Effect of dentinal bonded resin post-core preparations on resistance to vertical root fracture

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An in vitro study was conducted to compare the resistance to failure of two restorative protocols for endodontically treated teeth. Half of 24 specimens received cemented cast post-core restorations and the other half were restored with dentin-bonded composite resin using the ferric oxalate, NTG-GMA, and the PMDM system developed by Bowen. The dentin-bonded resin post-core restorations provided significantly less resistance to failure than the cemented custom cast post-core. The dentin-bonded resin post-core fractured in every instance before the root fractured. A greater force was required to cause failure of the resin post as the cross-sectional area of the post increased. (J PROSTHET DENT 1992;67:768-72.)

Despite efforts to reinforce endodontically treated teeth with internal posts and cores, fractures continue to occur. With recent improvements in the adherence of composite resins to dentin, true internal support may now be available.

Pulpless canals have long been used to increase the retention of full coverage restorations. Pierre Fauchard used a wooden post in the 18th century, and G. V. Black employed a screw within a gold foil canal filling in the 19th century. More recently, the post-core has been used for retention of crowns and as a reinforcement against root fracture. It has been generally accepted that the prime function of the post-core system is to provide resistance to fracture. Despite the findings of Guzy and Nicholls that no significant difference in the mean failure loads for central incisors and canines with and without posts could be demonstrated, the assumption prevails that the prime function of a post-core is tooth reinforcement. There is general agreement that prosthodontic abutments should be restored with a post-core and that almost all endodontically treated teeth should be reinforced.

Clinical procedures should minimize weakening of teeth, and techniques for placement of post-cores have been developed that minimize the internal stresses that predispose pulpless teeth to fracture. These include cast metal post-cores, pin-retained composite resin cores, and stabilizing metallic rods.

Composite resins have been studied both as material for the post-core itself and for the cementing agent. Composite resins are superior to zinc phosphate cement in tensile strength when used to cement serrated dowels. Composite resin placed in a post preparation that includes undercuts in the walls of the canal without the use of a bonding agent will fracture in the core section before it dislodges. Chapman et al. demonstrated clinically acceptable retention when cementing prefabricated posts with first-generation agents that bond to dentin, and resin-to-dentin bond strengths approximating 2000 psi have been reported. Composite resin has been studied as post-core material, as the luting agent with prefabricated posts, and most recently in a study by Trope et al. as the post material within an acid-etched post preparation. No study involving resin as both the post and core structure and as the bonding agent has been reported. This study determined whether dentin-bonded composite resin post-cores on anterior teeth would provide more resistance to vertical root fracture than cemented cast post-core restorations.

MATERIALS AND METHODS

The crowns of 24 extracted mature human maxillary anterior teeth without caries, cervical abrasion, or fracture were removed, using a low-speed diamond saw (Isomet, Buehler Ltd., Evanston, Ill.) perpendicular to the long axis at a level reaching the most incisal extension of the cementoenamel junction, following the procedure of Johnson and Sakumura. Teeth of similar length, shape, girth, and diameter were paired. Half were arbitrarily assigned to an experimental dentin-bonded composite resin group and the other half were assigned to a control (cemented casting)
group. All teeth were stored in 2% aqueous sodium azide solution before sectioning and between each manipulation.

**Endodontic procedures**

Each canal was prepared to within 1 mm of the radiographic apex. Each master apical file was three sizes larger than the initial instrument used. With the step-back technique, the canals were progressively enlarged and flared to accommodate a No. 70 file to within 6 mm of the established working length. All samples were obturated using a low-temperature injectable gutta-percha filling system (Ultrafil, Hygenic Corp., Akron, Ohio) to lessen the risk of creating internal stresses during lateral condensation and to eliminate the need for a sealer containing eugenol. Eugenol may compromise the dentin-resin bond or the polymerization of resin if it is incompletely removed from the canal. Gauze soaked in physiologic saline was used to hold the tooth during instrumentation and obturation to prevent dehydration of specimens. Post preparations were made with a No. 2 Peeso reamer (Union Broach Corp., Long Island City, N.Y.) to within 4 mm of the fill length.

**Cast post-core fabrication (control group)**

A custom cast post-core was the control because of its wide acceptance as a means of restoring endodontically treated teeth and as a method that conserves tooth structure. Resin post-core patterns (Duralay, Reliance Dental Mfg. Co., Chicago, Ill.) were obtained for 12 of the specimens. A micrometer caliper was used to prescribe the outline of a standard core. Four marks were made on the cut surfaces of the teeth 1.5 mm from the pulp chamber in lingual, mesial, and distal directions and 2 mm from the chamber in the facial direction. These marks were joined by an ovoid outline that prescribed the extent of the standard core. The patterns were sprued, invested in a phosphate-bonded material in rings without liners, and cast in Pentillium (Pentron Corp., Wallingford, Conn.). The restorations were cemented with zinc phosphate cement (Flecks, Mizzy, Inc., Clifton Forge, Va.) under digital pressure.

**Resin bonded post-core fabrication (experimental group)**

The dentin surfaces of the remaining 12 specimens were treated with an eight-step process prescribed by Bowen et al. The internal and occlusal surfaces were wet for 60 seconds with a 6.8% aqueous solution of ferric oxalate delivered with a tuberculin syringe. They were then washed with distilled water for 10 seconds with an irrigating syringe, dried with absorbent paper points, and blown with an air syringe for 10 seconds. A 10% acetone solution of NTG-GMA (the adduct of N[p-tolyl] glycine and glycidyl methacrylate) was then injected with a tuberculin syringe and allowed to stand for 60 seconds. The unbound NTG-GMA was eliminated with a 10-second bath of pure acetone. Internal and occlusal surfaces were again dried with paper points and compressed air. A 5% acetone solution of PMDM (the addition reaction product of pyromelitic dianhydride and 2-hydroxyethyl methacrylate) was then applied for 60 seconds with another tuberculin sy-
Table I. Mean failure loads

<table>
<thead>
<tr>
<th>Restorative method</th>
<th>Number of Samples</th>
<th>Failure load (N) Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cemented cast post-core</td>
<td>12</td>
<td>848 ± 334 *</td>
</tr>
<tr>
<td>Dentin-bonded resin post-core</td>
<td>12</td>
<td>280 ± 132</td>
</tr>
</tbody>
</table>

*Significant difference (Student's t test, p < 0.001).

Table II. Relation between failure load and cross-sectional area of resin posts

<table>
<thead>
<tr>
<th>Cross-sectional area (mm²) Mean ± SD</th>
<th>Failure load (N) Mean ± SD</th>
<th>Pearson correlation coefficient (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.3 ± 4.6</td>
<td>280 ± 132</td>
<td>0.82*</td>
</tr>
</tbody>
</table>

*Positive correlation for a sample size of 12 (r was significant, p < 0.05, when the two-tailed t test was used).

The mean failure loads are given in Table I. The types and numbers of failure are shown in Fig. 2. There were distinct differences in failure patterns between teeth with cemented cast post-cores and dentin-bonded resin post-cores.

Of the 12 teeth with cemented cast post-core restorations, 75% sustained vertical root fracture. Four of these fractured vertically through the mid facial section of the root, and five teeth fractured in a vertical-oblique pattern through the root, originating mid interproximal and ending in the facial mid third of the root. The three remaining teeth (25%) experienced a flexing of the casting at the post-core junction, with extrusion of the casting from the root. By inspection, these three posts had the smallest cross-sectional area at the junction of the post to the core. The mean failure load for these 12 teeth was 848 ± 334 N.

Of the 12 teeth with the dentin-bonded resin post-cores,
none had root fractures. Half of the composite resin cores exhibited cohesive fractures obliquely from the palatal aspect of the tooth-core interface, progressing incisofacially. Half of the resin cores separated cleanly from the tooth, along with a millimeter or less of the resin post. There was no visual evidence of resin tags at any of the core interfaces. The mean failure load for the dentin bonded resin group was 280 ± 132 N.

When the mean failure loads for the two groups were compared statistically using Student's t test, the difference was significant (p < 0.001).

The failure loads in the resin post-core group were compared with the cross-sectional surface of the posts at the orifice using Pearson's product-moment correlation coefficient. A positive correlation (r = +0.62) was found between the force required to cause failure and the post diameter (Table II). The results of a two-tailed Student's t test for significance of r was significant (p < 0.05). When sectioned, the teeth in the dentin-bonded resin group had densely filled resin in intimate contact with canal walls.

**DISCUSSION**

In the dentin-bonded resin group, the failure was at the core-root interface and within the core itself. Although the resin post-cores failed under less stress than the castings, the integrity of the root was preserved in every instance. The core failed before the root fractured, with the resin post-core acting as a "shear pin" under excessive loading. In the group with cemented cast post-cores, the predominant failure mode (75%) was vertical root fracture, rendering the teeth unrepairable. The mean failure load of the casting group was almost identical to that found by Guzy and Nicholls, who more nearly simulated physiologic conditions.

It was interesting to note that there was no apparent bonding between the resin core and the root truncation, possibly because of the method by which the dentin was managed. The processes of sectioning, storing in sodium azide, and endodontically treating dentin may have compromised the dentin smear layer essential for optimal dentin bonding, which could account for the lack of tag formation observed in the resin group.

A positive correlation was found between the failure load and the cross-sectional areas of the resin posts, suggesting the need for additional studies to determine which teeth (anterior/posterior; maxillary/mandibular) would be best suited for resin post-cores and at what stage of maturity the post-cores should be placed. Considering the strength that this treatment imparts to the tooth and the acceptable "shear pin" type of failure sustained, there is a strong possibility that restoring an endodontically treated tooth in this manner may be clinically indicated.

**Ferric oxalate, NTG-GMA, and PMDM experimental solutions within the pulp canal space raise questions about their effect on the periodontium and on gutta-percha. Studies by Stanley et al. and by Chohayeb et al. suggest that the protocol of Bowen et al. causes no adverse pulpal response. They surmise that insoluble products block the tubules and thereby protect the pulp externally. A similar mechanism of action may seal them from within and protect the periodontium when post spaces are being treated. Acetone plays an integral part in this protocol, but its solvent action might affect the remaining gutta-percha and subsequently jeopardize the integrity of the apical seal. This is another subject that needs to be examined.**

The steps presently required for this oxalate bonding system are numerous and cumbersome. This detailed process might be unnecessary if similar results could be obtained from simple acid etching of the canal space, as reported by Trope et al.22

**CONCLUSIONS**

An in vitro study was conducted to compare the resistance to failure of two restorative protocols for endodontically treated teeth. Half of 24 specimens received cemented cast post-core restorations and the other half were restored with dentin-bonded composite resin using the ferric oxalate, NTG-GMA, and the PMDM system developed by Bowen et al.2,3 The following conclusions were drawn:

1. The dentin-bonded resin post-core restorations provided significantly less resistance to failure than the cemented custom cast post-core.
2. The dentin-bonded resin post-core fractured in every instance before the root fractured.
3. A greater force was required to cause failure of the resin post as the cross-sectional area of the post increased.

**REFERENCES**