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The Effect of Blocking Out Pulp Chamber on the Strength of Upper Posterior Teeth with Endocrown

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ABSTRACT

Background and Objective: Designing a tooth preparation method for endocrown construction is effective in achieving clinical success. Considering that our knowledge about pulp chamber preparation is insufficient, this study was conducted with the aim of comparing the fracture strength of upper molar and premolar teeth treated with endocrown-reconstructed root based on two different methods of pulp chamber preparation.

Methods: In this laboratory study, 15 upper molars and 15 premolars were divided into three groups. The first group (5 healthy teeth) was considered as the control group. The teeth of the second and third groups of root treatment were mounted in an acrylic JIG and their crowns were cut 2 mm above the CEJ. In the second group, the undercut of the pulp chamber wall was eliminated by a dental lathe. In the third group, the undercut was blocked by resin-modified glass ionomer (RMGI) cement. The teeth of the second and third groups were scanned by a laboratory scanner and restored and cemented with lithium disilicate glass ceramic endocrown (EMAXCAD, Ivoclar Vivadent). Then, all the teeth were subjected to a fracture strength test by a universal testing machine with a crosshead speed of 1 mm/min.

Findings: The fracture strength of premolar teeth of group two (883.160±186.6) and group three (880.380±262.6) showed no significant difference. The fracture strength of molar teeth of group two (960.120±444.4) and group three (1290.740±400.7) was not significantly different. The mean fracture strength of healthy molars (2194.400±375.4) was significantly higher than restored molars ($p<0.05$). In terms of fracture type (repairable/non-repairable), there was no significant difference between molar and premolar teeth in the studied groups.

Conclusion: Based on the results of this study, two methods of eliminating the undercut or blocking out the pulp chamber with restorative materials can be used to make endocrowns in upper posterior teeth.

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Introduction

Reconstruction of root-treated teeth is one of the most challenging issues in dentistry due to more destruction and loss of tissue, dentin and collagen compared to vital teeth (1). When a large part of the crown of the tooth is destroyed, post and core are required for the restoration of the crown (2). Placing a post, regardless of the type of post, changes the biomechanical characteristics of the root and increases the probability of vertical root fracture (3). When placing a post, you should pay attention to the length, diameter, and material of the post, as well as the amount of ferrule remaining on the tooth (4). Placing a post in roots with short length, curved roots, taurodontic teeth, calcified roots, dilacerated roots, etc. faces problems (5) and is invasive in nature. For this reason, with the advancement of the adhesive system, another type of non-invasive crown restoration called endocrown was introduced (6).

Endocrown refers to the restoration of a fixed porcelain crown inside the cavity of the pulp chamber of the posterior teeth, which takes its grip macro-mechanically from the wall of the pulp chamber cavity and micro-mechanically from the band to the tooth (7). Pissis initially described the technique for using it (6) and later in 1999, Bindl et al. changed its name to endocrown (8).

Etchable ceramics are one of the materials of choice for endocrowns, and studies show that the success rate of endocrown depends on the correct preparation of the tooth, the choice of the right ceramic, and the choice of the right band and adhesive system (7, 9). Moreover, endocrons are able to save time compared to traditional post and blind tooth restorations (10).

Endocrowns, unlike old restorations, do not require ferrule (11, 12), and also because they are monoblock, unlike old restorations, their constituent materials do not have a different elastic coefficient (13), and treatment with endocrown shows a higher resistance to fracture compared to old restorations (14).

The most common cause of endocrown fracture is loosening and detachment (15). The three main factors causing the reduction of the bond between ceramic and tooth are the presence of sclerotic dentin in the pulp chamber, the high elastic modulus of ceramic materials and the shortness of the pulp chamber wall (less than 2 mm) (16). Regarding premolars, the rate of failure in clinical studies has been higher (16, 17).

According to a finite element analysis, the more crown tissue is conservatively preserved, the more stress is created around the cementum, but the stress in the dental tissue is reduced (18). Moreover, the use of composite with fibers in the floor of the pulp chamber has no effect on resistance to fracture and matching of the endocrown margin (19, 20). The use of immediate dentin flood immediately after grinding did not improve fracture resistance (21).

There are two methods of pulp cavity preparation for endocrown insertion in root-treated teeth. One of these methods is to insert endocrown by removing the endocrown from the pulp cavity wall, and the other method is to add a restorative material such as resin-reinforced glass ionomer (RMGI) or composite to the pulp chamber wall. However, there is no reliable study on which method is better. No study and research on the preparation of endocrown chamber pulp trimming, especially in the molar and premolar area, has been done. Considering this, the aim of the present study is to compare the fracture strength of molar and premolar teeth treated with endocrown and restored with two methods of pulp chamber preparation, including preparation with removal of undercut with a by a dental lathe and preparation with blocking out undercut with RMGI.

Methods

In this laboratory study, after obtaining permission from the ethics committee of Mashhad University of Medical Sciences with the code IR.MUMS.DENTISTRY.REC.1399.012, 30 fairly healthy teeth including

15 upper first molars and 15 upper first premolars with equal buccolingual and mesiodistal dimensions were selected and randomly divided into three groups (5 premolar and 5 molar in each group). According to a pilot study that was conducted on 6 samples, the mean and standard deviation of fracture strength in molar and premolar teeth were 750 ± 200 and 1200 ± 540, respectively, which were used to determine the sample size. With 95% confidence interval and 80% power and using the formula for comparing the mean values of two independent samples, the sample size in each group was calculated as 13 samples, but for more certainty, it was increased to 15 samples in each group. The first group was the control group. All teeth were free of caries, root fracture and root treatment. Teeth with curved or abnormally shaped roots were excluded from the study. All teeth had a pulp chamber depth of 4 mm. Samples that had more than 1 mm standard deviation of buccolingual and mesiodistal dimensions were excluded from the study. Then, all samples were mounted in a parallel manner 2 mm under cemento-enamel junction (CEJ) using a self-curing methyl methacrylate resin. The teeth that were assigned in groups two and three were prepared for making endocrown. These samples were marked and cut two millimeters above the CEJ using a cobalt chrome disk. Then, using a polishing bur, the created angles were polished. First, the root canal treatment was performed with Mani K File (Mani-Japan) up to file number 40, and then the root canal was filled using Meta Biomed Endodontic Gutta Percha (Meta Biomed-Korea) by lateral condensing method using AH-26 sealer (Dentsply Maillefer, USA). Then, the area of the pulp chamber was cleaned from the amount of excess gutta. In order to make endocrown on the samples, we had to eliminate the undercuts inside the pulp chamber cavity; dental lathe was used for the second group and block out method with glass resin-reinforced glass ionomer (GC Fujicem2, Japan) was used for the third group. In the second group, the elimination of the undercuts of the samples was done using a surveyor and trimming the walls in a completely parallel way. First, the samples were placed on the working table of the machine, parallel to the horizontal surface, then using a fissure bur, the inner surface of the pulp chamber cavity was trimmed parallel to the floor of the pulp chamber to eliminate the undercuts of the cavity (Figure 1).

In the third group, eliminating the undercut of the samples was done by blocking out the undercuts by RMGI. To mix the material, an equal amount of two pastes was placed on a paper pad and placed in the wall of the pulp chamber. The setting time of RMGI is about 4 minutes. After the final setting of the glass, the walls of the pulp chamber were parallelized with the help of a surveyor (Figure 2). All samples were placed in distilled water at 37 ˚C to be sent to the laboratory.

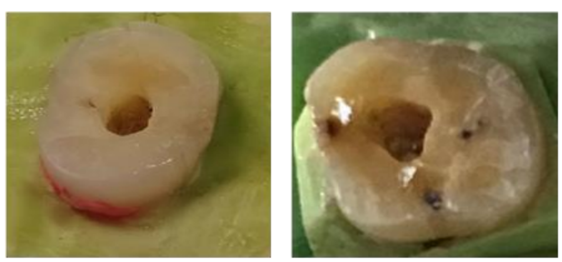

Figure 1. Premolars and molars trimmed by surveyor

Figure 2. Premolar blocked out by GC FujiCEM 2

In the next step, the samples were sent to the laboratory to make lithium disilicate glass ceramic endocrowns (IPS EMAX, Ivoclar Vivadent) and were scanned by a laboratory scanner, and the endocrowns were made by CAD/CAM. The inner surface of all samples was etched using 9.5% hydrofluoric acid (Bisco Porcelain Etchant Gel - 9.5% Buffered Hydrofluoric Acid, Bisco, USA) for 20 seconds, then washed for 60 seconds and then dried for 30 seconds (14). Then, Silane (Ceramic Primer, Bisco, US), which has two bottles, was used. For each sample, one drop from each bottle was poured into the well and after mixing, it was placed on the ceramic. 60 seconds were given for the silicone to dry. After that, endocrowns were cemented using PANAVIA dual-cure resin cement (Panavia SA, Kuraray Noritake Dental, Japan). According to the manufacturer's instructions and the fact that the cement was dual-cured, the teeth were cleaned only by dental pumice and had no preparation. For cementing, finger pressure was used to remove excess cement and they were immediately cleaned with a micro-brush, then we cured each tooth surface for 20 seconds. In all stages of the work, the samples were kept in distilled water at 37 ˚C. Then, all the samples were transferred to the universal testing machine (Santam, Iran) to test the fracture strength. The samples were subjected to a static load along the longitudinal axis in the device with a crosshead speed of 1 mm/min. The maximum force at the moment of fracture was recorded in Newton by the device. At the end of the test, the samples were examined to determine the type of fracture. The fractures were divided into two categories (22):

Favorable or repairable fracture: fracture occurred in the restoration or between the restoration and the tooth, or in the tooth above the CEJ in a way that the tooth can be repaired.

Unfavorable or irreparable fracture: the fracture of the tooth and the root of the tooth occurred in such a way that it cannot be repaired.

In data analysis, two-factor and one-factor analysis of variances, independent t test, Tukey's post hoc test, and Fisher's exact test were used. The statistical software used was SPSS version 23 and p<0.05 was considered significant.

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Results

The mean fracture strength of premolar teeth in group two (883.160±186.6) and group three (880.380±262.6) was not significant between groups, but the mean fracture strength of molar teeth was significant between groups (p=0.001) (Table 1).

Table 1. Mean fracture strength in groups and teeth

Group / Tooth	Control	Undercut elimination with lathe	Blocking out undercut with RMGI	The result of ANOVA
Premolar	750.5 ± 99.6^{B}	883.2±186.6	880.4±262.6	F=0.76, p=0.490
Molar	2194.4 ± 375.4^{Aa}	960.1 ± 444.4^{b}	1290.7 ± 400.7^{b}	F=2.27, p=0.001
The result of independent t test	T=8.31 p=0.001	T=0.36 p=0.730	T=1.91 p=0.092	

Lowercase letters written differently above numbers indicate significant differences between groups and capital letters written differently above numbers indicate significant differences between teeth.

Comparing two groups in molar teeth, it was determined that the mean fracture strength of molar teeth in group two (960.120±444.4) and group three (1290.740±400.7) compared to the control group (4 2194.400±375.4) was significantly lower (p=0.001 and p=0.011, respectively), but there was no significant difference between the two groups of undercut elimination with a lathe and undercut block-out group. In the control group, the mean fracture resistance of molar teeth was significantly higher than that of premolar teeth (p=0.001), but in the groups of undercut elimination with a lathe and undercut block-out, the mean fracture resistance between molar teeth and premolar teeth showed no significant difference. In none of the types of molar and premolar teeth, the groups showed significant difference in terms of fracture type distribution (Table 2). Figures 3 and 4 show two types of repairable and non-repairable fractures.

Table 2. Fracture types in groups based on molar and premolar teeth

Tooth type and group	Fracture types: Repairable (favorable) Number(%)	Fracture types: Irreparable (unfavorable) Number(%)	Total Number(%)	p-value*
Premolar				
Control	3(60)	2(40)	5(100)	
Undercut elimination with lathe	3(60)	2(40)	5(100)	>0.99
Blocking out undercut with RMGI	4(80)	1(20)	5(100)	
Molar				
Control	3(60)	2(40)	5(100)	
Undercut elimination with lathe	2(40)	3(60)	5(100)	0.800
Blocking out undercut with RMGI	4(80)	1(20)	5(100)	

***Fisher's exact test result**

Figure 3. Repairable and desirable fracture

Figure 4. Irreparable and unfavorable fracture

Discussion

In this study, the mean fracture strength of premolar teeth in the control group was lower than the mean fracture strength of the two study groups (group two: undercut elimination with lathe and group three:

undercut block-out with RMGI), although this difference was not significant. One of the reasons for the higher mean fracture strength in the restored premolar tooth compared to the healthy premolar is the mechanical and morphological properties of the restoration, and endocrown creates a higher resistance than the healthy tooth due to covering the tooth and filling the pulp chamber space (23, 24).

In the group of molar teeth, the mean fracture strength of the molar teeth of the control group was higher than the mean fracture strength of the molar teeth of the other two groups (undercut elimination with lathe and undercut block-out). The reason for this can be due to the fact that the amount of fracture strength directly depends on the volume of the remaining tooth (22). Moreover, the loss of marginal ridges is one of the main reasons for reducing fracture strength in restored molars, and root canal treatment also destroys a large amount of tooth structure and reduces fracture strength (23).

The maximum chewing force applied to posterior teeth in the mouth is 725 N (25). In the present study it was shown that all the studied teeth in all three groups have the ability to withstand functional and parafunctional chewing forces.

In the studied groups, in the premolars, in the control group and undercut elimination with lathe, 60% of the fractures were repairable and 40% were irreparable, and in the undercut block-out group, 80% of the fractures were repairable and 20% were irreparable. However, this relationship was not significant in premolars (retesting with more samples is recommended). In the study of Ferraris et al., the upper first premolars that were reconstructed as a full crown, most fractures could be repaired (26). However, the study of Fennis et al. shows that the use of adhesive restorations in upper first premolars with greater thickness shows higher fracture resistance, but causes irreparable fractures (24). The study by Bianchi E Silva et al. shows that covering the tooth cusps increases the fracture force (23).

Among the studied molars, 60% of the fractures in the control group were repairable, 40% in group two (undercut elimination with lathe), and 80% of the fractures in group three (undercut block-out) were repairable. The relationship between the type of fracture and the studied groups was not significant and there is a need to study with more samples. In a study conducted by Kassis et al. (27) on the restoration of root-treated molars, they concluded that endocrown provides more resistance to resistance than Onlay and Inlay, while most of fractures can be repaired again.

EMAX endocrown (lithium disilicate) has been used in this study. According to the study of Gresnigt et al., there was no significant difference between the use of endocrown lithium disilicate and nanoceramic resin (28). But in another study, it was shown that endocrown nanoceramic resin has the highest fracture strength and the best (reconstructable) fracture model (10).

In a study conducted by Turkistan et al., it was shown that the greater the coronal thickness of lithium disilicate endocrown, the endocrown will be less resistant to fracture, but it has no effect on the type of fracture (29). In the present study, each group of teeth (premolar and molar) had the same endocrown crown thickness and the study was not affected in this area.

In the study of Topkara et al., it was shown that the endocrown made on mandibular molars has a better marginal fit and a higher success rate than the endocrown made on maxillary molars (30). Maxillary first molars were used in this study.

In this study, the pulp chamber depth of 4 mm was used to make endocrown teeth. According to the performed studies, increasing the preparation depth significantly increases the resistance to fracture (31). In the study of Gaintantzopoulou et al., it was shown that using the maximum depth of the pulp chamber and root extension increases the contact surface and reduces the risk of endocrown failure (32). In this study, we did not use root expansion, but by removing the endocrown inside the pulp chamber cavity, we tried to use the maximum internal area of the pulp chamber in the second group of samples in order to have the largest contact surface of the endocrown with the internal space of the pulp chamber, but the results did not show much difference. In another study conducted by Veneziani, it shows that in some teeth where the margin is close to the CEJ and there is no possibility for a ferrule, creating a concave bevel on the peripheral enamel increases the surface of the enamel connection and improves the biomechanical behavior of the endocrown (33). In the present study, after cutting the crown, the enamel was beveled.

Based on the results of this study, the two methods of undercut elimination or blocking out the pulp chamber with restorative materials can be used to make endocrown in upper posterior teeth.

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