Comparison of Fracture Resistance among Different Post Placement Strategies and Core Build-up Materials in Endodontically Treated Maxillary Premolars: In Vitro Study

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Article

Keywords: Luxacoe Z, fiber post, composite build up, core build up, post and core, flexural strength, core build up

Posted Date: January 26th, 2024

DOI: https://doi.org/10.21203/rs.3.rs-3866205/v1

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Additional Declarations: No competing interests reported.
Abstract

Objectives: The aim was to compare the fracture resistance of endodontically treated premolars reinforced by one or two fiber-reinforced composites and different core build-up materials.

Materials and methods: 40 double rooted maxillary premolars were collected and divided into four groups (n=10). After endodontic treatment, teeth were prepared and received fiber posts as follow: group #1: single fiber post with Luxacore Z as luting cement and core build-up material, group #2: two fiber posts with Luxacore Z as luting cement and core build-up material, group #3: single fiber post cemented with RelyX Unicem followed by packable composite as a core build-up material, group #4: two fiber posts cemented with RelyX Unicem followed by packable composite as a core build-up material. The specimens were placed in the Universal testing machine for testing of the fracture resistance. Specimens were axially loaded on the center of the occlusal surface.

Results: Group 4 (two fiber posts with resin cement & packable composite resin) had significantly higher fracture resistance (1051.7 N) compared to group 1 and 2 (single and double posts with luxacora Z build up) respectively at p-value < 0.05.

Conclusion: The restoration of endodontically treated double rooted premolars using two fiber posts luted with resin cement, followed by packable composite build up showed promising performance regarding fracture-resistance.

Introduction

Coronal restorations for endodontically treated teeth are still a challenging and controversial subject[1]. Many factors affect the success of endodontically treated teeth. Caries, trauma, previous restorative treatment, and access cavity preparation are all factors that can weaken the endodontically treated tooth and make it more liable to fracture[1,2]. The risk for development of vertical root fracture and tooth loss during the first 8 years following endodontic treatment increases[2,3]. Premolars are the most prone to fracture because of their steep cusp slopes, and their position in the dental arch that subjects them to more detrimental lateral forces[2]. The use of a post can enhance core retention and distribute forces along the tooth[4–6]. The decision to place a post or not depends on the amount of remaining tooth structure. Since the 1990s, the frequency of using fiber-reinforced composite posts to restore endodontically treated teeth have been increasing[4]. Studies reported that fiber posts caused fewer root fractures since their modulus of elasticity is similar to that of dentin (around 20GPa) which allows stress absorption[7,8]. The prefabricated fiber-reinforced composite posts are made of a high percentage of continuous unidirectional reinforcing fibers embedded in a polymerized matrix[9]. Advancements in tooth-colored restorative materials has pointed attention towards the use of composite resin[7].

The bonding between the composite material of the fiber post and the dental structure can create a monoblock that resists occlusal loads. The interface between the dentin and cement is a crucial factor for
a post's clinical success. The interface between the post and core material is also a major factor for success. Hence, numerous studies described it as the weak link in this adhesive process\[10\]. A variety of resin cements with lesser mechanical properties in comparison to dentin and posts are available for post luting procedures. Which, in turn creates an area of higher stress, particularly in wide or flared root canals where a thick cement layer is present. The former results in several crack-formations and deficient bonding\[11,12\]. The weakest link in a restored tooth is the luting cement and it is located at the area that is subjected to the highest tensile stresses during function. Even with the present cements that contain particulate filler, a restored tooth is not biomechanically optimized. Recently, some manufacturers invented resin composites with different flowability or viscosity that claimed to restore structurally compromised teeth with fiber posts\[12,13\].

The advancement in tooth-colored restorative materials has pointed attention towards the use of composite resin\[7\]. The bonding ability of composite resin to tooth structure can offer cusp splinting effect and sufficient retention. In addition to the mechanical and esthetic properties, the conservation of tooth structure makes composite resin a preferred choice for many practitioners in coronal restorations. A major drawback of composite resin is the polymerization shrinkage as an inherent property. Consequently, incremental application was recommended to overcome this disadvantage and guarantee complete polymerization to achieve optimum performance of the composite resin restoration. However, this technique can be sensitive and timeconsuming\[1\].

Recently, the “bulkwill” dual cure composite resin build-up materials were introduced to cement the post and build up the core simultaneously\[1,14\]. This invention allows the formation of a monoblock that reduces the adhesive failures between resin cement and the post and core restoration\[14\]. The higher translucency and the advanced photoinitiator dynamics could permit a deeper curing light penetration. Bulkfill composite resins can be applied in 4–5 mm thickness and polymerize with low shrinkage\[1\]. Bulkfill application can reduce clinical time and simplify restorative procedures in deep cavities\[1,14\]. It has been reported that bulk-fill composite resin gives a better performance in terms of shrinkage stress and fracture resistance when compared to conventional composites in MOD cavities. However, other studies showed similar fracture resistance for two types of composite resins when used to restore endodontically treated teeth\[1\]. Kumar et al. compared the fracture resistance of three core build up materials and reported that Luxacore had the highest fracture resistance among them\[15\]. Therefore, Composite core build-up materials have been commonly used, owing to their good adhesion to tooth structure, high compressive strength, low modulus of elasticity, and their affordability\[15\].

Clinicians repeatedly ask if using more than one post is necessary to restore endodontically treated severely damaged posterior teeth. The use of two posts in such cases, to our knowledge, is not widely discussed\[6\]. Recently, a study reported that the fracture strength of teeth restored with a single post cemented in the palatal root canal was less than teeth restored with two posts in palatal and buccal root canals\[2\]. In addition, literature regarding the fracture resistance of double rooted endodontically treated teeth that are restored with two posts is still incomplete. The null hypothesis tested (H0) was that there
were no statistically significant differences in fracture strength between maxillary premolars restored with one or two posts cemented with two different luting and core build-up materials.

**Material & Methods**

Ethical approval was obtained from King Abdulaziz University following the Declaration of Helsinki. Forty freshly extracted maxillary premolars with two roots were collected. Informed consent was obtained from patients for collection of extracted teeth for research purposes. Teeth were cleaned of calculus and remaining tissues using an ultrasonic scaler. Teeth were examined to exclude caries, cracks, and fractures. Samples were stored in a 10% formalin solution at room temperature until used. The labial and palatal surfaces were marked.

40 premolars were accessed and endodontically treated using rotary pro-taper gold files (Dentsply Sirona). Pulp tissue was removed using barbed broach prior using the rotary files (Dentsply Maillefer, Tulsa, OK, USA). After removing pulp tissue, Size 10 K-file was used to establish the working length (Dentsply Maillefer, Tulsa, OK, USA) and to start a glidepath for the rotary files. Furthermore, the root canals were enlarged to size 20 (Dentsply Maillefer, Tulsa, OK, USA) before using the rotary files. Protaper gold Ni-Ti rotary instruments were used according to the manufacture instruction in the following sequence (sizes S1, S2, F1, F2; Dentsply Maillefer, Tulsa, OK, USA). A high torque endodontic motor was used. (X-Smart, Dentsply Maillefer, Tulsa, OK, USA). The canals were irrigated using NaOCl (5.25%) between each file to remove any remaining debris. The canals were then dried using F2 paper points. Subsequently, Obturation was done using Gutta percha size F2 (Kerr Corporation, Brea, CA, USA) and AH sealer (Dentsply Maillefer, Tulsa, OK, USA). The Gutta Percha was removed using gates glidden size 3, leaving approximately 5mm at the apical region.

The teeth were sectioned 2mm coronal to the cemento-enamel junction using a wheel-shaped diamond bur. The teeth were also apically and axially prepared to achieve a 2mm ferrule and a 1.5mm deep chamfer finish margin. A round-end diamond bur was utilized for this step. Next, Post space was created using post space drill RelyX (3M ESPE, Germany) corresponding to the selected post as follows:

A) RelyX™ fiber post size 2 (1.6 mm diameter) for double fiber post group.

B) RelyX™ fiber post size 3 (1.9 mm diameter) for single fiber post group.

In addition, two core build-up strategies were utilized:

A) LuxaCore Z (DMG, Hamburg, Germany), dual-cured core build-up composite as luting cement and core build-up material. LuxaCore Z composed of nanofiller and zirconium dioxide (70%) in a Bis-GMA-based dental resins (28%), additives, pigments, catalysts (2%)

B) RelyX Unicem self-adhesive resin cement (3M ESPE, Germany) as a luting cement, followed by composite 3M ESPE Filtek Z250 XT (3M ESPE, USA) nanohybrid as a core build-up material.
Teeth were divided randomly into 4 groups of 10 teeth each, depending on the number of fiber posts (single or double) and the core build-up material (LuxaCore Z or composite) used.

Group #1. Single fiber post with Luxacore Z as luting cement and core build-up material.

Group #2. Two fiber posts with Luxacore Z as luting cement and core build-up material.

Group #3. Single fiber post with RelyX Unicem as luting cement followed by composite as a core build-up material.

Group #4. Two fiber posts with RelyX Unicem as luting cement followed by composite as a core build-up material. (Table 1).

<table>
<thead>
<tr>
<th>Grouping</th>
<th>No. of posts</th>
<th>Luting material</th>
<th>Core build-up material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>Single</td>
<td>Luxacore Z</td>
<td>Luxacore Z</td>
</tr>
<tr>
<td>Group 2</td>
<td>Double</td>
<td>Luxacore Z</td>
<td>Luxacore Z</td>
</tr>
<tr>
<td>Group 3</td>
<td>Single</td>
<td>Resin cement</td>
<td>Packable composite</td>
</tr>
<tr>
<td>Group 4</td>
<td>Double</td>
<td>Resin cement</td>
<td>Packable composite</td>
</tr>
</tbody>
</table>

An intra-oral periapical radiograph was taken to confirm the position of the post in the canal. The post space and coronal dentin were etched using 37% phosphoric acid (N- etch, Ivoclar Vivadent) for 15s then rinsed and dried using air and paper points.

In group 1 and 2:

Luxacore Z was used as a luting cement for the post and core build up material. The posts were inserted in the root canals and held under digital pressure. Luxacore Z was light cured for 40 s. The core was allowed to set for 5 min for complete polymerization to occur because Luxacore Z is a dual cure composite resin.

In group 3 and 4:

RelyX resin cement was used to cement the posts in the root canals. The posts were inserted in the root canals and held under digital pressure. Excess cement was removed using a microbrush and a sharp instrument. The cement was then light cured for 20s. An adhesive resin (Single Bond, 3M ESPE) was applied following manufacturer’s instructions and cured for 10s. The core build-up composite resin was placed on the post and prepared tooth surfaces and light cured for 40s.
All teeth were finished using fine diamond cylindrical burs. All above procedures were done by a single operator. Subsequently, teeth were mounted perpendicular to the base of customized molds in an autopolymerising acrylic resin (Eco-Cryl cold, Protechno, Spain) 2mm below the cementoenamel junction to simulate bone support.

The specimens were placed in the Universal testing machine (5969L3504, Instron, USA) to test the fracture resistance. Specimens were axially loaded on the center of the occlusal surface. Load was applied using a stainless steel piston with 0.5 mm radius at a cross-head speed of 1mm/min until the specimen fractured. The maximum force required to produce a fracture was recorded in newtons (N). The statistical analysis was performed using One way ANOVA with tukey post hoc.

Results

This in-vitro study was carried out to evaluate the fracture resistance of two different composite resin core build-up materials on single and double prefabricated fiber posts, cemented in extracted endodontically treated maxillary premolars. Group 4 (two fiber posts with resin cement & packable composite resin) had higher fracture resistance (1062.1 N) compared to the other groups. The fracture resistance of group 4 was significantly higher than group 1 and 2 (p-value < 0.05) as shown in Table 2 and Fig. 1.

<table>
<thead>
<tr>
<th>No. of posts</th>
<th>Luting material</th>
<th>Core build-up material</th>
<th>Fracture resistance in Newton</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean ± SD</td>
<td>Median</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Min – Max)</td>
<td></td>
</tr>
<tr>
<td>Group 1</td>
<td>Single</td>
<td>Luxacore Z</td>
<td>Luxacore Z</td>
<td>874.47 N</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>± 59.94</td>
<td>(790–997.64)</td>
</tr>
<tr>
<td>Group 2</td>
<td>Double</td>
<td>Luxacore Z</td>
<td>Luxacore Z</td>
<td>872.16 N</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>± 151.18</td>
<td>(720.47–1190.61)</td>
</tr>
<tr>
<td>Group 3</td>
<td>Single</td>
<td>Resin cement</td>
<td>Packable composite</td>
<td>979.21 N</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>± 117.45</td>
<td>(858.08–1175.53)</td>
</tr>
<tr>
<td>Group 4</td>
<td>Double</td>
<td>Resin cement</td>
<td>Packable composite</td>
<td>1049.16 N</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>± 125.51</td>
<td>(893.55–1277.58)</td>
</tr>
</tbody>
</table>
Discussion

This in vitro study compared the fracture resistance of different post placement strategies and core build-up materials used in endodontically treated maxillary premolars. There was a statistically significant difference detected in the fracture resistance of endodontically treated premolars with the different post placement strategies and core build-up materials: the null hypothesis (H0) had to be rejected.

Maxillary premolars were selected for this in vitro study due to the high incidence of vertical fracture reported by many studies. Maxillary premolars are subjected to compressive and shearing forces due to their anatomical features and their location in the dental arch. Furthermore, there is a lack of evidence about the effect of two fiber posts in fracture resistance of premolars with separate double roots[^2,^4]. The occlusal force on maxillary premolars ranged clinically between 222–445 N, and it can reach as high as 520–800 N (average 660 N) during bruxism and clenching[^2,^4].

The results of this study conclude that endodontically treated maxillary premolars can withstand functional and para-functional occlusal forces in case of single and double post placement with Luxacore Z or packable composite build-up materials. This is in agreement with previous studies that recommended the cuspal coverage following root canal treatment in order to guarantee the long-term survival of the tooth. Additionally, in this study an axial load was applied parallel to the longitudinal axis of the teeth to simulate vertical occlusal forces. While premolars are often subjected to lateral forces, this load direction may overestimate the fracture resistance of specimens[^2]. Endodontic re-treatment can be complicated after post placement. Also, according to previous investigations, post should be placed in the palatal canal only since the buccal canal can be narrow or it can have a buccal furcation groove that can increase the risk of perforation and fracture. Notably, the result of this study shows a significant difference in the fracture resistance between single and double post placement. The highest fracture resistance values were obtained by placement of two fiber posts in each canal cemented with Rely-x and followed by packable composite build up. Contradictory results were obtained by Valentina et al. in their study where they compared the fracture strength of maxillary premolars restored with single or double fiber posts and they concluded that in maxillary premolars with two separate roots, the placement of a single post in the palatal root canal may be a more conservative and safer option and this can also simplify a possible root canal re-treatment in the future[^2].

The core materials strength is a key factor in long-term success of restored teeth especially when the remaining structure is compromised. The core build-up material selected in the present study is Luxacore Z with a flexural strength of 418.7 to 438 N which was compared to Filtek 250 XT packable composite of 311.4 V flexural strength[^16,^17]. The use of Luxacore Z for post cementation and core-build up allows the formation of a monoblock and ensures a stable adhesion which further reinforces the intraarticular tooth structure[^9]. Logically, this could possibly enhance the fracture resistance of the restoration, but on the contrary, the values of fracture resistance of group 1 and 2 (Luxacore Z with single and double posts were lower that group 3 and 4 (Packable composite with single and double posts) although the difference
wasn’t statistically significant for group 3. Oppositely, Shafiei et al. stated that conventional composite resin and bulk fill composite resin revealed no difference in the strength of restored teeth\textsuperscript{[1]}.

The present study and previous studies determined that the strength of the post, core and crown is given a lot of importance. The literature showed that the load at which teeth may fracture is much higher than that occurring during mastication. Higher load during trauma can lead to the fracture of the tooth. The decision of placing a post and core should be based on the amount of remaining tooth structure, type of final restoration and the occlusal forces it will be subjected to. Further research is required to investigate the effect of thermal cycling or cyclic loading on the fracture resistance of the single and double fiber post placement.

**Conclusion**

Within the limitations of this study, the restoration of endodontically treated double rooted premolars with the use of two fiber posts luted with resin cement and followed by packable composite build up showed promising results regarding fracture-resistance.

**Declarations**

**Author Contribution**

Ayman _ prepared the specimens and revised the manuscriptShatha- wrote the manuscriptHisham and narmeen- specimen preparation, testing, statistical analysis

**References**


Figures
Figure 1

Comparison of fracture resistance among the groups

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- rowdata.xlsx