Fracture Resistance of Endodontically Treated Premolars with Simulated Abfraction Restored with Fiber Posts and Zirconium Crowns

ความต้านทานการแตกของการบูรณะฟันกรามน้อยที่จำลองคอฟันสึกและได้รับการรักษาคลองรากฟันด้วยเดือยเสริมเส้นใยและครอบฟันเซอร์โคเนีย

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ABSTRACT

The aim of this study was to evaluate the fracture resistance of fiber posts and zirconium crowns on endodontically treated premolars with simulated abfraction. Twenty-four extracted upper first premolars were prepared for the abfraction, then restored with resin composite and endodontically treated. The teeth were randomly divided into 3 groups (n= 8); group1: resin composite filling, group2: fiber post with resin composite filling, and group3: fiber post with zirconium crown. The teeth in acrylic blocks were subjected to static loading at central fossae, 30° to long axis of the teeth until failure occurred. One-way ANOVA and Scheffe test analyzed that specifically group 3 had significantly higher fracture resistance than groups 1 and 2 ($p<0.05$). It concluded that crown restorations increased the fracture resistance of the teeth with simulated abfraction, while the fiber post did not affect them.

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาผลของความต้านทานการแตกของการบูรณะด้วยเดือยเสริมเส้นใยและครอบฟันเซอร์โคเนียในฟันกรามน้อยที่ผ่านการรักษาคลองรากฟันด้วยการจำลองคอฟันสึก นำฟันกรามน้อยบน 24 ซี่มาจำลองคอฟันสึกแล้วอุดด้วยวัสดุเรซินคอมโพสิตและรักษาคลองรากฟัน จากนั้นแบ่งฟันออกเป็น 3 กลุ่ม กลุ่มละ 8 ซี่; กลุ่มที่ 1 อุดด้วยวัสดุเรซินคอมโพสิต, กลุ่มที่ 2 ใส่เดือยเสริมเส้นใยแล้วอุดด้วยวัสดุเรซินคอมโพสิต และกลุ่มที่ 3 ใส่เดือยเสริมเส้นใยและครอบฟันเซอร์โคเนีย จากนั้นนำชิ้นงานที่ถูกใส่ลงบนฐานอคริลิกมากดลงบนแอ่งกลางและทำมุม 30 องศากับแนวแกนฟันจนเกิดความล้มเหลว การวิเคราะห์ความแปรปรวนแบบทางเดียวและเชฟเฟ่ที่ระดับนัยสำคัญทางสถิติ 0.05 พบว่ากลุ่มที่ 3 มีค่าความต้านทานการแตกสูงกว่า 2 กลุ่มแรกอย่างมีนัยสำคัญทางสถิติ สรุปว่าครอบฟันเซอร์โคเนียเพิ่มความต้านทานการแตกของฟันที่จำลองคอฟันสึกจากแรงบดเคี้ยว ขณะที่เดือยเสริมเส้นใยไม่มีผลต่อฟัน

Keywords: Abfraction, Endodontically treated premolars, Fracture resistance

คำสำคัญ: คอฟันสึกจากแรงบดเคี้ยว ฟันกรามน้อยที่ได้รับการรักษาคลองรากฟัน ความต้านทานการแตก

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Introduction

Cervical parts of teeth were the most areas that tended to receive tensile stresses from the occlusal forces (Lee, Eakle, 1996). Therefore, the cervical tooth wears are often presented which are called non-carious cervical lesions (NCCLs) (Grippo et al., 2012). Abfraction lesion is one of NCCLs that can eliminate the tooth structure of cervical regions. It caused from lateral occlusal forces that created tensile stress on cervical surface to destroy enamel and cementum (Lee, Eakle, 1984). The teeth occurred wear facets on their cervical aspects especially in premolars and in some cases, progressively exposed the tooth pulp (Antonelli et al., 2013). These teeth would require endodontic treatment and proper restoration thereafter, which might be resin composite filling or crown for cusp protection.

To dates, prefabricated fiber-reinforced composite (FRC) posts are popularly used in endodontically restorations which their modulus of elasticities harmonized with the teeth, resulting in good occlusal force distribution into tooth structures (Tay and Pashley, 2007). They are used mainly to gain retention of roots and crowns (Morgano, 1996; Cheung, 2005). However, some studies explained that the posts could strengthen the teeth for severe structural loss conditions (Salameh et al., 2007; Mangold, Kern, 2011; Scotti et al., 2013). Thereby, post-endodontic method in case of loss of cervical structures from abfraction, the role of FRC posts might help to reinforce the teeth or not is still questionable.

Objectives of the study

The aim of this study was to evaluate the effect of fiber posts and crowns on the fracture resistance of endodontically treated teeth with simulated abfraction lesions.

Materials and methods

Tooth preparation

Twenty-four extracted two-root upper first premolars were collected for orthodontic reasons. The teeth were nearly the same shape and sizes without caries, fractures or any existing restorations. This study was approved by the ethics committee of the faculty of dentistry, Chulalongkorn university (HREC-DCU 2015-063). They were cleaned and kept in 0.9% saline solution. The simulation of abfraction progressing to pulp exposure were prepared on the bucco-cervical areas of the teeth with diamond instruments. These lesions were 3-mm depth, 3.5-mm height and 4.5-mm width. Upper and lower borders of the lesions were both 30° from the cemento-enamel junctions (CEJ). Total etch technique of resin composite filling was used to restored the lesions with 37% phosphoric acid (Etching liquid, 3M ESPE, Seefeld, Germany), bonding agent (Adper single bond plus adhesive, 3M ESPE) and resin composite (Filtek Z250XT, 3M ESPE). The materials were applied to the lesions follow to instructions of manufacturer. They were definitely polished and the teeth were kept at 37°C in 100% humidity distilled water.

Root canal and access preparation

An access cavity was prepared on the occlusal surface of each tooth for root canal treatment. Root canals were prepared to sizes of No.30 K-files (Dentsply Caulk, Milford, DE, USA) with 1-mm working length higher from

apexes. They were obturated with gutta percha (Hygenic, Coltène/Whaledent Inc, Langenau, Germany) and root canal cement (AH Plus, Dentsply, Konstanz, Germany). The excess gutta percha was removed at orifices of the root canals. Provisional restorations were applied with cotton pellets and cavit (Cavit, 3M ESPE, Seefeld, Germany). All teeth were kept in distilled water at 37°C for 24 hours for complete setting of root canal cement (Zicari et al., 2013).

Resin composite filling and post placement

The teeth were randomly divided into 3 groups (n=8) for different types of the restorations (Figure 1). After removal of provisional restorations, for group 1 (control group), specimens were restored with resin composite in the access cavities. For group 2 and 3, the specimens were applied with prefabricated fiber posts and resin composite. The post spaces were prepared by peezo reamers into buccal root canals for sizes of No.1 D.T. light posts (Bisco Inc, Provence, France). The remaining gutta percha was 4 mm for apical seal. The fiber posts were cemented with self-adhesive resin cement (RelyX U200, 3M ESPE, Neuss, Germany). Resin composite was finally restored into the accesses.

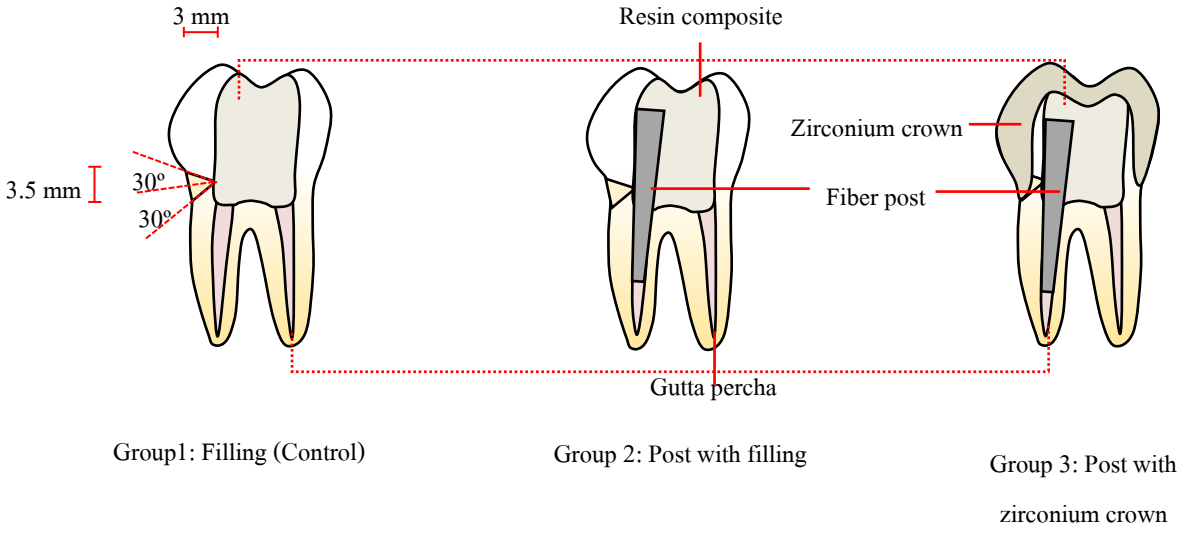

Figure 1 Three types of restorations were illustrated.

Acrylic resin block preparation

Root surfaces were pressed in melted pink wax as wax spacers to simulate a 0.2 mm thickness of the periodontal ligaments (PDL). Self-cured acrylic resin (Unifast Trad, GC corp, Tokyo, Japan) was then applied into PVC tubes (22 mm in diameter and 25 mm height) for providing acrylic resin blocks. The teeth were pressed into the blocks, which long axis of the teeth was perpendicular to the horizontal plane of the blocks. The acrylic resin was below the CEJ and lower margins of the resin composite at 2 mm. The teeth were pulled out from the blocks and removed the waxes. Silicone materials (Reprosil, Densply Caulk, Milford, DE, USA) were applied around the root surfaces for replacing wax thickness. The teeth were then pressed into the blocks with the same positions by using silicone indexes.

Crown placement

For group 3, the final restorations were zirconium crowns (LAVA™ Plus, 3M ESPE, Neuss, Germany) placement (Figure 1). The teeth were prepared by diamond instruments with 0.5 mm axial reduction and chamfer finishing lines circumferentially. Crown margins covered the lower borders of resin composite on buccal sides and were at the CEJ on the other sides. The resin cement (RelyX U200) was applied for crown cementation. They were then kept in distilled water at 37°C for 24 hours before testing (Hayashi et al., 2006).

Fracture resistance test

Fracture resistance test was performed using a universal testing machine (Instron 8872, Instron Corp, Canton, MS, USA). 2-mm diameter loading tip was located at central fossae of occlusal surfaces and 30° to the long axis of the teeth directed to palatal cusps (Figure 2). The compressive forces were applied with a crosshead speed of 1 mm/min until failure occurred. The fracture resistance were presented in Newton (N). The data were analyzed by 1-way ANOVA and Scheffe test at a 95% level of confidence.

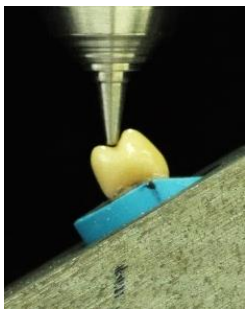

Figure 2 The specimen was located on universal testing machine at 30° to the long axis of the teeth.

Results

Mean fracture resistance ranged from 842 to1004 N (Figure 3). The highest fracture resistance was group 3 and the lowest fracture resistance was group 1 and 2. The analysis indicated that group 3 had significantly higher fracture resistance than groups 1 and 2 ($p<0.05$).

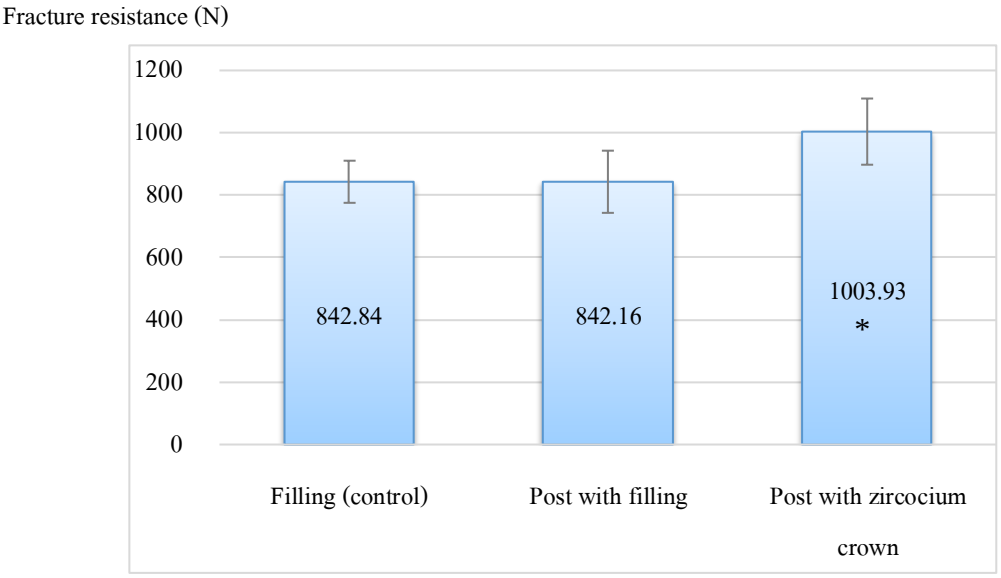

Figure 3 Mean and standard deviation of fracture resistance were shown in newton.

* means statistically difference ($p<0.05$).

Discussion

The loss of cervical structure from NCCLs lesion cause a critical situation to restore especially after endodontically treated. Apart from the increase in brittleness, the stress will continue concentrate at the cervical area during function where the structure will be replaced with the restoration.

From the results of this study, we found that there was no statistically difference between group 1 and 2 ($p>0.05$), while group 3 was significantly higher than those in group 1 and 2 ($p<0.05$). It indicated that the fiber posts did not improve the strength of the teeth with filling. Although, there were the loss of structures on buccal sides from abfraction, the other remaining walls were sufficient to resist the occlusal forces without post. The simulated abfraction in this study resulted in the reduction of coronal wall 1/3 circumferentially, therefore the 2/3 remaining coronal wall took a positive effect to the teeth more than the fiber posts. It was supported by Mangold, Kern (2011) that when more than 2 remaining coronal walls were kept, the posts could not help increase the fracture resistance. While they could strengthen the teeth when there was absence or one remaining coronal wall left. The previous studies which stated that the posts were only used for retention of the restorations (Morgano, 1996; Cheung, 2005). Therefore, the major factor that improve the strength of the teeth was the amount of remaining coronal tooth structure.

In case of restore with crown in group 3, the crowns themselves have an effect to strengthen the restoration. The preparation of crown in these cases involved the lower border of cervical fillings, and the thickness of surrounding axial wall were reduced, resulted in weakening of remaining tooth structure. However, these crowns were capable to resist more occlusal forces than conventional fillings and fiber post in group 2. The crowns in this study were made from zirconia which had flexural strength about 1100 MPa which are comparable to metal crown

(Pittayachawan et al., 2007). They can protect the cusp from accidentally fracture and are used for long term duration. It was agreed with a clinical study of Stavropoulou, Koidis (2007) which stated that the endodontically treated teeth with crowns had the high long-term survival rates, while Aquilino, Caplan (2002) showed that they were six times higher survival rates than the teeth without crown.

The average range of fracture resistance in this study was 840-1000 N that was higher than the 633 N maximum bite force of first premolars (Pruim et al., 1980). Therefore, all restorations of this study were able to resist normal occlusal forces. They were supported by other studies which explained that any restorations were acceptable to keep the strength of endodontically treated teeth. While unrestored endodontically treated teeth tended to be gradually reduce the strength from dentine and enamel removal by endodontic process (Soares et al., 2008; Taha et al., 2011).

Conclusion

The crowns increased the fracture resistance of the endodontically treated premolars with simulated abfraction lesions, while the fiber posts did not affect them.

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