Original Article

Bond Strength and Fracture Resistance of Flowable Bulk Fill Composite Posts and Cores in Endodontically Treated Teeth

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ABSTRACT

Objectives: Smart dentin replacement (SDR) is a new flowable bulk fill composite with many useful characteristics such as low viscosity and higher depth of cure. This study aimed to evaluate the bond strength and fracture resistance of flowable bulk fill composite posts and cores versus that of fiber posts and cores. **Materials and Methods:** Forty intact, extracted human maxillary central incisor roots were endodontically treated. Group A (n = 20) was prepared for the composite space and group B (n = 20) was prepared for the fiber post space. Group A and B were divided into two subgroups A1 and A2 and B1 and B2, respectively (10 roots for each subgroup). Root canal spaces of group A1 were filled with SDR composite, X-Post fiber post with Core X Flow composite was inserted into the root canal spaces of group B1. Group A2 was restored using SDR and group B2 was restored using post and core composite. Five hundred thermocycles were applied for the sample. Bond strength values were measured for segments in A1 and B1. Fracture force values were measured for specimens of A2 and B2. **Results:** No significant difference was observed between the two paired groups (A1 and B1) and (A2 and B2) in bond strength and fracture force values. **Conclusion:** SDR could be used for restoring endodontically treated teeth.

Keywords: *Bulk fill composite, endodontically treated teeth, fiber post, flowable composite*

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Introduction

Restoring the endodontically treated teeth (ETT) has always been challenging to clinicians, especially in structurally compromised teeth. Although cast or prefabricated metal posts are popular for this purpose, they have their own disadvantages. Besides the wedge effect of the post inside the root canal, which can lead to root fracture, the wide space between the post and root canal wall in compromised ETT, which is usually filled by luting cement, is the weakest area of the restoration. The widened and tapered anatomy of the compromised root also reduces the retention of the post. Therefore, in many situations, metal posts are not an appropriate choice for weakened ETT.[1-3]

The more popular alternative for metal posts are fiber posts in restoring ETT. Not only is the rigidity and modulus of fiber posts similar to that of dentine, but they can also bond to the dentine using adhesive agents.[1] Fiber posts also resolve the aesthetic problems for endodontically treated anterior teeth and need less dentine removal for post spaces. In addition, fiber posts eliminate the risk of corrosion or allergic reactions and can easily be removed from the root canal when needed.[2] Fiber posts can be bonded to root canals using different adhesive agents with different core materials or using a similar adhesive and core material such as X-Post and Core X Flow (Dentsply DeTrey, Konstanz, Germany).

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Recently, flowable bulk fill composites have been introduced for restoring the ETT.[1,2] Flowable bulk fill composites have a low viscosity and have easy handling properties. Because of their high flowability, flowable bulk fill composites can easily squeeze into difficult to access areas, decreasing the air bubbles inside the filling materials and can be appropriate for liners in deep cavities.[4] Further, more flowable bulk fill composites can be polymerized at a depth of up to 4 mm, this is nearly twice as much as conventional composites and is appropriate for post space in root canals.[1]

The aim of this study was to evaluate the bond strength and fracture resistance of smart dentin replacement (SDR) (Dentsply DeTrey) flowable bulk fill composite posts and cores compared to X-Post and Core X Flow fiber posts and cores.

Materials and Methods

This study was approved by the Research Ethics Committee of the University of Medicine and Pharmacy at Ho Chi Minh City, Vietnam. The approval number of the present study was 1399/QĐ-ĐHYD. Forty intact human extracted maxillary central incisors without caries, previous endodontic therapy, were chosen. These teeth had dimensions at cervical were 6.25 ± 0.25 and 6.77 ± 0.22 mm for mesiodistal and buccolingual directions, respectively. Teeth, which were extracted for reasons other than this study, that is, periodontal problems, were stored in 0.9% saline within six months until utilization. All incisors were radiographed to determine that the root canals were free of internal resorptions and calcifications. They were sectioned at 2 mm above the cementoenamel junctions using an IsoMet low speed saw under IsoCut Fluid for irrigation (Buehler, Lake Bluff, Illinois). The root canals were prepared using the step-back technique with a K-file to Master Apical File of 30 ISO [Figure 1] and were obturated using the cold lateral technique, using gutta-percha and AH26 sealer (Dentsply DeTrey).

Figure 1: Roots after instrumentation

The specimens were then divided into two groups, group A and group B (n = 20). Group A was prepared for the composite spaces with a depth of 4 mm and diameter of 2 mm using Peeso Reamers (size 1–4). Group B was prepared for the fiber post spaces with a depth of 9 mm and diameter of 2 mm using Peeso Reamers after storing at 37°C and humidity 100% for at least 24 h.

Group A was then divided into two subgroups, A1 and A2 (n = 10), and group B was divided into two subgroups, B1 and B2 (n = 10). The root canal spaces of group A1 were bonded using the Self-Etch Prime and Bond Select (Dentsply DeTrey) adhesive with microapplicator tips. The bond was applied onto the canal walls and left for 10 s, air-dried for 5 s, and then light cured for 10 s using LED SmartLite Focus (Dentsply). Root canal spaces of group A1 were then filled with pre-dosed SDR flowable bulk fill composite [Table 1] up to the orifices and then light cured with a LED curing light for 20 s. The root canal spaces of group A2 were treated the same as group A1 with the above SDR flowable bulk fill composite core using conical core-forming molds from the manufacturer with a cure time of 20 s. Light curing was performed twice for 40 s from the lateral sides. Root canal walls were etched using 36% phosphoric acid for 15 s and the X-Post fiber (Dentsply) post surfaces were cleaned by 90 % alcohol. Fiber posts were cut at a length of 9 mm for group B1 and 12 mm for group B2. A mixture of XP Bond and Self-Cure Activator (Dentsply) was created by mixing two equal parts of these two agents. This mixture was applied onto the root canal walls of group B1 using microapplicator tips and left for 20 s. Excess bond was removed by paper points and the root canal space was air-dried for 5 s. The mixture was also applied onto the fiber post surface, this was then air-dried to remove the excess bond. The Core X Flow composite [Table 1] was dispensed into the root canal and a 9-mm fiber post was inserted into the canal. Excess composite on the root surface was removed by an explorer and a curing light was applied to the post head for 20 s. With the roots of group B2, the procedure was similar to that of group B1 except for the post length of 12 mm and the above Core X Flow composite core. After applying the mixture of bond and activator into the canal and onto the fiber post surface, the Core X Flow composite was dispensed into the canal and a 12-mm fiber post was inserted into the canal. The Core X Flow composite was dispensed continually into the core-forming mold that inverted on the root surface and the composite was then light cured for 20 s. A curing light was applied for more 40 s to finish. All cores were prepared with a ferrule height of 1.5 mm and a chamfer finish line of 0.5 mm, using a round-ended diamond bur with the finished dimensions of 5, 5, and 4 mm for incisal-gingival height, buccal-lingual depth,

Table 1: Composites used in the study

Composite	Manufacturer	Content	Lot
SDR	Dentsply DeTrey, Konstanz, Germany	Barium-alumino-fluoro-borosilicate glass, strontium alumino-fluoro-silicate glass, urethane dimethacrylate resin modified, ethoxylated bisphenol A dimethacrylate (EBPADMA), triethylene glycol dimethacrylate, butylated hydroxytoluene, titanium dioxide, iron oxide	1502000253
Composite Core X flow	Dentsply DeTrey, Konstanz, Germany	EBPADMA urethane resin, urethane dimethacrylate resin, trimethylolpropane trimethacrylate, 2,2'-ethylendioxydiethyldimethacrylat, dibenzoyl peroxide	1603000964

and mesial-distal width, respectively. The specimens then underwent 500 thermocycles between 55°C and 5°C for 25 s for each temperature point and 5 s for transporting, using special equipment that was created by us. After experiencing 500 thermocycles, the specimens were embedded into clear auto-polymerized acrylic resin.

Segments, 3 mm in length, of coronal roots in group A1 and B1 were cut at 90° to the long axis of the root using IsoMet (Buehler, Lake Bluff, Illinois) machine with glycerin for cooling. All these segments were subjected to the push-out test for bond strength values using the universal testing machine (Lloyd LR30K, Lloyd, USA) with a special lathed device as described in a previous study [Figure 2].[5] The applying stress was in an apical-coronal direction, from the smaller diameter to the larger diameter of the root segment, following the root canal taper to avoid the interference from the smaller part of the composite or post. The test ended when the complete extrusion of the composite or post piece was observed. The force needed to extrude the composite or post piece was recorded and was converted into the bond strength (Mpa) using the following formula:

$$\text{Bond strength}(\text{Mpa}) = \frac{\text{Force}(\text{N})}{\text{Bonded area}(\text{mm}^2)}$$

The bonded area was calculated using the following formula:

Figure 2: Push-out test apparatus

$$A = \pi\,(r_1 + r_2)\sqrt{h^2 + (r_1 - r_2)^2}\ (\text{mm}^2)$$

where, π is the constant of 3.14, h is the thickness of the root segment in millimeters, and r_1 and r_2 were the radius of the coronal canal post space and that of the apical canal post space in millimeters, respectively.

Specimens in group A2 and B2 were subjected to a compressive force, under the constant crosshead speed of 1 mm/min, at 135° to the long axis of the root until fracture. The force was recorded whenever the first crack appeared. The crosshead continued to move and the force whenever the core was completely fractured was recorded. Data were collected and statistically analyzed using the Statistical Package for the Social Sciences (SPSS) (IBM, Armonk, New York) version 23.0. Student's *t*-tests were used to compare the bond strength values and values of the fracture resistance experiment.

Results

The push-out bond strength mean value of the SDR composite post group (A1) was 18.58 Mpa and for the X-Post post group (B1), it was 17.54 Mpa [Table 2]. No statistically significant difference ($P > 0.05$) was observed between the two experimental groups in the mean value of push-out bond strength.

The mean fracture resistance value of this force for the SDR composite post group (A2) was 641.89 N and for the X-Post post group (B2), it was 615.65 N [Table 3]. No statistically significant difference ($P > 0.05$) was observed between the two experimental groups in the mean value of fracture resistance for this force.

The fracture modes of the two experimental groups are shown in Table 4.

Table 2: The push-out bond strength values of the two experimental groups (Mpa)

Group	Min.	Max.	Mean	Std. deviation	*P*
SDR post	202.56	536.22	18.58	5.56	0.6621*
X-Post Post	189.47	426.52	17.54	4.85	

*Student's *t*-test, $P > 0.05$

Table 3: The fracture resistance values of the force leading to complete core fracture for the two experimental groups (N)

Group	Min.	Max.	Mean	Std. deviation	*P*
SDR post	531.24	808.63	641.67	103.36	0.4232*
X-Post Post	412.32	801.48	598.89	128.70	

*Student's *t*-test, $P > 0.05$

Table 4: Fracture modes of two experimental groups

Group	Fracture mode 1	Fracture mode 2	Fracture mode 3
SDR post	5	4	1
X-Post Post	3	4	3

Fracture mode 1 = adhesive-cohesive in composite, Fracture mode 2 = restorable (favorable) in dentine, Fracture mode 3 = unrestorable (unfavorable) in dentine

Discussion

The SDR was used commonly on the clinical setting and continuously studied in recent years *in vitro* as well as *in vivo*.[6-8] However, there was limitation of data for the SDR composite post and core even in the *in vitro* experiment.[1]

The thermocycle machine, which was produced by us, is the newest and the first device in this field for local manufacturers. Five hundred thermocycles regimen is an appropriate artificial aging test.[9] The utilization of thermocycles in this study was to stimulate the degradation of the adhesive bond, created by an environment like in the mouth.[9,10]

There are many methods to measure bond strength such as tensile, microtensile, shear or push-out bond strength techniques. Each method has its own advantages and disadvantages; however, previous studies have proved that the push-out bond strength measurement was more useful and reliable than the microtensile bond strength measurement.[11,12] Specimens were also less damaged when compared to other techniques in push-out bond strength measurement.[11] The push-out test also created more homogenous stress distribution and less variability in the process of testing.[12]

The thickness of the root segment was chosen to be 3mm similar to previous studies.[13,14] The results showed that the mean push-out bond strength value of the SDR group was higher than that of the X-Post group; however, no statistically significant difference ($P > 0.05$) was observed. These values were higher than the values of a previous study, which used the SDR as luting cement and were lower than the values of the other study.[4,15] The differences among these values seem to come from the dissimilar materials, thicknesses of root segments, and diameters of the prepared root canal spaces.

The length of the post space does not affect the fracture resistance of the post, so the length of 9mm of post space was chosen for this study.[16] The result of the fracture resistance in this study was similar to that of the previous study.[1] No significant difference was observed between SDR group and X-Post group in fracture resistance. However, the fracture resistance of the SDR group was higher in the previous study when compared to that of this study.[1] This difference seems to be due to the fact that the core was covered by the coping in the previous study. The result of this study about the fracture of resistance was dissimilar to that of the other study.[2] These differences might be due to the dissimilar materials and diameters of the post space in two of these studies. The diameter of the post space in the other study was smaller than that of this study; therefore, the fracture resistance of the post in the former was lower than that of the latter.[2] The light-transmitting post was also the appropriate choice for the ETT.[17]

The fracture resistances of both groups were approximately 600N, much higher than the human incisal maximum biting force, which is lower than 200N.[2,18,19]

The study used only anterior teeth and limited number of thermocycles when compared to other previous studies.[10,17]

Conclusion

The bond strength and fracture resistance of the SDR composite post and core were similar to those of the fiber X-Post post and Core X Flow core; therefore, the former could be used for restoring ETT.

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Conflicts of interest

There are no conflicts of interest.

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