ORIGINAL RESEARCH

Effect of Multilayering Incremental Technique on the Microleakage of High-viscosity Bulk-fill Composite Restorations in Endodontically Treated Teeth

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Abstract

Aim: The aim of this study is to evaluate the effect of multilayering incremental technique on the microleakage of high-viscosity bulk-fill composite restorations in endodontically treated teeth.

Materials and methods: A total of 60 human mandibular premolar teeth were divided into four groups after standardized access preparation with a protaper technique followed by single-cone obturation to receive the following restorations for the access preparations. Group I ($n = 20$): bulk-fill composite (Filtek™ Bulk fill) using a bulk technique, group II ($n = 20$): bulk-fill composite (Filtek™ Bulk fill) using an incremental layering technique, group III (negative control) ($n = 10$): gutta-percha was kept intact at the access orifice and covered with a nail polish, and group IV (positive control) ($n = 10$): gutta-percha was kept intact at the orifice. The samples were thermocycled at 5°C and 55°C for 500 cycles followed by dye penetration with 2% methylene blue and then the scoring was done under a stereomicroscope at 10× magnification. The data so obtained were compared for microleakage using a Chi-square test. There was a significant difference among all the groups except groups II and III.

Results: Bulk-fill composites used with an incremental layering technique sealed significantly better than the other groups followed by bulk-fill composite in the bulk technique.

Conclusion: Within the limitations of the present study, it can be concluded that the incremental layering technique with bulk-fill composites significantly decreases microleakage in the restored access preparations of endodontically treated teeth.

Keywords: Bulk-fill composite restorations, Incremental, Technique, Microleakage.

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Introduction

Endodontically treated teeth pose a big challenge when it comes to restoration, rehabilitation, and reinforcement. An ideal restoration for such teeth should not only restore but reinforce the remaining tooth structure and bring the tooth back to function as well.[1–4] Dental composites fulfill most of the restorative criteria as required for root canal-treated teeth.[3] This is attributed to the introduction of newer improved composites with superior properties. The placement and curing techniques have also revolutionized the successful use of these materials in the restorative dentistry.

Despite the advances in resin-based restorative materials, microleakage is still the most compromising factor in the longevity of postendodontic restorations, thus, affecting coronal seal which is an important factor like apical seal in the prognosis of root canal-treated teeth in the long term.[5]

More recently, nanohybrid composites with superior physical properties and minimal shrinkage have changed the restorative dentistry but in endodontically treated teeth, the depth of the access and high C factor still pose a challenge even for these materials.[6,7] Multiple increments are needed to restore these teeth because the depth of access is usually high.[8] The first layer of composite may be at 5–7 mm away from the light cure tip and achieving a high degree of conversion is challenging in such situations.[7]

The new and evolving trend in restorative materials, the so-called "bulk fill" dental composites, is slowly replacing all other resin-based restoratives in the market. These restoratives can be light cured to an increment thickness of 5 mm or more along with a high degree of conversion, minimal shrinkage, and superior physical and mechanical properties.[9–11] These restoratives are easy to place with superior adaptation to the preparation walls. They have low modulus of elasticity to reduce polymerization stress.[12,13] The layering technique is also not required to be followed. They have emerged as the most suitable restoratives for the post-endodontic restorations.[9] The incremental layering technique the most commonly used with all the composites is not required with bulk-fill composites. Bulk-fill composites have polymerization modulators which allow polymerization with a sufficient degree of

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conversion up to a depth of 5 mm.[14,15] Some authors have even tried preheating of bulk-fill composites to make them more adaptive to the preparation walls to be used in bulk.[16–19]

The present study was planned with the hypothesis that using the incremental layering technique for bulk-fill composites can lead to superior restorations with minimal shrinkage taking into consideration the benefits of polymerization modulation, improved chemistry, and incremental curing.

With this premise, the present study was undertaken to evaluate the effect of using the multilayering incremental technique on the microleakage of high-viscosity bulk-fill composite restorations in endodontically treated teeth.

Materials and Methods

A total of 60 recently extracted, intact, human mandibular premolars with noresorption, previous restorations, and structural deformities were selected for the study. The teeth were cleaned of tissue tags and subsequently stored in disinfectant solution of 1% chloramine T until use. All the teeth were transilluminated at 10× magnification for the detection of fractures/structural defects. Radiographs were taken and those presenting with more than single canal, calcifications, and excessive curvatures were eliminated.

The root canal treatment was performed by the same operator for all the teeth to reduce the operator variability. Endo access bur #2 (Dentsply/Maillefer, Switzerland) and Endo Z (Dentsply/Maillefer, Switzerland) bur were used for the standardized access preparation. The burs were changed after every five preparations. The prepared dimensions of the access were 2.5 mm buccolingually and 1 mm mesiodistally.

Cleaning and shaping were performed by rotary protaper universal files as mentioned in the following. The prepared access was flushed with 5.25% of sodium hypochlorite and a size 15 K-file (Dentsply/Maillefer, Switzerland) was inserted into the canal until it appeared at the apical foramen. The working length was calculated by reducing 1 mm from this particular length. All the teeth were prepared with rotary ProTaper files (Dentsply/Maillefer, Switzerland). The middle third of the canal was prepared with the SX instrument. Then, S1, S2, FI, F2, F3, and F4 files were used sequentially with torque and speed per the recommendations of the manufacturer.

The root canals were irrigated with 5.25% NaOCl and a 30-gauge side-vented needle. The files were changed after every three instrumentations.

After the final preparation, the canals were irrigated with 5 mL EDTA solution 17% for 30 seconds followed by 5 mL of 5.25% NaOCl. The last and final irrigation was done with saline. All teeth were prepared in the same sequence as described.

The root canals were dried with the paper points and obturation was done with the matching gutta-percha cone (Dentsply/Maillefer, Switzerland) and AH plus jet sealer (Dentsply/Maillefer, Switzerland) with the single-cone technique.

The prepared samples were randomly divided into four groups. First two were experimental groups with 20 teeth each. The third and fourth groups were control groups with 10 teeth each. The control groups composed of 10 positive and 10 negative control teeth.

Etching was done with the split etch technique in which the etchant (Scotchbond, 3M™ ESPE™, USA) was applied for 15 seconds to enamel first subsequently followed by 10 seconds to the dentin.

In all samples, curing for adhesive was done for 10 seconds and each composite increment was cured for 20 seconds with the LED curing unit (Valo, ultradent) with an output of 1,000 mW/cm^2. The composition of materials used in the study is summarized in Table 1.

Table 1: Characteristics of the materials used in this study (per manufacturer)

Material	*Manufacturer*	*Composition*
Bulk-fill composite Filtek Bulk fill (shade A2)	3M, ESPE, St. Paul, MN, USA	AUDMA, UDMA, and 1,12-dodecane-DMA
		Ytterbium trifluoride, zirconia, silica 76.5% by weight (58.4% by volume)
Bonding agent Adper™ Single Bond 2	3M, ESPE, St. Paul, MN, USA	BisGMA, HEMA, dimethacrylates, ethanol, water, a novel photoinitiator system and a methacrylate functional copolymer of polyacrylic and polyitaconic acids
		10% by weight of 5 nm-diameter spherical silica particles

Preparation of Samples for Experimental Groups (Fig. 1)

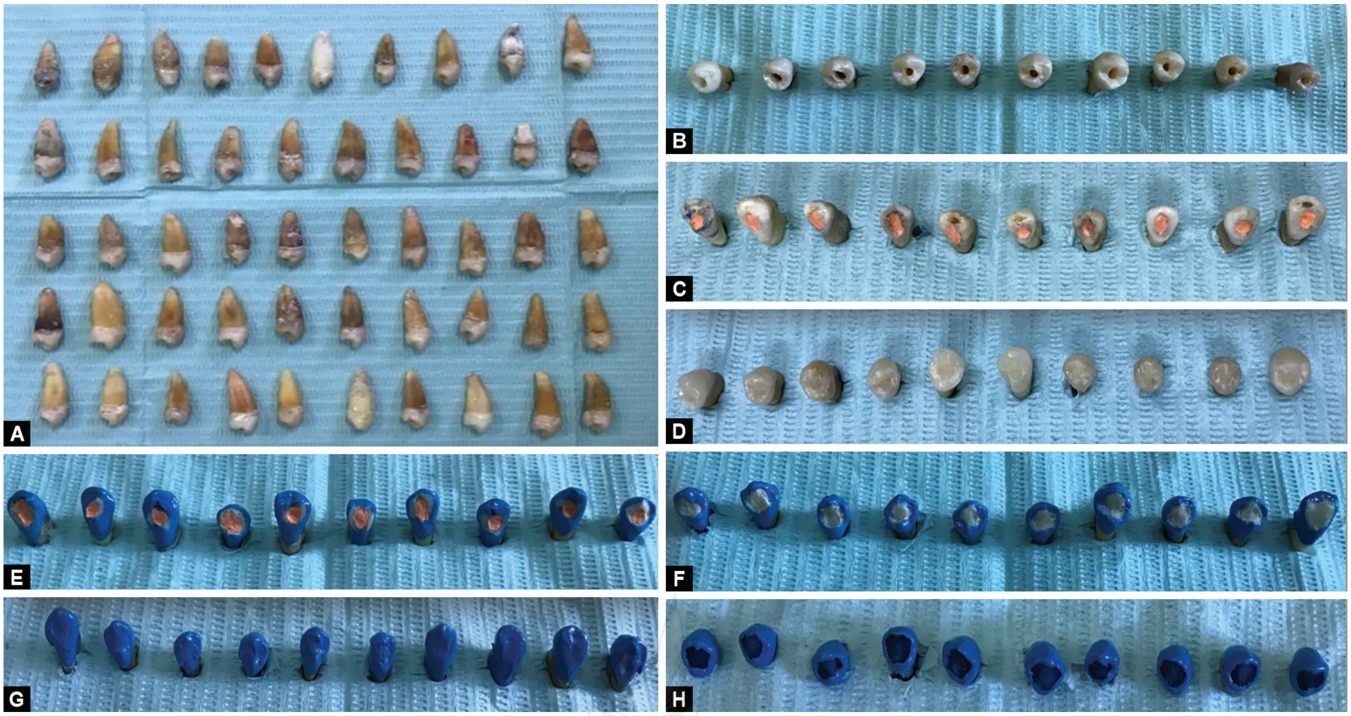
- Group I: The access preparations after etching followed by rinsing for 10 seconds were dried with cotton pellets. The nanofilled adhesive Adper™ Single Bond 2 (3M ESPE, USA) was applied followed by light curing. The preparation was restored with bulk-fill composite (Filtek™ Bulk fill composite, 3M ESPE, USA) in two increments. The depth of the access was measured with a periodontal probe and any depth more than 5 mm was first restored with the variable increment of 2–4 mm per sample to restore it to a depth so that the residual depth is 5 mm for the second increment. Then, the 5 mm increment was subsequently placed as the final increment followed by light curing.
- Group II: The same procedure as the group I except that whole of the preparation was restored in 2 mm increments followed by light curing, after every increment.

Preparation of Specimens for Control Groups

- Group III (negative): Gutta-percha was not removed and kept intact at the canal orifice of samples after obturation. The negative control group was coated with three nail polish coats including the gutta-percha filled access preparation completely.
- Group IV (positive): Gutta-percha was not removed and kept intact at the canal orifice of samples after obturation. The samples were coated with three layers of nail polish except the 1 mm area around the access preparation.

Preparation of Specimens for Dye Leakage Experiment

After the restorations, all the samples were stored in 100% humidity for 48 hours to allow for the sealer to set. The apices of samples were sealed with three layers of cyanoacrylate adhesive. Thermocycling was done at 5°C and 55°C: 500 cycles with a dwell



Figs 1A to H: A brief summary of sample preparation. (A) Teeth selected for the research; (B) Samples after root canal treatment and samples after restorations; (C) Control samples after root canal treatment (RCT) with gutta-percha till the margin of access; (D) Samples after restorations; (E) Control samples after nail polish application leaving 1 mm around margins; (F) Research samples after nail polish application leaving 1 mm around margins; (G) Control samples after complete nail polish application; (H) Samples after immersion in methylene blue and dye penetration

time of 30 seconds and a transfer time of 15 seconds per the standardized ISO protocol.

Thereafter, the samples will be coated with three layers of nail polish except the 1 mm area around the access preparation. The negative control group was coated with three nail polish coats including the gutta-percha filled access preparation completely. The samples were then immersed in 2% methylene blue for 24 hours. After 24 hours of immersion, the samples were washed in the tap water and dried.

All samples were sectioned longitudinally with a water-cooled diamond disk. The sections of each sample were examined under a stereomicroscope at 10× magnification (Fig. 2).

Fig. 2: Sectioned samples under stereomicroscope for microleakage evaluation and scoring

The photographs were also taken. The degree of microleakage was scored.

Dye leakage was graded per the following criteria:

- No leakage—if the dye has not penetrated along the gutta-percha and pulp chamber.
- Slight leakage—if the leakage was just reaching into the dentin.
- Moderate leakage—if the leakage was till the pulp chamber.
- Extensive leakage—if the leakage was penetrating until the floor of the pulp chamber and root canal.

Results

Statistical Analysis

Confidence interval was kept at 95%. The degree of dye penetration for groups is presented in Table 2 and Figure 3. The scored data from the groups were compared using the Chi-square test and there was a significant difference among the groups (Table 3).

There was no dye penetration for samples in the negative control group, whereas the positive control group had dye

Table 2: Microleakage scores for experimental and control groups

	Microleakage scores			
Groups	*0*	*1*	*2*	*3*
Group I ($n = 20$) (experimental)	6	10	3	1
Group II ($n = 20$) (experimental)	15	3	1	1
Group III ($n = 10$) (control)	9	1	0	0
Group IV ($n = 10$) (control)	0	0	1	9

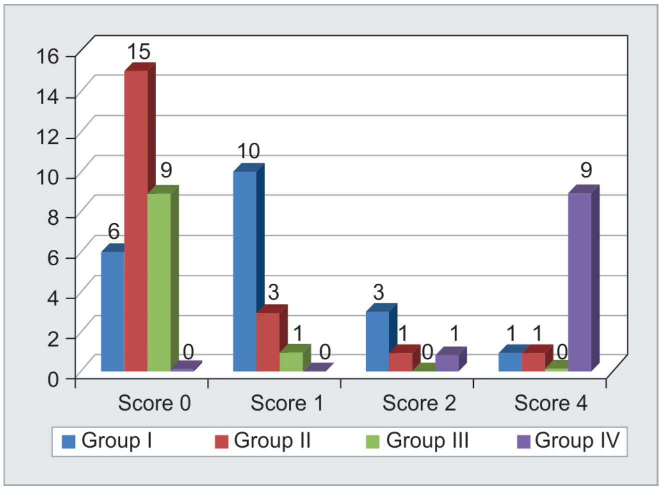


Fig. 3: Microleakage scores of experimental groups and control groups

Table 3: Statistical difference of microleakage scores between experimental groups and control groups

Group comparison	*Chi-square value*	*p value*	*Significance (p < 0.05)*
Group I vs group II	8.63	0.035	Significant
Group I vs group III	9.71	0.021	Significant
Group I vs group IV	22.57	<0.001	Highly significant
Group II vs group III	1.748	0.626	Nonsignificant
Group II vs group IV	23.7	<0.001	Highly significant
Group III vs group IV	20	<0.001	Highly significant

penetration in all the specimens. There was a significant leakage in all the research groups.

Bulk-fill composites groups with the incremental layering technique were better in performance than the bulk-fill technique. Incrementally filled bulk-fill composites sealed significantly better than the bulk-fill composite used with the bulk technique.

Discussion

Dental composites are mostly used and the recommended materials for the restoration of structurally weakened root canal-treated teeth.[2–4] One of the major reasons restricting the use of composites for these restorations is the inherent polymerization shrinkage which leads to microleakage and compromised coronal seal.[5]

With the fast pace of research, new restoratives and techniques which tend to decrease microleakage have changed the dental field. These restoratives and techniques require further research to verify the claims of the manufacturers.

The present study compared the effect of two placement techniques with bulk-fill composites on the microleakage of restored access preparations in endodontically treated teeth. The results showed that regardless of the technique used, coronal leakage was observed. The least microleakage values were observed in the incremental layering technique using bulk-fill composites as compared with the bulk technique.

The results of microleakage studies vary due to the inability to mimic clinical conditions and control all variables. Within the limits of this study, the parameters were standardized by careful selection of teeth, standardized access preparation, and following the instructions from the manufacturer. To best mimic the oral conditions, thermocycling was undertaken.[20]

The dye penetration method was used in the study to assess and score microleakage. A lot of research is done using the methylene blue dye because it is not expensive, easy to manipulate and handle, and has a high staining degree. The molecular weight of this dye is lower than bacterial toxins. This dye exhibits microleakage the same as butyric acid which is a metabolic product for microbes.[21] The deep access preparations pose a difficult situation for restorations as they have a high C factor.[8] Dentin bonding is also a challenge. The bulk-fill composite used in the study when applied in bulk to the access preparation base which was 7–8 mm in depth posed a big challenge to curing at that depth leading to weak bonding with dentin at the base and the degree of conversion was also compromised.[7] The distance between the light curing tip and the composite surface to be cured is also a limiting factor. When the distance between the tip of curing light and the surface of resin is more than 2 mm, the intensity of light is reduced significantly. This can compromise polymerization of resins and even the bond between the adhesive and the dental composite.[8] In this study, incremental curing provided more chance for the complete curing as compared with the bulk technique and compensation of the shrinkage was also better with this technique. Similar observations were obtained by Van Ende et al.[7] on comparing bulk-fill composites with other composites in preparations with different C factors. They observed that bulk-fill composites were superior in performance as compared to other composites in cavities with excessive depth and high C factor.[7] In this study, both the factors that is the use of bulk-fill composite and the incremental technique were favorable to combat polymerization shrinkage.

Different dental composite placement techniques have been clinically recommended (bulk technique and incremental technique). The bulk placement technique is mainly indicated in deep cavities like the access preparation. In this technique, high stresses internally may be generated leading to a loss of marginal integrity as the larger volume of dental composite is polymerized, leading to more polymerization shrinkage.[22]

The incremental technique which is based on the polymerizing dental composite in layers less than 2 mm can help in obtaining good marginal seal and prevent distortion of the preparation walls with good adhesion to dentin. Using this technique, complete polymerization of the composites is achieved.[23]

The manufacturers claim that the polymerization modulators present in bulk-fill composites can help in complete polymerization and the unique chemistry of these materials helps to decrease microleakage. In this study, the authors used the Filtek™ Bulk fill posterior restorative with an improved chemistry as claimed by the manufacturer which has two new methacrylate monomers which together can help to lower polymerization stress.[18,24] Aromaticdimethacrylate (AUDMA), a high molecular weight monomer, reduces the reactive groups in the resin to reduce volumetric shrinkage and increases flexibility of the polymer matrix. Polymerization shrinkage stress is decreased with this strategy.

The second novel methacrylate: addition-fragmentation monomers (AFMs) are reactive to any methacrylate monomer during polymerization reaction, including the cross-linking in between composite resin chains. It has a third reactive site which breaks through during polymerization by the fragmentation leading to stress relief in the forming matrix. The fragments still retain the ability to react with the sites in the forming resin matrix.

This leads to stress relief without disturbing the overall properties of the resin composite.[18,24]

1,12-Dodecanediol dimethacrylate (DDDMA) is a low viscosity, high-modulus resin with good flexibility and impact resistance. Urethane dimethacrylate (UDMA) decreases the viscosity of the resin and the molecular weight which highly decreases the shrinkage while developing a highly cross-linked networked structure.[18]

This improved chemistry not only helps in bulk curing but also helps to limit the polymerization shrinkage as depicted by less microleakage in our results.

The similar results with bulk-fill composites were published by Yongwen et al.,[9] Siavash et al.,[13] Shrivastav et al.,[11] Scotti et al.,[12] Peutzfeldt et al.,[15] and Mirosław et al.[14]

The most significant finding was that the bulk-fill composites when incrementally filled displayed the best results with minimal shrinkage combining the benefits of both the improved chemistry and the incremental technique. No other research compliments or support our results as there is no other study like this conducted till now but there is a plethora of studies which support the benefits of incremental techniques: Loguercio et al.,[25] Al-Harbi et al.,[26] Tiba et al.,[27] Moezyzadeh and Kazemipoor,[28] Jang et al.,[29] and Reis et al.[30]

This study clearly supports a new multilayering incremental placement approach for the use of bulk-fill composites in deeper access preparations without compromising the marginal integrity. There is not much research to support this study as it is a relatively novel concept and more clinical studies are needed to further validate this research.

Conclusion

Within the limitations of the present study, it can be concluded that the incremental layering technique with bulk-fill composites significantly decreases microleakage in the restored access preparations of endodontically treated teeth. Bulk-fill composites used with the incremental layering technique are a suitable alternative for restoring access preparations of endodontically treated teeth.

Consent for Publication

Not applicable

Clinical Significance

Bulk-fill composites used with the incremental layering technique are a suitable alternative for restoring access preparations of endodontically treated teeth.

Acknowledgment

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