Fracture resistance of endodontically treated roots after restoration

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SUMMARY This study evaluated the shear strength resistance of endodontically treated roots that were restored by two different techniques. Twenty-seven recently extracted single-rooted teeth with similar anatomic characteristics were sectioned to obtain the same length for all specimens. Group I (GI) consisted of 14 roots restored with cast post-core (nickel-chromium alloy) and cemented using zinc phosphate cement; group II (GII) consisted of 13 roots restored with steel prefabricated posts (FKG®) cemented with zinc phosphate cement and rotated with caution for anchorage. The crown portion of this group was made using a hybrid composite resin (Prisma APH®). Results showed that on all specimens of GI the fracture occurred in the cervical root structure while in GII the composite resin fractured in all specimens. Statistical analysis showed a significantly higher resistance to fracture for GI than GII. The specimens were sectioned longitudinally for stereoscopic microscope analysis (63X) and did not show fracture lines in the dentin anchorage post area for any of the specimens.

Introduction

Anterior teeth that have lost their coronal portion by traumatic injury are commonly restored by means of cast post-cores and artificial crowns. Such injuries often occur in children, which makes the use of permanent indirect crowns questionable because of the potential for changes in the gingival outline, thus creating greater potential for aesthetic problems in the future. The use of an indirect technique has additional disadvantages such as the necessity for several clinical sessions; excessive loss of the coronal portion of the remaining dental structure during preparation; difficulty of matching existing aesthetics; and high cost.

The construction of dowels and cores using a macrofilled composite resin performed well in an in vivo study (Stahl & O'Neal, 1975). The hybrid system of fillers is evolutionary because these materials have shown better physical properties than macrofilled systems. Therefore, the use of composite resins reinforced by a post-core may be possible for total reconstruction of anterior teeth.

A study (Jansson & Donly, 1990) described a clinical case of a crown reconstruction utilizing a prefabricated post in conjunction with a composite resin core. Another clinical study (St Germain & Meiers, 1995) described a restoration technique for fractured anterior root canal-treated teeth using a prefabricated cemented post and a self-threaded 0.017 inch pin for a direct composite resin core build-up. The use of these posts in combination with composite resins were recommended for dental restorations after 10 years of favourable results (Linde, 1993). This restoration may be considered a temporary solution or, depending on the patient's occlusion and financial situation, as a definitive restoration since colour alterations of the composite resin may be corrected by means of periodic reapplication of composite resin on the facial surface of the restoration.
Fig. 1. Force was applied in the cervical third of the specimens at an angle of 45° to the long axis of the tooth.

Slightly turning the prefabricated posts in the root canal during cementation was felt to provide better post fixation and prevent microleakage (Standlee et al., 1980). The rotary movement must not be excessive, thereby preventing the risk of producing dentinal tension and creating fracture lines in the dental structure. Studies have analysed the stress induced by these posts (Mattison, 1982; Burns et al., 1990; Cailleteau, Rieger & Akin, 1992; Thorsteinsson, Yaman & Craig, 1992). A comparative study (Rolf, Parker & Pelleu, 1992) showed that cemented posts created less stress than threaded posts.

Various protrusive movements can cause excessive oblique forces in restored anterior teeth. Therefore, it would be interesting to evaluate the probability of occurrence of fractures of teeth that have been restored utilizing steel prefabricated posts. It is possible that incisal function added to dentinal stress produced by the posts may be the cause of root fractures.

Thus, the purpose of this study was to compare the fracture strength resistance of endodontically treated roots restored by cast post-cores or prefabricated cemented posts with a hybrid composite resin build-up.

Materials and methods

Freshly extracted single-rooted teeth, with similar anatomic characteristics, were selected for this research.

The coronal portions were sectioned to obtain the same length (12 mm) for all specimens. After sectioning, the crown portions were discarded and the coronal portion of the remaining root diameters measured. Only 27 roots showing similar cervical diameters were selected for this study.

The roots were embedded into acrylic resin blocks at a depth of 10 mm. The canals were prepared with a Largo RA number 2 drill to create the same anchorage space in all roots (8 mm), then separated into two groups:

Group I (GI)

Fourteen roots were restored by nickel-chromium alloy cast post-core cemented utilizing zinc-phosphate cement. An autopolymerizing acrylic resin patterns were fabricated, invested and cast to provide the metal post-cores. The coronal thickness of the posts was standardized using the diameter of the cervical area, where the force would be applied, and all of the cervical area of the roots was covered by the cast, because the margins were finished in a chamfer design, with the object of getting a similar effect to that of a total crown.

Group II (GII)

Thirteen roots were restored using steel prefabricated posts, cemented with zinc phosphate cement and cautiously rotated for anchorage. The margins of the roots were finished in chamfer. Posts that were 10 mm in length were selected for all specimens in this group (8 mm for anchorage and 2 mm for the coronal portion). The coronal core portion was made using a hybrid composite resin. A bonding agent was applied to the cervical dentin and the coronal portion of the post and autopolymerized for 20 s. Eight increments of the composite resin with 60 s of photopolymerization each were necessary to complete the coronal cores. The cervical root diameter was used to standardize the thickness of composite resin around the heads of the posts in the cervical area.

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† Nicron, 1029244; Vigodent S.A., Rio de Janeiro, Brazil.
‡ Lee Smith, 0503325; Vigodent S.A.
§ Duralay; Reliance Co, Worth, Illinois, U.S.A.
★ Obturation Screws; FKG, Flückiger & Huguenin Dentaire S.A., La Chaux-de-fonds, Switzerland.
** Prisma APH, 1290/52; Dentsply, Petrópolis, RJ, Brazil.
†† Prisma Universal Bond 3, 21139; Dentsply.

The inciso-gingival dimension was about 3 mm for all specimens. Since the force would be applied to the cervical area, it was not necessary to reproduce the clinical length of the anterior teeth. After completion, the post-cores were stored in distilled water at 37 °C for 30 days before testing.

The shear strength tests were carried out using a universal testing machine* with a constant crosshead speed of 0.05 cm/min. Tests were carried out at the same coronal position on all samples (Fig. 1) and the results were recorded. The specimens were abraded longitudinally and polished for stereoscopic microscope analysis (63×) to facilitate examination for probable fracture lines in the dentin anchorage post areas.

The statistical analysis (Student’s t-test) showed that group GI had a significantly greater resistance to fracture than group GII. The mean results and standard deviations are reported in Table 1.

**Results**

All GI specimens fractured in the cervical root structure, while all GII specimens fractured in the composite resin (Figs 2, 3).

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**Table 1. Mean shear strengths, standard deviations and Student’s t-test results**

<table>
<thead>
<tr>
<th>Group</th>
<th>Number</th>
<th>Mean (kgf)</th>
<th>s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>14</td>
<td>48.36</td>
<td>7.8</td>
</tr>
<tr>
<td>II</td>
<td>13</td>
<td>30.92</td>
<td>6.9</td>
</tr>
</tbody>
</table>

GI vs. GII*.

$t = 6.13; t$ Critical value = 2.06.

*Significant ($P < 0.05$); s.d., standard deviation.

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None of the specimens, in either group, exhibited fracture lines in the anchorage post area.

**Discussion**

Restoration by prefabricated posts and composite resin is a viable technique for endodontically treated fractured anterior teeth (Jordan, 1987). A composite resin fracture, when occlusal force is applied, may be a positive occurrence because it could prevent a possible root fracture. The cervical fractures in the cast post-core group (GI) occurred with significantly higher force than that necessary to fracture the composite resin in the prefabricated post-core group (GII). This fact was related to the higher strength of nickel–chromium alloy. However, under normal clinical conditions composite resin could resist incisal function. Our results are in agreement with a study which concluded that composite resin fractures at a lower force than that necessary to fracture roots (Bex et al., 1992).

Another study (Chang & Millstein, 1993) recommended that composite resins have a post-head covering thickness of 3 mm. The post-head diameter in the current study was about 1 mm. Two mm of composite resin was used to cover each side of the posts because in most clinical cases an inter-incisal distance of 3 mm is not feasible.

The most common cause of failure when the option is the direct technique (prefabricated post and composite resin) is the fracture of the restorative material. This occurrence was observed in this study. Displacement by rotation of the composite resin is impeded by the square design of the post-head. The visual effect is acceptable, because the use of an opaque composite resin coat on the coronal portion of the post avoids the loss of aesthetic appearance to some extent.

A large cement line between a prefabricated post and canal wall may be the cause of higher displacement risk of this technique when compared with cast post and cores (Hunter & Flood, 1989). An in vitro study (El-Mowafy & Milenkovic, 1994) showed that the use of dentin-bonded resin cements were efficient in reducing these displacements. The stress depends on variables such as the diameter, length and loading. Unquestionably, procedural errors during post space preparation, such as perforation, may significantly affect the overall prognosis of the case.

A clinical study (Sorensen & Martinoff, 1984) concluded that 97.7% success can be obtained by the use of a cylindrical prefabricated post. No dentin fracture was observed, so displacements were considered failures. The cylindrical prefabricated posts were analysed in an in vitro study (Thorsteinsson et al., 1992). They found that stress was the result of specific design features of the posts, as the posts generally concentrate stresses where they are in contact with the walls of the post-hole. Non-threaded posts clearly demonstrated the highest apical stresses while threaded posts concentrated stresses under the flanges and at the threads according to their specific design. A study was conducted to analyse the influence of dentinal fatigue in the anchorage area of different designs of prefabricated posts (Kahn et al., 1996), showing that there were no significant differences. The FKG system, that was used in the present investigation, has a cylindrical design. Deustsch, Cavallari & Muskant, (1985) indicated that this design promotes the lowest risk of fracture.

It was demonstrated that roots restored by individual cast posts exhibited significantly higher fracture forces than cemented posts with composite cores. In spite of a lower resistance, the technique of restoring by prefabricated posts and hybrid composite resin may be feasible because all of the fractures occurred in the composite resin core, thereby protecting the tooth structure.

Obviously a cast post-core alone is not a complete restorative technique. A total crown would be cemented over the cast post, but for this laboratory study we found this procedure to be unnecessary. Because the cervical margins of the roots were covered by the coronal portion of the cast post, a total crown effect was achieved. However, the reader should exercise caution when relating the results of this in vitro study to the clinical treatment of patients.

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**References**


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