored cavities and they were all rated alpha score. The good marginal adaptation of both bulk fill resins may be due to visco-elastic properties of the material; means that stresses generated during the setting process might be compensated by the flow of the material. Stresses transferred to the margins doesn't affect the quality of the restoration.

Post-operative sensitivity

Post-operative sensitivity has been attributed to many factors including; operative trauma, desiccation, dentin etching, leakage, bacterial penetration to the pulp, occlusal discrepancies, cuspal deformation by shrinkage stress and deformation of composite resin by occlusal forces. Sealing of the exposed dentin tubules by a dental adhesive should eliminate possible thermal and mechanical oral stimuli.[33]

The good results of postoperative sensitivity in the present study at recall visit might be related to the excellent two-step etch and rinse adhesive systems, using sharp cutting bur under abundant irrigation with cold water spray, rubber dam isolation, careful drying of the cavity and occlusal adjustment. Also application of calcium hydroxide-based liner over deep restorations which was sealed with glass ionomer cement base might reduce postoperative sensitivity.

Inter-proximal contact

Investigating the friction and wear behavior of dental material is of vital importance. It is well known that wear is a complicated process, which is affected by loads ,speed, friction mode, surface characteristics, and lubrication.[34] Composites mechanical properties can be improved by being strengthened using harder and higher strength fillers. On the other hand, chemical bonding between fillers and resin matrix should be improved, this can be achieved with pre-treatment of the filler surface with a silane coupling agent.[35]

Regarding the anatomic form and interproximal contact criteria, no significant differences were found between the materials. The good results might be attributed to the high filler content and good mechanical properties of the tested restorations. Both bulk fill composite are nanofilled composites. The unique nanofiller size and technology of both bulk filled materials; allow excellent anatomic form and high wear resistance.

V. Conclusion

Within limitation of the present study, it can be assumed that all the tested restorative materials showed a satisfactory clinical performance regarding retention, recurrent caries, marginal discoloration, marginal adaptation, interproximal contact and post-operative sensitivity.

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