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Fracture Resistance of Endodontically Treated Upper Premolar Teeth Restored with Bulk-fill and Conventional Resin Composite#

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Research Article

Acknowledgment

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History

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ABSTRACT

Objectives: The aim of this in vitro study was to evaluate the fracture resistance of endodontically treated upper premolar teeth restored with different resin composites.

Materials and Methods: Hundred and eight maxillary premolar teeth were randomly divided into nine groups (n=12). The teeth in the first group were left intact and tested as unprepared group 1 (negative control). Other eight groups were prepared with MOD cavities and endodontically treated. The teeth in group 2 (positive control) were unrestored. Other groups were restored with different resin composites. Group 3: conventional resin composite and group 4-9 six bulk fill resin composite (group 4: 3M Filtek Flowable Bulk Fill, group 5: 3M Filtek Posterior Bulk-fill, group 6: Voco X-tra base, group 7: Voco X-tra fil, group 8: Dentsply SDR Flow, group 9: Dentsply Quixfil). Single Bond Universal was applied as self-etch, according to application instructions. The restored teeth were stored in distilled water for 24 hours at 37°C. The compressive force was applied parallel to the long axis of the teeth. The test was carried out at a speed of 1mm/min. ANOVA and Tukey HSD tests were used in the analysis of the data.

Results: Negative control group showed significantly higher fracture resistance than other tested groups. The bulk-fill resin composites were showed higher fracture resistance than teeth restored with conventional resin composite. No statistically significant differences were found in the fracture resistance values of the bulk-fill resin composites. The significantly lowest values were obtained in the positive control group (group II)

Conclusions: The fracture resistance values of endodontically treated teeth restored with bulk-fill composites were higher than teeth restored with conventional resin composite.

Keywords: Fracture Resistance, Endodontic Treatment, Bulk-Fill Composite, Endodontics, Resin Composite.

Bulk-Fill ve Geleneksel Kompozit Rezin ile Restore Edilmiş Endodontik Tedavi Görmüş Üst Premolar Dişlerin Kırılma Direncinin Değerlendirilmesi#

Bilgi
#Bu çalışma 23-25 Kasım 2021 tarihleri arasında düzenlenen 'Sivas Cumhuriyet Üniversitesi 1. Uluslararası Diş Hekimliği Kongresi'nde sözlü bildiri olarak sunulmuştur.
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ÖZ

Amaç: Bu in vitro çalışmanın amacı, farklı tip kompozit rezinler ile restore edilmiş endodontik tedavi görmüş üst premolar dişlerin kırılma direncini değerlendirmektir.

Gereç ve Yöntemler: Yüz sekiz maksiller premolar diş rastgele dokuz gruba (n=12) ayrıldı. Birinci gruptaki dişler negatif kontrol grubu olarak belirlendi ve herhangi bir preparasyon yapılmadı. Kalan sekiz gruptaki dişlere MOD preparasyonlar hazırlandı ve endodontik tedavi yapıldı. Sekiz gruptan biri (2.grup) pozitif kontrol grubu olarak seçildi ve dişlere koronal restorasyon yapılmadı. 3. grup (3M UR200) geleneksel kompozit rezin ile restore edildi. Geri kalan 6 grup ise (4. grup 3M Filtek Flowable Bulk-fill, 5.grup 3M Filtek Posterior Bulk-fill, 6. grup Voco X-tra base, 7. grup Voco X-tra fil, 8.grup Dentsply SDR Flow, 9.grup Dentsply Quixfil) altı farklı bulk-fill kompozit rezin ile restore edildi. Restorasyonlarda adeziv olarak Single Bond Universal, uygulama talimatlarına göre self-etch olarak uygulandı. Restore edilen dişler distile suda 37°C'de 24 saat saklandı. Örnekler üniversal test cihazında 1mm/dak hızda kırıldı. Veriler, tek yönlü ANOVA ve post hoc Tukey HSD testi kullanılarak analiz edildi. Analizler, SPSS 20.0 programı ile %5 anlamlılık düzeyinde gerçekleştirildi.

Bulgular: Negatif kontrol grubunda elde edilen skorlar diğer gruplara göre anlamlı ölçüde daha yüksek bulundu. Bulk-fill kompozit rezinler ile restore edilen dişlerin kırılma direnci geleneksel kompozit rezinle restore edilen dişlerden daha yüksek bulundu. Bulk-fill kompozit rezinler ile restore edilen gruplar arasında kırılma direnci açısından anlamlı farklılık bulunmadı. En düşük kırılma skorları ise pozitif kontrol grubunda görüldü.

Sonuçlar: Bulk-fill kompozit ile restore edilen endodontik tedavili dişlerin kırılma direnci skorları, geleneksel kompozit rezinler ile restore edilen dişlerden daha yüksek bulunmuştur.

Anahtar Kelimeler: Kırılma Direnci, Endodontik Tedavi, Bulk-Fill Kompozit, Endodonti Kompozit Rezin.

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Introduction

The loss of anatomical structures, water content, pulp chamber tissue makes teeth more fragile.[1] Extensive restorations, trauma, access cavity preparation, endodontic procedures, post space preparation, extensive cavities are the most reasons for tooth fracture.[2-4] A good coronal restoration and support of the remaining tooth tissue are very important for the long-term success of the endodontic treatment.[5-7] There are many treatment options and different materials to be used according to the amount of tooth tissue remaining after endodontic treatment. Such as direct or indirect resin composites, crown, endo crown, inlay-onlay, or post placement.[7,8]

Resin composite restorations increase the fracture resistance of endodontically-treated teeth by supporting the remaining tooth tissues.[7,9-11] But when the cavity size increase, the traditional maximum two millimeter composite layering technique can both prolong the treatment time and increase the risk of moisture contamination and air bubbles.[12,13]

Bulk-fill resin composites are developed to simplify the placement of direct composite restorations and to overcome these disadvantages.[14] Bulk-fill resin composites are available in low and high viscosity, flowable and packable types. Manufacturers and researchers have reported that bulk-fill resin materials can effectively polymerize up to 4-5 mm (light-cured) and 10 mm (dual-cured) and have low polymerization stresses. Conventional microhybrid composites and flowable composites cannot achieve sufficient polymerization amounts and microhardness at these sizes.[15-18]

There is limited data about the fracture resistance of endodontically treated teeth restored with traditional and bulk-fill resin composites.[19-22] This study was conducted to investigate the fracture resistance of endodontically treated teeth restored with bulk-fill and micro-hybrid composites to gain more information on this subject. The null hypothesis was that there would be no statistically significant difference in the fracture resistance of endodontically treated teeth restored with bulk-fill and conventional resin composites.

Materials and Methods

The present study was approved by the ethics committee of Izmir Katip Celebi University with the number 2014-159. A hundred and eight sound human maxillary premolars were used for this study. Teeth were extracted for periodontal problems and orthodontic reasons. The calculus and soft tissues were removed using a scaler. The teeth were checked for cracks or fractures using a stereomicroscope (Zeiss, Oberkochen, Germany) at 25X magnification. The mesiodistal and buccopalatal dimensions of the teeth were evaluated using a digital calipper (Max Extra Digital Calipper, Numan Özkara İstanbul, Turkey) to ensure that teeth were similar size. The means of buccolingual and mesiodistal dimensions were 9,3mm (9-9,4) and 7,2mm (7-7,5) respectively. The teeth were stored in distilled water at 37ºC until use.

Teeth were embedded in self-curing acrylic resin (SC Acrylic, IMICRYL, Konya, Turkey) using a teflon cylinder mold (3cm in diameter and 3 cm in height) up to 1mm below the cemento-enamel junction (CEJ). The teeth were randomly divided into nine groups of 12 teeth (n=12). The teeth in the first group were left intact and tested as a negative control (group 1).

Cavity preparations, endodontic treatments and restorations are done by an operator. The mesio-occluso-distal (MOD) cavities and endodontic access cavities of the eight groups were prepared using a high-speed diamond fissure bur (Aida 1392/556) under cooling air and water. The MOD cavities were prepared a width of one-third of the intercuspal distance (mean 2,2mm) on occlusal, an one-third of the buccopalatal distance (mean 3mm) on gingival. The cavity depth of the preparations was set to 4mm. The bur was changed after three cavities. All edges were smoothed after the preparation.

The canal length was measured with a 10 K file (Dentsply Maillefer, Switzerland). The working length was determined by subtracting 1 mm from this length The canals were prepared with ProTaper Next rotary files up to #X2 (Dentsply Maillefer, Switzerland) according to the manufacturer's guidelines. 5.25% 5ml NaoCl (sodium hypochlorite) was used for irrigation for each tooth. Smear layer was removed with 17% EDTA. 2ml EDTA was used for each tooth. Finally, the canals were rinsed with distilled water and dried with paper points. AH plus canal sealer (Dentsply De-Trey, Konstanz, Germany) and single cone (ProTaper Next-X2) technique was used for filling the canals. The endodontic access cavity was cleaned with alcohol and cotton pellets. The endodontic access cavities were restored up to the MOD cavity floor with a light-cured glass ionomer Glass Liner (WP Dental, Hamburg, Germany).

Groups;

Group 1: Negative control group. Intact teeth without any cavity preparation.

Group 2: Positive control group. MOD preparation and endodontic treatment were done. These teeth were not restored.

For group 3 to 9 adhesive application and matrix placement: The Single Bond Universal (3M ESPE) adhesive was used in self-etch mode. The adhesive was applied for 20 seconds according to the manufacturer's instructions. Then air dried 5 seconds and cured 10 seconds with Anthos T-LED (Anthos, Imola, Italy, 1200 mW/cm2) light cure device. Conventional and Bulk Fill resin composites were cured with Anthos T-LED according to the guidelines. 6mm metal band with a tofflemeire retainer used for cavity restorations.

Group 3: UR 200™ (3M ESPE) conventional microhybrid resin composite. Cavities were restored with UR 200 incrementally, each layer was 2mm thick and light cured for 20 seconds.

Group 4: Filtek Bulk Fill Flowable Restorative (3M ESPE) bulk fill resin composite. The cavity was filled with 4mm thickness Filtek Bulk Fill resin composite. It was light cured for 10 seconds.

Group 5: Filtek Bulk Fill Posterior Restorative (3M ESPE) bulk fill resin composite. The cavity was filled with 4mm thickness Filtek Bulk Fill Posterior Restorative. It was light cured for totally 30 seconds from occlusal, mesial and distal.

Group 6: X-tra base (Voco) bulk fill resin composite. The cavity was filled with 4mm thickness X-tra base resin composite. It was light cured for 10 seconds.

Group 7: X-tra fil (Voco) bulk fill resin composite. The cavity was filled with 4mm thickness X-tra fil resin composite. It was light cured for 10 seconds.

Group 8: SDR (Dentsply) bulk fill resin composite. The cavity was filled with 4mm thickness SDR resin composite. It was light cured for 20 seconds.

Group 9: QUIXFIL (Dentsply) bulk fill resin composite. The cavity was filled with 4mm thickness QUIXFIL resin composite. It was light cured for 10 seconds.

The materials used in study are listed in Table 1.

The restorations were finished with finishing burs. The specimens were stored for 24 hour in distilled water at 37°C.

Fracture strength test

The teeth were submitted to a compression test in a universal testing machine (AGS-X; Shimadzu Corporation, Tokyo, Japan). The test was performed at a speed of 1mm/min with a 5mm diameter round tip, parallel to the long axis of the tooth until a fracture occurred in the tooth or restoration (Figure 1). The testing machine stopped automatically when fracture occurred in the restoration materials or teeth. The maximum force values obtained with the software supporting the operation of the device (TRAPEZIUM X Version 1.3.1, Shimadzu Corp., Japan) were recorded in newtons (N).

Statistical Evaluation

The data was analyzed using a software (SPSS 20.0 for Windows, SPSS Inc, Chicago, IL, USA) at a significance level of 0.05. ANOVA and post hoc Tukey HSD test was used for multiple comparison.

Results

The mean fracture resistance values (N) and the standard deviations of each group are given in Table 2. There was a significant difference between the groups as a result of the ANOVA test ($p<0.05$). Group 1 showed significantly higher fracture resistance than did the other tested groups ($p<0.05$). The lowest fracture resistance was seen in group 2 (positive control group) ($p<0.05$), which was not restored after endodontic treatment. Conventional resin composite (group 3) showed lower fracture resistance than bulk fill resin composites ($p<0.05$). There was no significant difference between the groups restored with bulk fill composites. No statistically significant differences were found between groups restored with bulk-fill resin composites (group 4-9) ($p\geq0.05$).

Table 1. Materials used in the study

Product Name-Shade	Type	Manufacturer / Lot No	Composition
Filtek UR 200-A1	Microhybrid Composite	3M-ESPE Seefeld GERMANY /611629	Bis-GMA, UDMA, Bis-EMA zirconia/silica
Filtek Flowable Bulk-U	Bulk-fill flowable resin composite	3M-ESPE Seefeld GERMANY /461826	Inorganic fillers, Bis-GMA, UDMA, Bis-EMA, zirconia/silica
Filtek Posterior Bulk-A1	Bulk-fill posterior restorative	3M-ESPE Seefeld GERMANY/ 640699	Inorganic fillers, Bis-GMA, UDMA, Bis-EMA, procrylat resins, ytterbium trifluoride, zirconia/silica
X-tra base-U	Bulk-fill flowable resin composite	VOCO Cuxhaven Germany/1409663	Bis-EMA, MMA, silica
X-tra fil-U	Bulk-fill restorative	VOCO Cuxhaven Germany/ 1410271	Bis-GMA, UDMA, BHT, TEGDMA
SDR Flow-U	Bulk-fill flowable resin composite	DENTSPLY Milford, DE USA/ 1309183	Barium and strontium alumino-fluorosilicate glass, TEGDMA, modified UDMA, dimethacrylate, Bis-EMA, pigment, photoinitiator
QUIXFIL-U	Bulk-fill restorative	Dentsply Kontanz, GERMANY/ 1502000709	Bis-EMA, UDMA, TCB TEGDMA, TMPTMA, strontium glass
Single Bond Universal	Universal Adhesive (self-etch mode)	3M ESPE, St Paul, MN, USA/ 527687	MDP phosphate monomers, dimethacrylate resins, HEMA, methacrylate-modified polyalkenoic acid copolymer, fillers, ethanol, water, initiators, silane

*Abbreviations: Bis-EMA: ethoxylated bisphenol A dimethacryrlate, Bis-GMA: bisphenol A glycidyl methacrylate, HEMA: hydroxyethyl methacrylate, MDP: methacryloyloxy-decyl dihydrogen-phosphate, TEGDMA: triethylene glycol dimethacrylate, UDMA: urethane dimethacrylate, PMMA: polymethyl methacrylate, TCB: Tetracarboxylic acid-hydroxyethylmethacrylate-ester, TMPTMA: Trimethylolpropane trimethacrylate, EMA: ethyl methacrylate

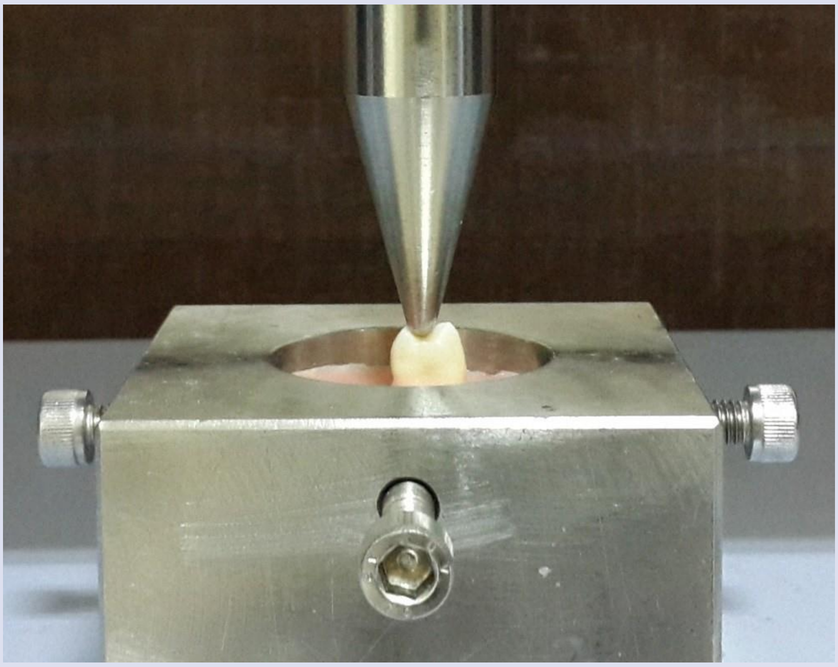

Figure 1. Fracture resistance test

Table 2. Means and standard deviations of fracture resistance of groups

Groups	(n)	Mean (N)	Standart Deviation (N)
Group 1- Negative Control	12	1437.93a	251.94
Group 2- Positive Control	12	283.62b	78.30
Group 3- UR200	12	575.94c	129.07
Group 4- 3M Filtek Flow Bulk	12	1010.79d	221.64
Group 5- 3M Filtek Post Bulk	12	958.98d	249.04
Group 6- X-tra base	12	1056.47d	174.63
Group 7- X-tra fil	12	1100.24d	173.49
Group 8- SDR	12	1023.88d	189.59
Group 9- QUİXFİL	12	965.56d	155.15
ANOVA	F(8,99)	36,648	p<0.05

*Different letters indicate significant differences at level of significance p.0.05.

Discussion

The results of our study confirmed that the use of bulk-fill resins in endodontically treated maxillary premolar teeth increases the fracture resistance of teeth. Therefore, the null hypothesis was rejected.

It is accepted that endodontic treatment reduce the fracture resistance of teeth. Remaining coronal tooth structure, selection of restorative material and correct restoration are the most important factors affecting the success of endodontic treatment, which increases the fracture resistance of teeth after endodontic treatment.[23]

It has been reported that endodontic procedures reduce the fracture resistance of premolars by 5%, occlusal cavity preparation by 20%, and MOD cavity preparation by 63%.[24,25] Other researchers reported that the fracture resistance of upper premolar teeth with class II preparations is lower than that of other teeth.[10,26,27] Accordingly, we used upper premolar teeth and MOD preparation in our study.

The results of the present study showed that the cavity preparation significantly reduced the fracture resistance of the specimens in the positive control group compared to the negative control group (p<0.05). This finding is consistent with the previous studies.[23,28] There were significant differences between bulk-fill resin composites and conventional resin composites in the fracture resistance of endodontically treated upper premolars (p<0.05). The bulk-fill composites were found to be higher than teeth restored with conventional resin composite. These findings can be explained by the fact that bulk-fill composites have lower polymerization stress and lower modulus of elasticity.[28,29]

Also, our findings are not in agreement with studies Atalay *et al.*, Toz *et al.* and Yasa *et al.* that investigated the fracture resistance of endodontically treated teeth restored with bulk-fill and conventional resin composite.[19-21] In their studies, no significant difference was found between groups restored with bulk-fill composites and conventional resin composite. The reason for this situation may be that they used nano-hybrid resin composite as conventional resin composite and we used micro-hybrid composite. Mohan *et al.* and Kaur *et al.* found that the teeth restored with nanohybrid composite had higher fracture resistance than teeth restored with micro-hybrid resin composite.[30,31]

In our study, no significant difference was found between the fracture resistance of teeth restored with flowable bulk-fill resin composites and packable bulk-fill composites (p≥0.05). The fracture resistance of teeth restored with flowable bulk-fill composites was higher than other resin composites (X-tra base 1056.47N, SDR 1023.88N, 3M Filtek Flow 1010.79N) except for X-tra fil group (1100.24 N). These findings may be attributed to the elastic buffer effect, low shrinkage stress and low modulus of elasticity of the use of flowable bulk-fill composites.[29,32] Also, these findings are in agreement with Isufi *et al.* and Atiyah *et al.* who reported increased fracture resistance of endodontically treated premolars restored with flowable bulk-fill resin composites.[28,33]

Our in vitro study was conducted under a static load. Fatigue stress is an important process in oral conditions. Therefore, more in vitro and in vivo studies are needed.

Conclusions

Within the limits of this study, our findings demonstrate that the bulk-fill composites increase the fracture resistance of endodontic treated teeth, provide ease of use and decrease the time of application of the upper restoration.

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Conflict of Interest Statement

The authors report no conflicts of interest.

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