Original Article

J Babol Univ Med Sci
22; 2020. P: 215-221

Effect of Using Bulk fill Composites on Fracture Resistance of Maxillary Premolars with MOD Cavities

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J Babol Univ Med Sci; 22; 2020; PP: 215-221

Received: Oct 31st 2019, Revised: Jan 5th 2020, Accepted: Jan 25th 2020.

ABSTRACT

BACKGROUND AND OBJECTIVE: Bulk fill composites are an innovative class of dental resin composite materials, developed to simplify the restoration procedures, and are preferred to conventional composites if they have good mechanical properties and marginal seal. The aim of this study was to evaluate the fracture resistance of premolar teeth with mesio-occlusodistal (MOD) cavities restored with bulk and conventional composites.

METHODS: In this experimental in-vitro study, 40 sound maxillary premolar teeth were randomly divided into five groups: Group I: Positive control, intact teeth. In the remaining four groups, MOD cavities were prepared. Group II: Negative control, unrestored teeth. In other groups, cavities were restored as follows; Group III: (X-tra fil, bulk filling with 4mm-thick increment), Group IV: (X-tra base, bulk filling+Grandio, incremental filling) Group V: (Grandio, incremental filling with 2mm-thick increment). The restored teeth were stored in distilled water for 24 hours at 37oC and thermocycled (500 cycles). Specimens were subjected to a compressive load until fracture, and the fracture resistance was recorded in Newton.

FINDINGS: The highest fracture resistance values were obtained in group I (1150±507 N) and the lowest in group II (85±62.51 N), which was significantly lower than other groups (p=0.001). The fracture resistance of bulk fill composites and conventional composite did not differ significantly with intact teeth.

CONCLUSION: The restoration of teeth with moderate MOD cavity size using bulk fill composites can restore the lost tooth strength to a level comparable to intact teeth and similar to conventional composite.

KEY WORDS: *Composite Resins, Tooth Fracture, Polymerization.*

Please cite this article as follows:

Shadman N, Hoseinifar R, Ghafar Poor M, Dortaj D. Effect of Using Bulk fill Composites on Fracture Resistance of Maxillary Premolars with MOD Cavities. J Babol Univ Med Sci. 2020; 22: 215-21.

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Introduction

Removal of dental structures during cavity preparation, can weaken teeth, predisposing complete or incomplete fracture (1). Stress transfer occures differently in intact versus restored teeth (2). Various studies have been conducted on the dental structure strength after Mesio Occluso Distal (MOD) cavity preparation and the effect of different restorative materials on the strength of the remaining structures. It has been confirmed that the cuspal flexure can be reduced with bonding restorations compared with amalgam restorations (1), and these restorations are able to partially or completely improve poor fracture resistance (3). The fracture resistance of restored teeth is influenced by several factors, including the type of tooth, size and extent of cavity, type of restorative material used, presence or absence of marginal ridge and the amount of shrinkage and bond strength of composite (2, 4).

The polymerization shrinkage of composites is a common concern (5). Polymerization stress distribution is affected by factors such as type of composite, cavity dimensions, filling technique and light cure process (6) and provide better tooth protection against fatigue caused by occlusal forces and thermal changes (7).

Moreover, various techniques have been introduced to reduce shrinkage, including incremental techniques, use of stress-breaker liner, change in the photo-initiator system and the use of low-shrinkage composites. The incremental composite placement is a standard technique in cavities with more than 2 mm depth, but it is time-consuming and increases the risk of voids and poor adaptation between layers, so it is very useful to provide new methods to take less time with better physical properties such as the use of bulk fill composite, which has recently been introduced to the market, and has the ability to place the restoration to a thickness of 4 mm (8, 9). Slow polymerization, efficient cure and less shrinkage in bulk fill composites lead to reduced cuspal flexure (10, 11).

Differences exist in the light activation system, filler size and loading and translucency in the bulk fill composites, which reduces shrinkage stress and increases the depth of cure (12). Moorthy et al. (2012) indicated that bulk fill flowable composite significantly reduced the cuspal deflection compared to conventional composites, though had no effect on the degree of microleakage (13). Taha et al. in 2017 evaluated the effect of bulk fill composites on the fracture strength and pattern in root-canal-treated teeth and MOD cavities using different types of composites. The results showed that the fracture strength in bulk fill composites had no significant difference with intact teeth (14). Mincik et al. in 2016 compared the effect of different restorative materials on the fracture resistance of the endodontically treated maxillary premolars, and observed no difference between the bulk fill and conventional composites (15). Moreover, similar result was obtained by Assis (16). In a study by Atalay et al. in 2016, it was concluded that the fracture resistance of teeth restored with bulk fill composites were significantly lower than intact teeth (17). The aim of this study was to evaluate the effect of bulk fill and conventional composites on the fracture resistance of the maxillary premolars with MOD cavities.

Methods

This in vitro experimental study, which was approved by the ethics committee of Kerman University of Medical Sciences under ethical code IRKMU.REC.1395.957, was conducted on 40 sound maxillary premolars, without any caries and crack. After removing calculus and soft tissue, they were disinfected and restored in saline solution. The teeth selection was based on having similar mesiodistal and buccolingual dimensions. The selected teeth were randomly divided into five groups. The specification of the materials used in this study is presented in table 1. The groups were as follows;

Group 1 (Positive control; intact teeth, without preparation): In the other four groups, the MOD cavities were prepared using a cylindrical diamond bur 01 (Teezkavan, Iran) with air-water coolant as follows: Occlusal width: 1/2 distance between two cusps, pulpal depth: 2 mm, proximal box width: 1/2 of faciolingual tooth dimension, axial wall depth: 1.5 mm, occlusogingival box height: 4 mm and gingival margins were placed above the cementoenamel junction (CEJ). Each bur was replaced after 5 preparations.

Group 2 (Negative control; those prepared as described above and without any restoration): In Groups 3, 4 and 5 the cavities were fulfilled as follows: First, the metal matrix strip was fixed using a tofflemire holder. Then, all walls of the cavities were etched with 35% phosphoric acid (Vococid, Voco, Germany), washed and dried with cotton pellets, two coats of Solobond M adhesive (Voco, Germany) were applied

30 seconds on all walls, and were dried with gentle air and then light-cured using Quartz Tungsten Halogen (QTH) light curing device (Coltolux 75, USA) with a minimum intensity of 600 mW/cm^2 from the closest possible distance, which was monitored with a radiometer. The adhesive was cured for 20 seconds in each area by overlapping. Then, the restoration procedure was completed as mentioned below.

Group 3 (X-tra fil composite): each box was first filled individually with the composite so that the thickness of the first layer was 4 mm. After 40 seconds light curing of each box, the occlusal part was cured and filled also in a single step. After removing the matrix band, each buccal and lingual box was cured for 20 seconds.

Group 4 (X-tra base+Grandio): each of the boxes were first filled separately with a thickness of 4 mm X-tra base, and cured. The occlusal part was also filled and cured with incremental method by the Grandio composite.

Group 5 (Grandio composite): the teeth were restored by the incremental method (each layer with a maximum thickness of 2 mm) and cured the same as other groups.

All restorations were restored in water for 24 hours at 37°C and then thermocycled for 500 times (5-55°C) (Baradaran Pouya, Iran). In the next step, the specimens were mounted in self-curing acrylic resin (Acropars, Iran) to 1 mm below the CEJ and then samples were placed in universal testing machine (Testometric M350-10CT, England) to test the fracture resistance under the compression force along the longitudinal axis of the tooth. The cross-head speed of the device was 1mm/min. The fracture resistance was recorded in Newton. The fracture modes of the specimens were determined using a stereomicroscope and according to the following specification, determined by Burk et al. (1):

Mode 1: Minimal destruction of teeth

Mode 2: Fracture of one cusp, without restoration fracture

Mode 3: Fracture of at least one cusp and up to one-half of the restoration

Mode 4: Fracture of at least one cusp and more than one-half of the restoration

Mode 5: Severe fracture in most of the tooth structure and/or vertical fracture.

Data were analyzed by SPSS version 20 using ANOVA and Tukey's post hoc test. $p<0.05$ was considered as the level of significance.

Table 1. The specification of the materials used in this study

Type	Material	Organic or inorganic matrix	Manufacturer	Filler percentage
Bulkfill composite with high viscosity	X-tra fil	Matrix methacrylate Bis-GMA,UDMA,TEG-DMA	Voco, Germany	86% wt. 70.1% vol.
Bulkfill composite with low viscosity	X-tra base	Matrix methacrylate Bis-GMA,UDMA,TEG-DMA	Voco, Germany	75% wt.
Conventional Composite	Grandio	Matrix methacrylate Bis-GMA,TEG-DMA	Voco, Germany	87% wt. 71.4 vol.

Results

The highest and lowest values of fracture resistance were obtained in the positive (1150±570) and negative control group (85±62.51), respectively. The mean fracture resistance values (in Newton) of the studied samples are shown in Table 2.

Tukey's analysis showed that only the negative control group (group 2) had significantly less fracture resistance than the other groups (p=0.001) and the difference among the other groups was not significant (p>0.05). This means that the fracture resistance of restored teeth with bulk fill composites (X-tra fill and X-tra base) and conventional composite did not differ significantly with intact teeth (p=0.89, 0.112, 0.92 respectively). The fracture patterns of restored teeth are shown in Table 3.

The sound teeth showed seven fractures of one cusp, among which six cases were in the lingual cusps. The prepared unrestored teeth revealed 4 cases of fracture in the lingual cusp and 3 cases with mode 5 and one case of fracture in two cusps.

Table 2. The mean fracture resistance values±standard deviation (in Newton) of the studied samples and two-by-two comparison of groups

Groups	Mean±SD	P-value
1 (intact teeth)[a]		
Prepared unrestored teeth		0.001
Restored teeth with X-tra fil	1150±507	0.89
Restored teeth with X-tra base		0.112
Restored teeth with Grandio		0.92
2 (prepared unrestored teeth)[b]		
Restored teeth with X-tra fil		
Restored teeth with X-tra base	85±62.51	0.001
Restored teeth with Grandio		
3 (Restored teeth with X-tra fil)[a]		
Restored teeth with X-tra base	1012±236.38	0.49
Restored teeth with Grandio		1.00
4 (Restored teeth with X-tra base)[a]	761.87±248.45	0.44
Restored teeth with Grandio		
5 (Restored teeth with Grandio)[a]	1026±316.39	

Table 3. The fracture patterns of specimens in the studied groups

Group	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
X-tra fil	0	3	3	3	1
X-tra base	1	1	1	5	2
Grandio	4	1	0	3	2

Mode 1: Minimal destruction of teeth, Mode 2: Fracture of one cusp, without restoration fracture, Mode 3: Fracture of at least one cusp and up to one-half of the restoration, Mode 4: Fracture of at least one cusp and more than one-half of the restoration, Mode 5: Severe fracture in most of the tooth structure and/or vertical fracture

Discussion

According to the results of this study, the sound teeth exhibited the highest mean fracture resistance, which is in agreement with the results of a large number of studies (17, 18). Higher fracture resistance of sound teeth is due to the rigidity and existence of intact buccal and palatal cusps and mesial and distal marginal ridges, which maintains the integrity of the tooth (19).In this study, the lowest amount of fracture resistance was found in the group II, which was significantly lower than the other groups. This can be attributed to the amount of remaining tooth structure after the MOD cavity preparation and the weakening of tooth structure, due to the loss of marginal ridges (19). The loss of marginal ridge integrity is the main factor in the loss of tooth resistance. The MOD cavity preparation on average decreases 63% of tooth rigidity (20). According to the results of this study, all restored teeth, regardless of the type of material, showed the fracture resistance comparable to intact teeth. Studies have shown that the use of composite with adhesive, directly or indirectly, increases the fracture resistance of restored teeth (21, 22). This may be due to the micromechanical adhesion between the tooth structure and adhesive, which tends to splint the walls of prepared tooth together and strengthen the residual tooth structure (19). Atalay et al. (17) evaluated the fracture resistance of root canal-treated teeth restored with various composites and showed that the fracture resistance of intact teeth was significantly higher than the other groups, which is inconsistent with the results of our study, probably due to the form of cavity preparation (an access+MOD cavities). The access cavity preparation can cause more stress accumulation in tooth compared with vital tooth, which may be due to increased volume of composite consumption. In addition, the level and the severity of cuspal flexure are greater in endodontically treated teeth due to the dentin removal in the cervical area (20). Taha et al. (23) showed that the elastic modulus and polymerization shrinkage of composites are the main factors influencing the fracture resistance of composite restorations. The restorations with high-modulus composites show less cusp movement and protect the teeth from the fatigue caused by occlusal forces or thermal changes (23). Grandio has been introduced in various studies as the best material for flexural strength and elastic modulus (24, 25). Ilie et al. showed that X-tra fil, among the bulk fill composites, has the highest elastic modulus (26). Papadogiannis et al. (2015) also revealed that X-tra base among the bulk fill flowable composites has the highest filler percentage (74% vol), resulting in less deformity under occlusal loadings (27). The polymerization shrinkage is also an effective component of fracture resistance restorations (27). Grandio is a composite with a high filler content, which results in the reduction of polymerization shrinkage (1.57%) (28). In bulk fill composites, due to changes in monomer formulations, the use of stress-reducing resins and slower reaction of polymerization during light curing, the shrinkage stress during polymerization was reduced (29, 30).

The results of this study showed that the fracture resistance of restored teeth with the bulk fill composites (both flowable and paste consistencies) was not significantly different from conventional composite. Isufi et al. (20) showed no significant difference in the fracture resistance of restored teeth with the bulk fill flowable composite (SDR) compared with conventional composite. Rabuer et al. (2016) also indicated that the teeth restored with conventional composite (Tetric N-Ceram) and high-consistency bulk fill composite (Tetric N-Ceram Bulk) present similar fracture resistance (31), which is in agreement with this study. The present study showed that there was no significant difference in the fracture resistance between the two different consistencies of the bulk fill composites. Although flowable composites exhibit higher polymerization shrinkage than paste type composites, their shrinkage stress is low due to their lower elastic modulus and the possibility of more flow before the Gel-point stage. Furthermore, although the polymerization shrinkage of the bulk fill flowable composite used in this study was 2.7%, the final layers of restorations were coated with the composite with low polymerization shrinkage (10, 25). The maxillary premolars due to anatomical shape and cusp inclination are more likely to fracture under the occlusal loading than other posterior teeth (32, 33). The cohesive fracture analysis of tooth structure has shown that the probability of palatal cusp fracture of maxillary premolars is more than buccal cusps (23), which is similar to this study. In our study, the intact teeth exhibited six lingual cusps fracture compared with one buccal cusp fracture. The present study showed that the restoration of teeth with moderate MOD cavity size using both consistencies of bulk fill composites can restore the lost tooth strength to a level comparable to intact teeth.

Acknowledgment

The authors would like to thank the Kerman University of Medical Sciences for financial support of the research.

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