



THE EFFECT OF TWO BULK-FILL RESIN COMPOSITES ON FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH

ABSTRACT


Objectives: The aim of this study was to compare the effect of two commercially available bulk-fill restorative materials on the fracture resistance of endodontically treated human molar teeth.


Materials and methods: A total of 44 mandibular third molar were divided into four groups: Group 1; 4 mm thick bulk-fill fluid composite (SDR™, Dentsply, Konstanz, Germany) was applied to the cavities. The restoration of the proximal walls and the occlusal region was completed with posterior composite (Valux Plus, 3M ESPE, St. Paul, MN, USA). Group 2; 4 mm thick fiber-resin reinforced bulk-fill composite (EverX Posterior; GC Corp., Japan) was placed in the cavities and the procedure in Group 1 was repeated. Group 3 (negative control group); no restoration was applied to the cavities. Group 4 (positive control group); comprised intact molar teeth without any treatment. The root canals were shaped using rotary instruments, irrigated with NaOCl, and obturated. All samples were incubated in distilled water at 37°C for 1 week and then fracture strength test was performed. The values were recorded in Newton and the data were evaluated using Kruskal Wallis and Mann-Whitney U test.

Results: No statistically significant difference ($p > 0.05$) was observed between group 1, 2, and the positive control group. However, the bulk-fill fluid composite material showed higher fracture resistance than the fiber-resin reinforced composite material ($p < 0.05$). The highest fracture resistance was observed in the positive control group. The fracture resistance of the negative control group was statistically lower than the other groups ($p < 0.05$).

Conclusions: Both of the bulk-fill restorative materials in endodontically treated teeth showed similar fracture resistance to intact teeth. In addition, the clinical use of the bulk-fill fluid composites may be recommended because of their high fracture resistance and ease of application.

Keywords: Composite resin, fracture resistance, endodontics.

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INTRODUCTION

Long-term success in endodontic treatment can be achieved through a durable and impermeable coronal restoration following an ideal root canal treatment. In these teeth, the loss of healthy tooth structure is usually considerable, and crown fracture following treatment can negatively affect their prognosis due to the secondary caries or unsuccessful restorations. Previous studies have demonstrated that the fragility of endodontically treated teeth was increased due to loss of tooth tissue resulting from the access cavity and root canal preparation rather than the changes in dentin tissue.

For many years, adhesive restorations were quite successful in protecting the remaining hard tissues in the endodontically treated teeth and increasing their fracture resistance.⁴⁻⁶ Composite resins could be the material of choice to replace ceramic crowns due to their potential to mimic the dental anatomy, protect the periodontal structure, and provide a cost-effective, durable, and functional restoration of the tooth structure. The most important drawback of composite resin restorations is polymerization shrinkage. Prior to the placement of direct restorative materials; applying flowable composites having a low elastic modulus using a coating technique can reduce the shrinkage stress of composite resin. However, this procedure could be difficult, especially in the posterior teeth because it is time-consuming and isolation is not easy. The recently developed adhesive technologies have aimed at reducing the polymerization shrinkage and increasing the durability of one-stage (bulk-filling) restorations by adding glass or polyethylene fiber to the structure of composite materials.³⁻⁶

The first bulk-fill composite introduced into the market was the SureFil SDR flow (SDR, Dentsply, Konstanz, Germany). It has advantages such as having a flowing consistency, allowing polymerization of 4-5 mm thick layers at a time, easy and short time of application.^{7,8} Another bulk-fill composite material currently used is the fiber-reinforced Ever X Posterior (EXP; GC Europe, Leuven, Belgium), which is a successful product with many proven mechanical properties.^{9,10} There

has been increasing interest in this material due to the reports of its superior durability, especially against pressure.

The aim of this study was to compare the effect of two commercially available bulk-fill restorative materials on the fracture resistance of endodontically treated human molar teeth. The null hypothesis was that there would be no difference between the materials used regarding the fracture resistance of root-filled teeth.

MATERIALS AND METHODS

In this study, 44 non-carious human third molar teeth extracted due to periodontal reasons, were used. The study was approved by the Akdeniz University Faculty of Medicine Ethics committee No:2012-KAFK-20/238. The extracted teeth were stored in distilled water at +4°C until the study was performed. The specimens were examined under 2.5X magnification with loupes in order to identify the teeth with root caries, broken and cracked teeth, teeth with oblique roots or open apices. The teeth with a mesiodistal width of 11 ± 1 mm and a buccolingual width of 10 ± 1 mm were included in the study. Teeth that meet the criteria of this study were randomly divided into 4 groups with 11 specimens per group. The schematic distribution of the groups is shown in Figure 1.

Grup 1 (SDR)	Inlay cavity 4 mm SDR posterior composite
Grup 2 (EverX)	Inlay Cavity 4 mm EverX Posterior composite
Grup 3 (positive control)	Inlay cavity No restoration
Grup 4 (negative control)	No inlay cavity No restoration

Figure 1. Schematic representation of the groups

Class II mesio-occlusal-distal (MOD) cavities were prepared in all samples except the Group 4. Group 4 was designated as the positive control group and the tooth specimens in this group were

left untreated and stored at +4 C until the fracture resistance test. The buccolingual width of each cavity was measured with a digital caliper (Mitutoyo, Corp., Kawasaki, Japan), and standardized to be half of the intercuspal distance and it included the pulp chamber. For root canal treatment, the access cavities were prepared by using a diamond bur and fissure burs under water cooling. The working length of the root canals was determined with a # 15 K type file (Mani Inc, Tochigi, Japan). The canals were shaped using the Protaper Next (PTN, Dentsply Maillefer, Switzerland) rotary file system. The mesial canals were extended up to X2 and the distal canals up to X3 file. During extension, the canals were irrigated with 2 ml of 2.5% NaOCl between each file. The last irrigation protocol included 2 ml 17% long version (EDTA) and distilled water, respectively. After the root canals were dried with paper points, the root canals were filled using gutta-percha (PTN, Dentsply Maillefer, Switzerland) and resin-based root canal sealer (2Seal, VDW, Munich, Germany) using the single cone method.

In Group 1, Clearfil SE bond (Kuraray Co, Osaka, Japan) was applied to the cavity in accordance with the manufacturers' recommendations and polymerized for 20 light/sec (Valo, Ultradent, USA). The mesial and distal margins of the tooth specimens, shaped using metal matrix bands, were restored with a posterior composite (Valux Plus, 3M ESPE, St. Paul, MN, USA), and a Class I cavity form was created. SDR was placed at a thickness of approximately 4 mm at a time, corresponding to 1.5-2 mm below the occlusal level, and the was polymerized for 40 seconds with dental light curing unit (Valo, Ultradent, South Jordan, USA). The remaining cavity was restored with the posterior composite resin. Following Class I cavity preparations similar to Group 1, EXP was placed in a single phase at a depth of 4 mm to the specimens of Group 2 and

polymerized for 40 seconds. The remaining cavity space was restored with posterior composite resin. No restoration was applied on Group 3 specimens. Following these procedures, polishing was performed under water cooling using aluminum oxide coated discs (Soflex, 3M ESPE, MN, USA). The root surfaces of the restored tooth specimens were covered with a thin wax layer up to 1 mm below the cemento-enamel junction in order to mimic the periodontal ligament. The specimens were then placed vertically in a self-hardening acrylic mold (Imicryl, Turkey) in cylinder blocks of 4.5x2.5 cm up to 1 mm lower the level of enamel cement combination.

After being stored in the incubator at 37°C for a week at 100% humidity, the teeth were inserted to the universal test device (AG-5 kNG, Shimadzu, Tokyo, Japan). At the point corresponding to the central fossa of the teeth, fracture strength test was performed by applying parallel forces to the long axis of the tooth at a speed of 1 mm/min. The forces at the moment of fracture were recorded as Newton (N).

Statistical Analysis

All of the statistical analyses were conducted using SPSS 19 software (SPSS Inc., Chicago, IL USA). The data were assessed by using Kruskal Wallis and Mann-Whitney U tests. The level of significance was determined at $p < 0.05$.

RESULTS

No statistically significant difference was found among the Group 1, Group 2 and the positive control group (Group 4) ($p > 0.05$). However, the bulk-fill flowable composite material showed higher fracture resistance than the fiber reinforced composite material. The highest fracture resistance was observed in the positive control group. The fracture resistance of the negative control group was statistically lower than all the other groups ($p < 0.05$). The results are shown in Table I.

Table 1. Fracture strength of the groups (Newton, Mean \pm SD)

Group	N	Mean \pm SD
Group 1 (SDR)	11	2207.95 \pm 431.85 ^a
Group 2 (EverX)	11	2064.13 \pm 415.67 ^a
Group 3 (negative control)	11	729.03 \pm 161.54 ^b
Group 4 (positive control)	11	2417.11 \pm 266.21 ^a

SD: Standard deviation. Same superscript letter indicates statistically similar values ($p > 0.05$) (Kruskal Wallis and Mann Whitney U test)

DISCUSSION

The most important factor affecting the clinical success of endodontically treated teeth is the remaining coronal tooth tissue. In order to achieve long-term success after treatment, apart from restoring the tooth function, the retention and durability of restoration should also be enhanced. The choice of restorative material and the restoration technique are very important to increase the durability of the teeth against fracture. In many studies it was shown that fiber-reinforced composites have many advantages as better adhesion of composite luting agent to the fiber, physiological stiffness of the denture framework made of fiber, and a better elastic modulus match between fiber-reinforced composite restoration and dentin/enamel.^{9,10,11} In this study both bulk fill composite restorations showed fracture resistance values similar to intact teeth.

The preparation of cavity access in posterior teeth having a MOD cavity without marginal support or with significant structural loss may cause loss of resistance.¹² The recently developed bulk-fill composites can replace the layering technique due to the application of a single mass of 4 mm thickness.¹³ In our study, when compared to the positive control group, cavity preparation in the negative control group significantly reduced the fracture strength of the dental specimens ($p < 0.05$). The findings are consistent with previous studies.^{5,14}

In the teeth with considerably decreased fracture resistance due to cavity preparation, completing the canal treatment and coronal restoration with the most suitable material in one session significantly increases the success. EXP, a fiber-reinforced bulk-fill composite, has recently

become a preferred material for endodontically treated posterior teeth with large cavities. EXP is designed as a single-layer substructure material consisting 7.2% short fibers by volume. A conventional composite resin restoration is further required. EXP has more advanced fracture strength, bending resistance, and load-bearing capability than conventional composites.^{15,16} The reinforcing effect of EXP is based on versatile, discontinuous short E-glass fibers that prevent crack propagation in a semi-intertwined polymer matrix. These fibers can provide an isotropic reinforcing effect, since each fiber acts as a crack stopper and transfers stress from the polymer matrix to stronger fibers.¹⁵

In this study, there was no statistically significant difference between the positive control group and the EXP group. The fracture strength values were found to be similar to a healthy tooth. The reason for fracture resistance could be because of glass fibers which increase the material stiffness and resistance to bending forces. This result is important because it provides safe clinical use. SDR that is the other composite resin used in our study, was the first bulk-fill composite. It contains a photoactive group in the modified urethane dimethacrylate resin. This structure allows the light, which is required for the polymerization, to reach the deeper layers of the composite. This enables the application of the composite at a thickness of 3-4 mm at a time.^{17,18} In this study, no statistically significant difference was observed among the fracture strength values of SDR, EXP, and the positive control group. These findings are consistent with those in previous studies.⁷ In another study, EXP showed better results than SDR in terms of compressive and flexural strength

values except hardness. In this study, the higher fracture resistance of SDR than EXP, can be explained by higher nano hardness values.¹⁹

The chemical solutions, especially NaOCl, used in the root canal treatment may cause mechanical changes in the dentine tissue residues and increase the risk of crown fracture. In a recent study, it has been demonstrated that the irrigation protocol with 5.25% of NaOCl significantly reduces the crown fracture resistance.^{20,21} Thus, the choice of materials that are close to the physical and mechanical characteristics of healthy tooth tissue is very important for endodontically treated teeth. In this context, both bulk-fill composite materials used as upper restorations, have demonstrated fracture resistance values close to that of a healthy tooth. As far as the ease of clinical applications is concerned, SDR, through its flowable feature, may provide the clinicians with advantages.

CONCLUSIONS

Within the limits of this study, our findings demonstrate that the bulk-fill composites provide ease of use, decrease the time of application of the upper restoration, and increase the fracture strength of root canal treated teeth. It is important that the findings of this *in vitro* study should be supported with *in vivo* studies.

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CONFLICT OF INTEREST STATEMENT

Authors declare no conflicts of interest.

İki Güncel Bulk-Fill Rezin Kompozitin Endodontik Tedavili Dişerin Kırılma Direnci Üzerine Etkisi ÖZ

Amaç: İki güncel bulk-fill özellikte restoratif materyalin, endodontik tedavili insan molar dişlerinin kırılma direnci üzerine etkisini karşılaştırmaktır. **Materyal ve Metod:** Bu çalışmada 44 adet üçüncü molar diş seçilerek rastgele 4 gruba ayrıldı (n=11). Grup 1'de kavitelere 4 mm kalınlığında bulk-fill akışkan kompozit materyal (SDR™, Dentsply) yerleştirildikten sonra proksimal duvarlara rezin kompozit (Valux Plus, 3M ESPE) uygulandı ve kalan okluzal bölgenin de restorasyonu yapılarak işlem tamamlandı. Grup 2'de kavitelere 4 mm kalınlığında fiberle güçlendirilmiş bulk-

fill kompozit materyal (EverX Posterior; GC) yerleştirildikten sonra 1. gruptaki işlemlerin aynı uygulandı. Grup 3'de (negatif kontrol grubu) kavitelere herhangi bir restorasyon uygulanmadı. Grup 4'de (pozitif kontrol grubu) tamamen sağlam dişler kullanıldı. Diş kök kanalları NaOCl ile irriga edilerek döner aletlerle şekillendi ve güta perka ile dolduruldu. Tüm örnekler 37°de 1 hafta süreyle inkübatörde bekletildikten sonra kırılma dayanımı testi gerçekleştirildi. Newton olarak kaydedilen veriler Kruskal Wallis ve Mann-Whitney U istatistiksel analizi ile değerlendirildi. **Bulgular:** Grup 1, Grup 2 ve Grup 4 (pozitif kontrol grubu) arasında istatistiksel farklılık gözlenmedi (p>0.05). Bununla birlikte bulk-fill akışkan kompozit materyali, fiber-rezinle güçlendirilmiş kompozit materyalinden daha yüksek kırılma direnci göstermiştir (p<0.05). En yüksek kırılma dayanımı pozitif kontrol grubunda görülürken, negatif kontrol grubunun kırılma dayanımı diğer gruplardan istatistik olarak anlamlı ölçüde düşük bulunmuştur (p<0.05). **Sonuç:** Her iki güncel bulk-fill restoratif materyali de endodontik tedavili dişlerde benzer kırılma direnci göstermiştir. Bunun yanı sıra bulk-fill akışkan kompozitlerin daha yüksek kırılma direnci sağlaması ve uygulama kolaylığından dolayı klinik kullanımı tavsiye edilebilir. **Anahtar Kelimeler:** Kompozit rezin, kırılma dayanımı, endodonti.

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