

Fracture Resistance of Endodontically Treated Teeth Restored with Fiber-Reinforced Composite Posts and Composite Core with Varying Remaining Coronal Tooth Structure

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Background: Endodontically treated teeth often have a varying remaining coronal tooth structure, is an important factor in the successful of post-core with crown restoration.

Objective: This study compared the fracture resistance of pulpless teeth with variable amounts of remaining coronal tooth structure restored with fiber-reinforced composite posts and composite core.

Material and Method : Fifty extracted human premolars were endodontically treated and divided into 5 groups of 10 teeth each. Four groups were prepared having axial wall heights of 4 mm around the preparation circumferences. In 3 of the groups with axial tooth structure, mesial axial tooth structure was removed, mesial and lingual axial tooth structure were removed, mesial-lingual and distal axial tooth structure were removed. For the fifth group, all axial tooth structure was removed to the level of the prepared finish line. All 50 prepared teeth were restored with fiber-reinforced composite posts (FRC Postec Plus) and composite resin cores (Multicore Flow). Testing was conducted with a universal testing machine with the application of a static load to the lingual incline plane of buccal cusp at a crosshead speed of 5 mm/min at 45 degrees to the long axis of the tooth. The load at failure was recorded. The data were subjected to 1-way analysis of variance.

Results: The mean value \pm standard deviation for the failure load of group 1 to 5 were 237.48 ± 81.87 , 242.97 ± 66.80 , 257.67 ± 70.42 , 239.56 ± 70.42 and 297.70 ± 99.42 (N), respectively. There were no significant differences in the fracture resistance ($p < 0.01$). No root fractures occurred in any of the groups.

Conclusion: The varying remaining coronal tooth structure of endodontically treated tooth had no influenced on the fracture resistance when restored with fiber-reinforced composite posts and composite core.

Keywords: Endodontically treated tooth, Fiber-reinforced composite posts, Composite core, Fracture resistance

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Teeth that have undergone endodontic treatment often have varying remaining coronal tooth structure which effect their esthetics and functions. Factors responsible for such event are extensive caries, fracture, trauma to an immature tooth, congenital disorders, and endodontic access cavity preparation. Pulpless teeth with reduced coronal tooth structure may required post-core and reconstruction⁽¹⁻³⁾. Recent investigations suggest that the modulus of elasticity of post should be similar to the root dentine, so that

the occlusal loads may be better distributed along the root, and thus reducing the risk of root fracture more than cast post⁽⁴⁾. The fiber- reinforced composite post and resin composite core have this property and are now commonly used in order to achieve higher esthetical results, especially in the anterior teeth⁽⁵⁾. Furthermore, some kinds of fiber- reinforced composite post are able to transport light energy. This is important for the polymerization of light hardening composite in the root canal⁽⁶⁾.

The amount of remaining coronal tooth structure may compromise the success of fiber-reinforced composite posts-core and crown restoration. When the restored tooth has a vertical band of sound tooth structure at gingival aspect of a crown preparation

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there will be ferrule effect, an important factor in the successful restoration of pulpless teeth. Al-Wahadni and Gutteridge demonstrated that retained coronal buccal dentine improved the fracture resistance of teeth restored with partial post and cores when compared to teeth without retained coronal dentine⁽⁷⁾. On the contrary, Patel and Gutteridge showed that retained coronal dentine will not strengthen a tooth restored with a cast post and partial core. There was no statistically significant difference in the strength of a post with partial cores in teeth with retained lingual coronal dentine or buccal or lingual dentine when compared to teeth without coronal dentine⁽⁸⁾.

Thereby, the aim of this study was to compare the fracture resistance of pulpless teeth with varying remaining coronal tooth structure restored with fiber-reinforced composite posts and composite core.

Material and Method

Fifty extracted human premolar were used in this study. Inclusion criteria were that these teeth have straight root and single canal, absence of cracks and micro root fractures. All collected teeth were cleaned with 0.9% normal saline and stored in a 5% thymol solution at room temperature^(7,8). The buccolingual and mesiodistal dimension of each tooth was measured using a caliper at the midpoint of the cemento-enamel junction (CEJ) level, and root length was measured from the apex to the CEJ. All teeth were divided into five groups of ten teeth, each group consisted of even distribution of the root size. Root canal access was opened using round diamond burs (#010 Diatech Dental AG, Heerbrugg, Switzerland) and root canal was instrumented to a working length, leaving 0.5-1 mm from the root apex using a conventional step-back technique to the size No. 50 K-files (Dentsply Maillefer, Ballaigues, Switzerland). During the instrumentation, canals were irrigated with 2.5% sodium hypochlorite (sodium hypochlorite, Chulalongkorn University, Bangkok, Thailand). Final irrigation was done with 10 ml of distilled water, and the canals were aspirated and dried with absorbent paper points (Chulalongkorn University, Thailand). Root canals were obturated with gutta-percha (gutta percha, Coltene Whaledent, USA.) and endodontic cement (Chulalongkorn University, Bangkok, Thailand) using a lateral condensation technique. Vertical condensation was performed with same instruments, and the pulp chambers were sealed with provisional restorations (Fermin, Detax, Germany). Specimens were immersed in distilled water and maintained at 37°C for 7 days.

Post space was prepared with No. 3 drill of FRC postec (FRC Postec Plus, Ivoclar Vivadent, USA) leaving 4 mm. of gutta percha at the apical end of the root. All groups were prepared for varying remaining coronal tooth structure. Group 1 (control group) has 360° of sound coronal tooth structure. In group 2, 3 and 4 the following axial walls were eliminated mesial axial wall, mesio-lingual axial wall and mesio-linguo-distal axial wall, respectively. Group 5 was decoronated at CEJ, no remaining coronal tooth structure. All groups were restored with fiber post (FRC postec plus, Ivoclar Vivadent, USA). According to the manufacturer's instructions, silance coupling agent (Monobond-S, Ivoclar Vivadent, USA) was coated on the post surface and cemented with resin cement (Multilink, Ivoclar Vivadent, USA). The core was subsequently fabricated with composite resin (MultiCore Flow, Ivoclar Vivadent, USA). All five groups were finally prepared with deep chamfer on buccal finished line and chamfer on lingual finished line (Fig. 1).

The teeth were embedded in self cure acrylic resin block with the long axis of the tooth at right angle to horizontal plane. The samples were loaded on a universal testing machine (Instron 5566, London, UK) with a crosshead speed of 5 mm/min on the buccal cusp at 45° angles to the long axis of the tooth until failure occurred (Fig. 2).

The statistical analysis used includes 1-way analysis of variance ($p < 0.01$) to detect the presence of group differences. The mode of failure for each of the specimens was noted by visual inspection.

Results

The mean failure load is shown in Table 1, and the mode of failure is presented in Table 2. Statistical analysis with ANOVA revealed no significant difference of the fracture resistance between the groups ($p < 0.01$). No root fractures occurred in any of the groups. The mode of failure was typically Post/Core detachment, and the majority of fractures were oblique extending from the post-core junction on the lingual incline plane of buccal cusp near loading point down to the bucco-cervical surface except in group 5 vertical fracture extending along the post-core interface (Fig. 3).

Discussion

Many studies have suggested that a ferrule enhances fracture resistance especially cast post⁽⁹⁻¹¹⁾. Arunpraditkul S and other found that the fracture resistance of a cast post-core and crown with ferrule of four walls of remaining coronal tooth structure was

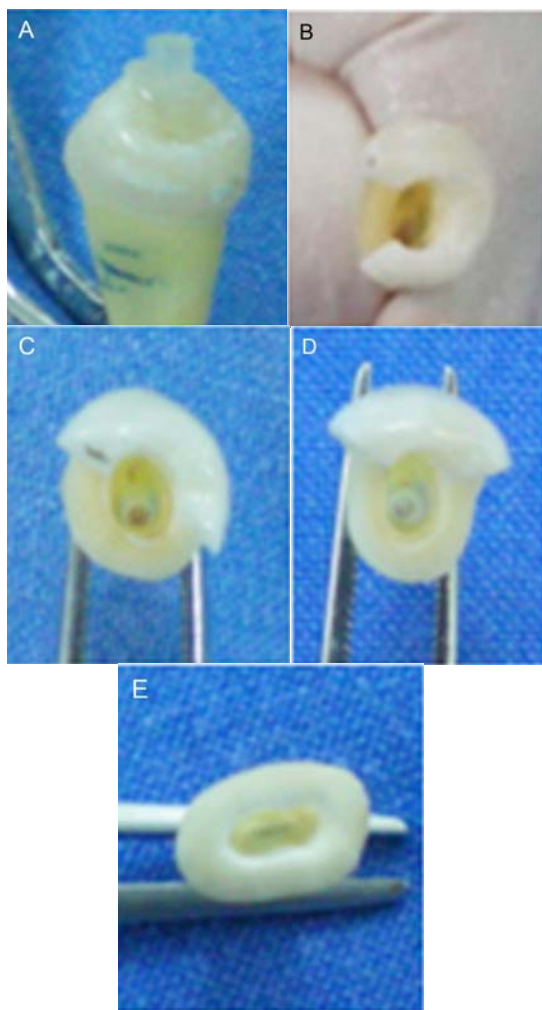


Fig. 1 Experimental group, A) four remaining axial walls, B) without mesial wall, C) without mesio-lingual walls, D) without mesio-linguo-distal walls, E) no coronal tooth structure

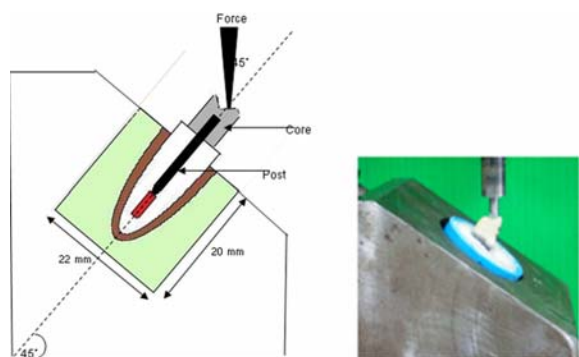


Fig. 2 Specimen positioned in holding device for testing in universal testing machine

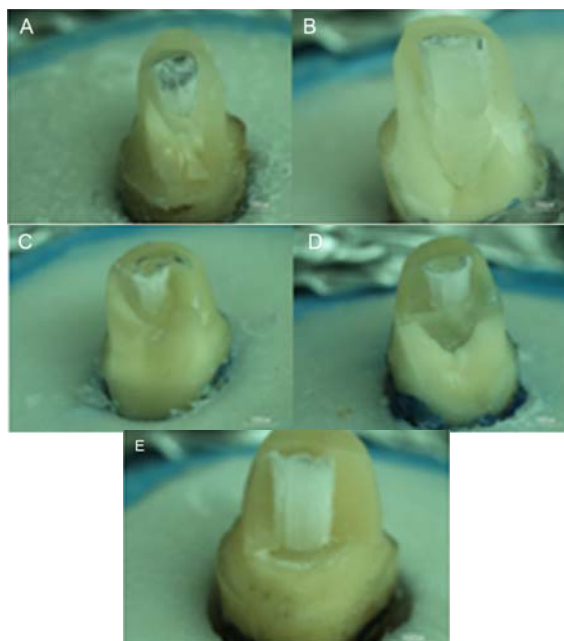


Fig. 3 Mode of failure for group 1 to 5 (A to E)

significantly greater than that with three walls⁽¹²⁾. The result suggested that a ferrule can distribute the stress concentrations at the junction between the tooth and crown margin passing through the remaining coronal dentine above the crown margin, and therefore improve fracture resistance⁽¹³⁾. However, there are many clinical situations where it is not possible to obtain ideal ferrule. In clinical study, Ferrari compared the survival rate of 240 endodontically treated premolar in 210 patients⁽¹⁴⁾. All the teeth were restored with fiber-reinforced composite posts, resin composite core, and full coverage crowns. The author found no difference in survival rate among those teeth with 1 to 4 dentine walls. The result of this in vitro study is in concurrent with the above clinical investigation. The reasons explain is that fiber-reinforced composite posts and resin composite core have modulus of elasticity similar to the dentine. The nature of the bonds between these creates a “quasi-monoblock” restoration, which in effect becomes an integral part of the restored tooth and positively affects the success rate⁽¹⁵⁾. As a monoblock, the occlusal loads may be better distributed along the root⁽⁵⁾ and thus reducing the risk of root fracture better than cast post^(4,5).

Besides, the fracture patterns of group 1 to 4 in this study were similar. Fracture line was oblique, extending from loading point near post-core junction to bucco-cervical surface, instead of along the post-

Table 1. Mean fracture resistance (N) and SD of the study groups

Group	Means	SD
1 (control)	237.48	81.86
2	242.97	66.81
3	257.67	70.42
4	239.56	62.15
5	297.70	99.42

Table 2. Mode of failure

Group	Dentine/Core detachment	Cervical root fracture
1	10	-
2	10	-
3	9	1
4	10	-
5	9	1
Total	48	2

core interfaces. It is also noteworthy that group 1 to 4 have buccal wall bond with composite core which may prevent fracture along the post-core interfaces. In contrast, the fracture pattern of group 5, without axial wall was along post-core interface. The result correspond to an experiment by K. Genovese et al who showed that lack of coronal dentine induce large stresses concentration at the post-dentine interface⁽¹⁶⁾. Therefore, the fracture line occurred at loading point along this interface.

There are several limitations to this study. Static load does not replicate forces in the oral cavity with regard to the nature of load. For more meaningful results, further studies should incorporate fatigue load/thermocycling and the specimens should be crown, to simulate clinical situation.

Conclusion

Within the limits of this *in vitro* study, the following conclusions were drawn:

1. The mean fracture resistance of endodontically treated teeth restored with fiber-reinforced composite posts and resin composite core with varying remaining axial wall were not significantly different.
2. Site of the missing axial wall did not affect the fracture resistance of endodontically treated teeth restored with fiber-reinforced composite posts and resin composite core.

Potential conflicts of interest

None.

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ความต้านทานการแตกหักของฟันที่ได้รับการรักษาคลองรากฟันและบูรณะด้วยเดือยคอมโพสิตเสริมเส้นใยและแกนฟันเรซินคอมโพสิตในฟันซึ่งมีปริมาณเนื้อฟันที่เหลืออยู่แตกต่างกัน

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วัตถุประสงค์: เพื่อศึกษาความต้านทานการแตกหักของฟันที่ได้รับการรักษาคลองรากฟัน และบูรณะด้วยเดือยคอมโพสิตเสริมเส้นใยและแกนฟันเรซินคอมโพสิตในฟันซึ่งมีปริมาณเนื้อฟันที่เหลืออยู่แตกต่างกัน

วัสดุและวิธีการ: แบ่งฟันเป็น 5 กลุ่มคือ กลุ่มที่ 1 เป็นกลุ่มควบคุม มีเนื้อฟันเหลือโดยรอบทุกด้าน กลุ่มที่ 2 สูญเสียเนื้อฟันด้านไกลกลาง กลุ่มที่ 3 สูญเสียเนื้อฟันด้านไกลกลางและด้านไกลลิ้น กลุ่มที่ 4 สูญเสียเนื้อฟันด้านไกลกลางด้านไกลลิ้น และด้านไกลกลาง และกลุ่มที่ 5 ไม่มีเนื้อฟันเหลือคอฟันเลยนำฟันแต่ละกลุ่มมาทำการรักษาคลองรากฟันและบูรณะด้วยเดือยคอมโพสิตเสริมเส้นใย (FRC Postec Plus) แล้วทำการยึดเดือยฟันด้วยเรซินซีเมนต์ (Multilink) จากนั้นทำการสร้างแกนฟันทดแทนส่วนของเนื้อฟันที่ขาดหายไปในแต่ละกลุ่มด้วยเรซินคอมโพสิต (MultiCore Flow) แล้วทำการกรอแต่งฟันให้มีลักษณะที่พร้อมในการใส่ครอบฟัน จากนั้นนำฟันมาทำการจำลองเอ็นยึดปริทันต์ และลบลิ้นยึดฟัน แล้วนำฟันไปทดสอบความต้านทานการแตกหักด้วยเครื่องทดสอบสากล (Instron testing machine model 5566) โดยใช้หัวกดคดลงที่ด้านไกลแก้มทำมุม 45 องศากับแนวแกนฟัน ใช้ความเร็วหัวกด 5 มิลลิเมตรต่อวินาที

ผลการศึกษา: พบว่าค่าเฉลี่ยของแรงต้านทานการแตกหักของฟันในแต่ละกลุ่ม เรียงจากกลุ่มที่ 1 ถึงกลุ่มที่ 5 มีค่าเท่ากับ 237.48 ± 81.87 , 242.97 ± 66.80 , 257.67 ± 70.42 , 239.56 ± 70.42 และ 297.70 ± 99.42 (นิวตัน) ตามลำดับ ซึ่งเมื่อนำมาวิเคราะห์ความแตกต่างระหว่างกลุ่มพบว่า ค่าเฉลี่ยของแรงต้านทานการแตกหักของแต่ละกลุ่มไม่แตกต่างกันที่ระดับนัยสำคัญ 0.01

สรุป: การต้านทานการแตกหักของฟันที่ได้รับการรักษาคลองรากฟัน และบูรณะด้วยเดือยคอมโพสิตเสริมเส้นใยและแกนฟันเรซินคอมโพสิต ในฟันซึ่งมีปริมาณเนื้อฟันที่เหลืออยู่แตกต่างกันทุกกลุ่ม มีค่าเฉลี่ยของแรงต้านทานการแตกหักไม่แตกต่างกัน รวมทั้งรูปแบบการแตกที่เกิดขึ้นเป็นการแตกที่สามารถซ่อมแซมได้ทั้งสิ้น และไม่พบการเกิดรากฟันแตกในแนวตั้งในทุกกลุ่ม