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ORIGINAL RESEARCH

Comparison of Fracture Strength in Endodontically Treated Teeth Restored with Bulk fill, Bulk Fill Flowable and Conventional Composite with or without Using Ribbon

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Abstract

Background: **The most important change in the mechanical properties of endodontically-treated teeth is the reduction of fracture resistance. The aim of the present study was to compare the fracture resistance of teeth restored with bulk-fill resin, flowable bulk-fill resin and conventional composite resin in the presence or absence of fiber.**

Material and Methods: **In this laboratory study, 120 healthy maxillary first premolar teeth were selected and divided into eight groups, each containing 15 teeth. The division was based on the type of composite used for restoration, with three types available: conventional, bulk-fill, and flowable bulk-fill with or without fiber. Additionally, there were two negative control groups (intact teeth) and one positive control group (cavity creation with no restoration). In all groups, except for the negative control group, a MOD cavity was prepared after root canal treatment. For the fiber-reinforcement groups, a piece of fiber was placed on top of the first composite layer and cured accordingly. Following restoration, all teeth underwent polishing, mounting and were evaluated. The Data was analyzed with the t-test, Kruskal-Wallis, and Mann-Whitney tests ($\alpha=0.05$).**

Results: **The fracture strength in the fiber-reinforced bulk-fill composite group was higher than the fiber-free group in the sample, but the difference was not significant ($p = 0.283$). There was no significant difference between the fiber-reinforced conventional bulk-fill composite group in comparison to the fiber-free group in terms of fracture resistance ($p = 0.375$). The fracture resistance was the same in the samples treated with conventional and bulk-fill composite resins, and it was significantly lower in the samples treated with flowable bulk-fill composite than those treated with conventional and bulk-fill composites. There was a significant difference in fracture resistance of fiber-reinforced composites ($p<0.001$).**

Conclusion: **Tooth restoration reduces fracture resistance. Fiber addition has no significant effect on increasing the fracture resistance of composites.**

Keywords: **Composite resins, endodontically treated teeth, Fracture strength**

Introduction

Endodontically-treated teeth lose a major part of their structure due to excessive decay or fracture. The most important change in the mechanical properties of endodontically-treated teeth is the reduction of fracture resistance (1, 2). The fracture resistance of restored teeth is influenced by numerous factors such as the type of tooth, cavity size and expansion, the type of restorative material, the presence or absence of the marginal ridge, and the bond shrinkage and strength (3). The fracture resistance of the restorative material is one of the important characteristics that must be considered to ensure the reliable performance of a restorative material (4). Restorative material with high fracture resistance tends to resist the formation and expansion of small cracks caused by masticatory forces (5). To maintain the structure of teeth , it is suggested to use resin composite restorations directly after endodontic treatments (6, 7).

Conventional resin composites are the first generation of composites that have large filler particles such as quartz, borosilicate glass, and lithium aluminum glass. Most particles in conventional composites are 20 to 50 µ with a general particle size of 0.1 to 150 µ (8).

Considering their ability to administer in deep cavities, bulk-fill composites have been introduced for tooth-colored restoration in posterior teeth to ensure better stress tolerance and occlusal forces (9). More effortless restoration of proximal contact points, creating similar functional properties to amalgam, eliminating complex

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techniques, increasing filling speed, and reducing the number of clinical steps and dentist fatigue are the bulk-fill composite advantages (10).

Flowable bulk-fill composites are the new generation of bulk-fill composites, used not as liners but as posterior restorations for cavities deeper than 4 mm, because of their better mechanical properties (11).

In recent years, the development and expansion of fiber technology for fiber-reinforced composites have improved the performance of restorative materials. The combination of resin composite and fiber-reinforced composites has increased the mechanical properties, direct chair side use, and better adhesion to the tooth structure (12).

Ribbon fibers are reinforcing ribbons made of polyethylene fibers with high molecular weight and tensile strength due to their exceedingly high elasticity coefficient, surface hardness, and fracture resistance. These materials prevent the spread of cracks inside the restorative material and increase their fracture resistance. They are biocompatible and have excellent optical properties (13).

The disadvantages of incremental composite restorations include the possibility of bubble formation between composite layers, contamination of composite layers, failure to establish a proper interlayer bond, and finally, there is difficulty in placing layers in cavities with minimal access with an increase in the chair time (14). Therefore, bulk-fill composite, which can reduce the problems of incremental technique while maintaining the optimal properties, including sufficient polymerization, can be helpful (15).

Eweis et al. (16) compared the flexural characteristics of bulk-fill, flowable bulk-fill, and conventional composites and showed that bulk-fill restorations had a higher flexural modulus than conventional and flowable samples. Pham and Huynh (17) evaluated the post and core bond strength and fracture resistance in flowable bulk-fill composite and fiber-reinforced posts and cores and reported no significant difference between the two groups regarding this matter.

Considering that the type of composite is one of the key factors in the stress resistance of the restored tooth, the present study aimed to investigate and compare the fracture resistance of bulk-fill, flowable bulk-fill and conventional composites in the presence or absence of fiber.

Materials and Methods

This laboratory study was conducted on 120 maxillary first premolar teeth that were extracted for orthodontic reasons. The teeth were free of caries, cracks, and fractures, and had two separate roots. The teeth were disinfected and any soft tissues surrounding them were removed before cleaning the surface.

The selected teeth were divided according to size and randomly placed in eight groups (n=15 per group). To calculate the teeth size according to Earle's method, the maximum buccolingual and mesiodistal dimensions were calculated by callipers in the occlusal third of the teeth, and the two numbers were multiplied together (18).

The studied groups included:
Group 1 (negative control): intact teeth
Group 2 (positive control): creation of mesio-occlusal-distal (MOD) and no restoration
Group 3: Restoration with fiber-free bulk-fill composite (X-tra fil, Voco, Germany)
Group 4: Restoration with fiber-reinforced bulk-fill composite (X-tra fil, Voco, Germany)
Group 5: Restoration with fiber-free flowable bulk-fill composite (X-tra Base, Voco, Germany)
Group 6: Restoration with fiber-reinforced flowable bulk-fill composite (X-tra Base, Voco, Germany)
Group 7: Restoration with fiber-free conventional composite (Grandio Voco)
Group 8: Restoration with fiber-reinforced conventional composite (Grandio Voco)

To perform endodontics, an access cavity with dimensions of 2 x 3 mm was first prepared (19). Then k-file (MANI-Japan) No. 15 was inserted into each of the dental canals until the tip of the file could be seen from the apex area, one millimeter was subtracted from its length and the obtained size was selected as the functional length. Step-back preparation of the root canal was conducted using K-file No.30. Then, gutta-percha (size 30) (META-Korea) was impregnated with AH 26 sealer (Dentsply-Germany) placed inside the canal (Figure 1d).

When preparing the MOD cavity, the buccolingual width at the occlusal plane was equal to 3 mm, the height of the axial wall of the proximal boxes was 2 to 4 mm so that the gingival floor of the proximal box was considered 1 mm above the CEJ area (19).

To restore the teeth, gutta-percha was removed from the pulp chamber at a level 2 mm from the canal orifice. All glass-filled areas were treated with 20% polyacrylic acid as a cavity conditioner for ten seconds. Then Fuji II LC Gold type glass ionomer cement (GC-Japan) was placed on the gutta-percha as a MOD restorer (20) (Figure1a).

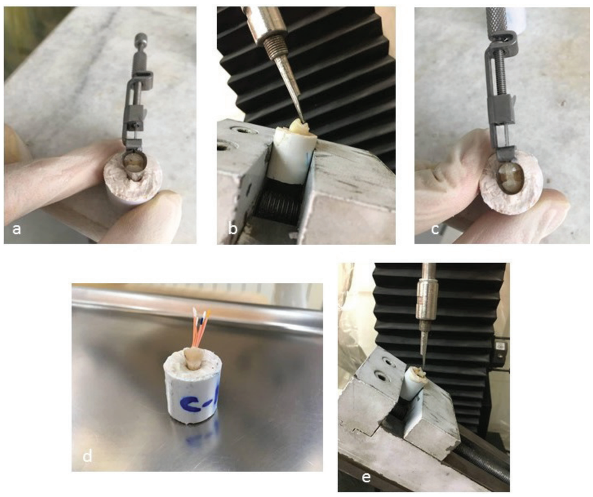

Figure 1. a) Prepared tooth ready for restoration b) Tooth under load c) ribbon fiber placement d) RCT-Obturation e) Tooth fracture at the end of test

When the glass ionomer hardened, the entire cavity was etched with 37% phosphoric acid for 20 seconds and then washed for 10 seconds. After drying the area inside the cavity, the parts related to dentin and enamel were etched with acid and cured for 20 seconds (VALO, ULTRADENT (USA).

In each group (group 3 to group 8), the composite of the same group was used to repair the teeth through incremental thickness of 2 mm.

When the glass ionomer hardened, the entire cavity was etched with 37% phosphoric acid for 20 seconds and then washed for 10 seconds. After drying the area inside the cavity, the parts related to dentin and enamel were etched with acid and cured for 20 seconds (VALO, ULTRADENT (USA).

Then cyclic loading was conducted by the Universal testing machine machine (Santam Co, Tehran, Iran) and a conical steel cylinder. A compressive force was applied to the teeth at 150° to the longitudinal axis and 45° to the palatal slope of the palatal cusp (Figure 1b). The above machine was in contact with the slope of the buccal palatal cusp at a speed of 0.5mm/ min. The force level was increased until a fracture occurred. The loading steps were recorded by the Universal testing machine software in the stress (N) to strain (µm) diagram and the maximum force required to achieve fracture was determined in megapascal (MPa) (Figure 1e).

To investigate the fracture pattern, the teeth were placed under a stereo microscope, and their fracture pattern (restorable or non-restorable) was carefully examined.

Considering the normality of the data distribution by the Kolmogorov–Smirnov test, the T-test was used to compare the strength between the ribboned and non-ribboned state in each of the composites, and the comparison of different groups in the non-ribboned state, which had a non-normal distribution, was done by the Kruskal-Wallis test and It was a two-by-two comparison with the Mann-Whitney test. The comparison of distinct groups in the condition with a ribbon which had a normal distribution was done by ANOVA analysis of variance and a two-by-two comparison was done with Tukey's test.

The collected obtained was analyzed with SPSS 25 software and P-value<0.05 was considered as the significant level.

Results

The fracture resistance of the endodontically-treated premolar teeth restored with the studied fiber-reinforced and fiber-free composites was compared using a t-test, and it was found that the fiber addition led to no significant increase in fracture resistance of the bulk-fill composite (p<0.283), the flowable bulk-fill composite (p<0.095) and conventional composite (p<0.375) (Table 1).

Table1. Comparison of the fracture strength of endodontically-treated premolar teeth with studied composites with and without ribbon

Groups	No	No ribbon	with ribbon	p value
		Mean ± SD	Mean ± SD	
bulk-fill	15	396.36±64.43	420.39±55.37	0.283
flowable bulk-fill	15	328.26±31.47	358.75±61.23	0.095
conventional	15	383.76±65.44	405.34±65.57	0.375

Comparing the fracture resistance of endodontically-treated premolar teeth restored with three studied fiber-free composites (bulk fill, flowable, and conventional bulk-fill), the results of the Kruskal Wallis test showed that the restored teeth had lower fracture resistance compared to intact teeth. Also, the fracture resistance was the same in samples treated with conventional and bulk-fill composites, and the fracture resistance in samples treated with flowable bulk-fill composite was significantly lower than the samples treated with conventional and bulk-fill composites (P <0.001) (Figure 2).

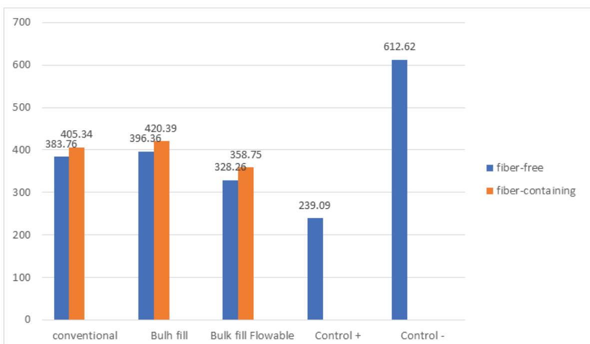

Figure2. Comparison of fracture strength in fiber-free and fiber-containing composites

Comparing the fracture resistance of endodontically-treated premolars restored with three types of fiber-reinforced composites (bulk-fill, flowable bulk-fill, and conventional), the results of the ANOVA test showed a significant difference in the fracture resistance of fiber-reinforced composites (P<0.001) (Table 2).

Table 2. Comparison of the fracture strength of the endodontically-treated premolar teeth between three types of composites with and without ribbon

Groups	without ribbon	with ribbon
	Mean ± SD	Mean ± SD
Conventional	383.76 ±65.44	405.34±65.57
Bulk fill	396.36 ±64.43	420.39±55.37
Bulk Fill Flowable	328.26 ±31.47	358.75±61.23
CONTROL +	239.09 ±43.00	-
CONTROL -	612.62 ±54.70	-
Pvalue	<0.001	<0.001

A pairwise comparison of the composites showed a significantly higher fracture resistance in the fiber-reinforced bulk-fill composite than flowable bulk-fill composite, but there was no significant difference between bulk-fill and conventional composites in terms of fracture resistance. Also, conventional, and flowable bulk-fill composites had the same fracture resistance (Figure 2).

The results showed that the fracture pattern of all studied fiber-reinforced and fiber-free groups were the same. Both fiber-reinforced and fiber-free bulk-fill composite had no “ non-restorable fractures”. The frequency of non-restorable fracture was reduced in the fiber-reinforced flowable bulk-fill and conventional composites. The frequency of “enamel chipping” and “restorative material-tooth fracture” was almost similar in all groups. The fracture frequency of “ restorative materials “ decreased in the fiber-reinforced bulk-fill composite but increased in the fiber-reinforced bulk-fill composite, and it had no effect on the fracture frequency of the restorative materials in the fiber-reinforced conventional composite (Table 3).

Table3. The fracture resistance of endodontically-treated premolars was restored with three types of fiber-reinforced composites (bulk-fill, flowable bulk-fill and conventional)

Groups		enamel chipping	restorative material-tooth fracture	restorative materials	Enamel and dentin fracture/Breakdown	Castastrophic failure (unrepairable
control	+	6	0	0	7	2
	-	7	0	0	8	0
bulk-fill	No ribbon	7	3	2	3	0
	with ribbon	6	3	1	5	0
flowable bulk-fill	No ribbon	7	3	1	2	2
	with ribbon	6	2	3	4	0
conventional	No ribbon	6	3	2	3	1
	with ribbon	6	2	2	5	0

Discussion

In the fiber-reinforced samples, the fracture resistance of bulk-fill composite was significantly higher than that of flowable bulk-fill composite, but there was no significant difference between bulk-fill and conventional composites in terms of fracture resistance, and the fracture resistance was similar in conventional and flowable bulk-fill composites.

Ribbon fibers are made of polyethylene fibers with high molecular weight and have high fracture resistance and can support restoration considering their high elasticity and hardness. Also, considering their special nature and form, these materials prevent the spread of cracks, which leads to fractures.

According to the results of a systematic review by Cidreira Boaro et al. (22), bulk-fill composites have similar marginal quality, flexural strength and fracture resistance compared to conventional composites. However, they do not have problems such as polymerization shrinkage of conventional composites, and for this reason, they can be useful for deep cavities.

Tekçe et al. (23) reported similar fracture resistance for bulk-fill composites with low and high viscosity and conventional composites. Grazioli et al. (24) showed similar flexural strength for conventional resin and bulk-fill composites. In a study of flexural characteristics of bulk-fill, flowable bulk-fill, and conventional composites, Eweis et al. (16) showed that bulk-fill restorations show a higher flexural modulus than conventional and flowable composites.

Bulk-fill composites, considering their convenient and easy handling and extraordinary flexibility, prevent the formation of air bubbles. Homogeneous dispersion of particles provides a very favorable coverage and remarkable resistance and durability in the restoration process

In the present study, the fracture resistance was the same in fiber-reinforced conventional and flowable bulk-fill composites. Isufi et al. (25) reported no difference between conventional resin and flowable bulk-fill composites in terms of fracture resistance.

Insufficient polymerization is one of the main reasons for fracture in composite restorations (26). According to the results of the present study, Bulk-fill composite had a higher fracture resistance than flowable bulk-fill composite in the presence and absence of fibres.

Mahdisear et al. (26) found that the polymerization rate of x-tra bulk-fill composites was lower than x-tra base flowable bulk-fill composites. While the fracture resistance of bulk-fill composite was higher than that of flowable bulk-fill composite in the current study. This discrepancy can be attributed to the fact that the polymerization shrinkage of restorative materials is not the only factor involved in creating shrinkage stress. The lower fracture resistance of the flowable composite may be related to the lower flexural modulus, lower fillers, and slower shrinkage rate. On the other hand, considering their physical properties and lower wear rate, flowable bulk-fill composites need the addition of a 2-mm thick conventional composite resin layer (27).

A restorative material with a low modulus of elasticity leads to further deformation under occlusal stresses. In other words, the higher the filler content, the higher the modulus and deformation resistance (28).

According to the results of the present study, fiber addition causes a slight increase in fracture resistance and the fracture resistance was slightly higher in all three fiber-reinforced composites than in fiber-free composites.

Pham and Huynh (17) showed that fiber addition had no significant effect on bond strength and fracture resistance of posts and cores with flowable bulk-fill composites. Eliguzeloglu Dalkılıç et al. (29) also showed that although different fiber placement techniques did not increase the fracture resistance of teeth restored with bulk-fill composites, it increased the optimal fracture modes and thermomechanical aging did not change the fracture resistance of the groups.

According to the results of the present study, "non-restorable fractures" were reduced in fiber-reinforced flowable bulk-fill and conventional composites. Also, the results indicated that fiber-reinforced and fiber-free bulk-fill composites lacked " non-restorable fractures". Frater et al. (30) found that the use of short fiber-reinforced resin composite did not lead to a significant increase in fracture resistance. However, there was a clear trend towards greater fracture resistance and restorable fractures when using this material with the diagonal layering technique.

The present study also revealed that the fiber addition did not change the fracture pattern in the bulk-fill composite, but it insignificantly increased the fracture resistance of composites. The results of other studies have also shown that fibre addition had a positive and significant effect in increasing the restoration bond strength (23, 31-33).

Badakar et al. (34) recommended that fiber-reinforced composite resin can be considered a suitable method for the restoration of fractured anterior teeth both in terms of aesthetics and durability.

Conclusion

Based on the findings of this research, restoration can decrease fracture resistance. The addition of fibers did not show a significant increase in the fracture resistance of composites. The fracture resistance of bulk-fill composite was comparable to that of conventional composite and was significantly higher than that of flowable bulk-fill composite. Nonetheless, the fracture resistance of conventional and flowable bulk-fill composites was similar.

Conflict of Interests: None

References

1. Gutmann JL. The dentin-root complex: anatomic and biologic considerations in restoring endodontically treated teeth. J Prosthet Dent. 1992;67(4):458-67.
2. Hegde V, Sali AV. Fracture resistance of posterior teeth restored with high-viscosity bulk-fill resin composites in comparison to the incremental placement technique. J Conserv Dent. 2017;20(5):360-4.
3. Shahrbaf S, Mirzakouchaki B, Oskoui SS, Abed Kahnamoui M. The effect of marginal ridge thickness on the fracture resistance of endodontically-treated, composite restored maxillary premolars. Oper Dent. 2007;32(3):285-90.
4. Bonilla ED, Hayashi M, Pameijer CH, Le NV, Morrow BR, Garcia-Godoy F. The effect of two composite placement techniques on fracture resistance of MOD restorations with various resin composites. J Dent. 2020;101:103348.
5. Van Ende A, De Munck J, Lise DP, Van Meerbeek B. Bulk-Fill Composites: A Review of the Current Literature. J Adhes Dent. 2017;19(2):95-109
6. Alvanforoush N, Palamara J, Wong RH, Burrow MF. Comparison between published clinical success of

direct resin composite restorations in vital posterior teeth in 1995-2005 and 2006-2016 periods. Aust Dent J. 2017;62(2):132-145

7. Veloso SRM, Lemos CAA, de Moraes SLD, do Egito Vasconcelos BC, Pellizzer EP, de Melo Monteiro GQ. Clinical performance of bulk-fill and conventional resin composite restorations in posterior teeth: a systematic review and meta-analysis. Clin Oral Investig. 2019;23(1):221-233.
8. Van Dijken J, Pallesen U. Three-year randomized clinical study of a one-step universal adhesive and a two-step self-etch adhesive in class II composite restorations. J Adhes Dent. 2017;19?(4):287-94.
9. Lawson NC, Robles A, Fu CC, Lin CP, Sawlani K, Burgess JO. Two-year clinical trial of a universal adhesive in total-etch and self-etch mode in non-carious cervical lesions. J Dent. 2015; 43(10):1229-34
10. Savadi Oskoee S, Bahari M, Jafari Navimipour E, Ajami AA, Ghiasvand N, Savadi Oskoee A. Factors affecting marginal integrity of class II bulk-fill composite resin restorations. J Dent Res Dent Clin Dent Prospects. 2017; 11(2):101-109.
11. Gupta R, Tomer A, Pyasi S. An in Vitro Analysis of Fracture Strength of Various Bulk Fill Flow Able Composite Resins. Journal of Medical Sceinces.2018;17:40-44.
12. Tuloglu N, Bayrak S, Tunc ES. Different clinical applications of bondable reinforcement ribboned in pediatric dentistry. Eur J Dent. 2009;3(4):329-34.
13. Cobankara FK, Unlu N, Cetin AR, Ozkan HB. The effect of different restoration techniques on the fracture resistance of endodontically-treated molars. Oper Dent. 2008;33(5):526-33
14. Bicalho AA, Pereira RD, Zanatta RF, Franco SD, Tantbirojn D, Versluis A, Soares CJ. Incremental filling technique and composite material--part I: cuspal deformation, bond strength, and physical properties. Oper Dent. 2014;39(2):E71-82
15. Versluis A, Douglas WH, Cross M, Sakaguchi RL. Does an incremental filling technique reduce polymerization shrinkage stresses? J Dent Res 1996;75(3):871-878
16. Eweis AH, Yap AU, Yahya NA. Comparison of Flexural Properties of Bulk-fill Restorative/Flowable Composites and Their Conventional Counterparts. Oper Dent. 2020;45(1):41-51.
17. Pham KV, Huynh TTT. Bond Strength and Fracture Resistance of Flowable Bulk Fill Composite Posts and Cores in Endodontically Treated Teeth. J Int Soc Prev Community Dent. 2019;9(5):522-526
18. Fennis WMM, Tezvergil A, Kuijs RH, Lassila LVJ, Kreulen CM. In vitro fracture resistance of fibre-reinforced cusp-replacing composite restoration. Dent Mater 2005;21(6):565-572
19. Yamada Y, Tsubota Y, Fukushima S. Effect of restoration method on fracture resistance of endodontically treated maxillary premolars. Int J Prosthodont 2004;17(1):94-98
20. Taha NA, Palamara JE, Messer HH. Fracture strength and fracture patterns of root-filled teeth restored with direct resin restorations. J Dent 2011;39(8):527-35
21. Xie KX, Wang XY, Gao XJ, Yuan CY, Li JX, Chu CH. Fracture resistance of root filled premolar teeth restored with direct composite resin with or without cusp coverage. Int Endod J 2012;45(6):524-29
22. Cidreira Boaro LC, Pereira Lopes D, de Souza ASC, Lie Nakano E, Ayala Perez MD, Pfeifer CS, et al. Clinical performance and chemical-physical properties of bulk fill composites resin -a systematic review and meta-analysis. Dent Mater. 2019;35(10):e249-e264.
23. Tekçe N, Pala K, Tuncer S, Demirci M, Serim ME. Influence of polymerisation method and type of fibre on fracture strength of endodontically treated teeth. Aust Endod J. 2017;43(3):115-122.
24. Grazioli G, Cuevas-Suárez CE, Nakanishi L, Francia A, de Moraes RR. Physicochemical characterization of two bulk fill composites at different depths. Restor Dent Endod. 2021;46(3):e39
25. Isufi A, Plotino G, Grande NM, Ioppolo P, Testarelli L, Bedini R, et al. Fracture resistance of endodontically treated teeth restored with a bulkfill flowable material and a resin composite. Ann Stomatol (Roma). 2016;7(1-2):4-10.
26. Mahdisear F, Alizadehoskooee Z, Ataee M, Savadi Oskoee S, Emami Arjomand M. Comparison of Bulkfill x-tra base and x-tra fill composites on polymerization levels. J Res Dent Sci. 2017; 14(1):22-26
27. Atalay C, Yazici AR, Horuztepe A, Nagas E, Ertan A, Ozgunaltay G. Fracture Resistance of Endodontically Treated Teeth Restored with Bulk Fill, Bulk Fill Flowable, Fiber-reinforced, and Conventional Resin Composite. Oper Dent. 2016;41(5):E131-E140.
28. Braem M, Finger W, Van Doren VE, Lambrechts P, Vanherle G. Mechanical properties, and filler fraction of dental composites. Dent Mater. 1989;5(5):346-8
29. Eliguzeloglu Dalkılıç E, Kazak M, Hisarbeyli D, Fildisi MA, Donmez N, Deniz Arısu H. Can Fiber Application Affect the Fracture Strength of Endodontically Treated Teeth Restored with a Low Viscosity Bulk-Fill Composite?

Biomed Res Int. 2019;2019:3126931.

30. Fráter M, Forster A, Keresztúri M, Braunitzer G, Nagy K. In vitro fracture resistance of molar teeth is restored with a short fibre-reinforced composite material. J Dent. 2014;42(9):1143-50.

31. Lazari PC, de Carvalho MA, Del Bel Cury AA, Magne P. Survival of extensively damaged endodontically treated incisors restored with different types of posts-and-core foundation restoration material. J Prosthet Dent. 2018;119(5):769-76

32. Aslan T, Sagsen B, er Ö, Ustun Y, Cinar F. Evaluation of fracture resistance in root canal-treated teeth restored using different techniques. Niger J Clin Pract. 2018;21(6):795-800

33. Khan SI, Anupama R, Deepalakshmi M, Kumar KS. Effect of two different types of fibers on the fracture resistance of endodontically treated molars restored with composite resin. J Adhes Dent. 2013;15(2):167-71.

34. Badakar CM, Shashibhushan KK, Naik NS, Reddy VV. Fracture resistance of microhybrid composite, n ano composite and fibre-reinforced composite used for incisal edge restoration. Dent Traumatol 2011;27(3):225-9.