Influence of Different Root Canal–Filling Materials on the Mechanical Properties of Root Canal Dentin

Nicola M. Grande, DDS, Gianluca Plotino, DDS,* Luca Lavorgna, DDS,* Pietro Ioppolo,† Rossella Bedini,† Cornelis H. Pameijer, DMD, DSc, PhD,‡ and Francesco Somma, MD, DDS**

Abstract

The aims of this study were to compare Resilon (Resilon Research LLC, Madison, CT) in conjunction with either a bonding (Epiphany; Pentron Clinical Technologies, Wallingford, CT) or a nonbonding endodontic sealer (Pulp Canal Sealer; Kerr Corporation, Orange, CA) to EndoRez (Ultradent Products Inc, South Jordan, UT) and gutta-percha with regards to the physical properties and flexural stress in standardized dentin cylinders and the flexural stress of Resilon and gutta-percha. The external surface of 50 maxillary central incisors was reduced by means of mechanical milling to obtain dentin cylinders with an external diameter of 3 mm and minimum length of 12 mm. Root canals were prepared to obtain a standardized cylindrical preparation of 1.3 mm in diameter at the center of the root. The cylinders were randomly divided into five groups ($n = 10$): group 1: obturation with gutta-percha and Pulp Canal Sealer; group 2: obturation with Resilon, Epiphany primer, and Epiphany; group 3: obturation with Resilon and Pulp Canal Sealer; group 4: obturation with EndoRez methacrylate-based endodontic sealer; and group 5: dentin cylinders were not obturated. Ten gutta-percha (group 6) and Resilon (group 7) pellets for the Obtura gun were also tested. A three-point bending test was used to measure the maximum load values of specimens from groups 1 to 5 and the flexural strength and flexural modulus values for specimens from groups 6 and 7. Statistical analysis was performed to determine significance differences ($p < 0.05$). An analysis of variance test showed no significant difference among groups 1 to 5 ($p = 0.697$; $F = 0.60$). An independent sample t test showed statistically significant differences between groups 6 and 7 in flexural strength ($p = 0.000$) and flexural modulus ($p = 0.000$). Within the limits of this study, it may be concluded that the currently available endodontic-filling materials and their recommended adhesive procedures are not able to influence the mechanical properties of root canal dentin and that the flexural properties of Resilon and gutta-percha are too low to reinforce roots. *(J Endod 2007;33:859–863)*

Key Words

Filling materials, flexural properties, root reinforcement

Endodontic and restorative procedures have been suggested as precipitating factors for tooth fracture (1, 2). There is an appreciable loss of dentin when preparing an access cavity for endodontic treatment. One of the possible disadvantages of endodontic treatment is the weakening effect as a result of canal preparations (3, 4). In fact, it is generally accepted that the removal of excessive amounts of dentin compromises the survival of root-filled teeth (5, 6) and that the strength of an endodontically treated tooth is directly related to the amount of remaining sound tooth structure (4, 7, 8).

Developing materials that strengthen the root and compensate for the weakening effect of root canal preparation should be mandatory (9, 10), and a technique that supports this concept is preferable over nonreinforcing methods and materials (10). Composite resins exhibit great potential to reinforce and strengthen the remaining root (11, 12).

In recent years, a new endodontic filling material based on a thermoplastic-filled polymer composite (Resilon; Resilon Research LLC, Madison, CT) has been developed that handles and performs like gutta-percha. It is used in conjunction with a self-etching primer and a dual-cure resin-based root canal sealer, which forms a bond to the dentin walls as well as the Resilon core, commonly referred to as a "monoblock." Teixeira et al. (13) recently reported that this new polycaprolactone-based filling material may reinforce teeth, thus becoming more resistant to vertical root fracture. On the other hand, Stuart et al. (14) reported no significant differences in reinforcement of endodontically treated roots of immature teeth when Resilon, gutta-percha, and a self-curing composite resin were compared with unfilled controls. This was further substantiated by Williams et al. (15) who reported that the stiffness of Resilon and gutta-percha were too low to reinforce roots after root canal therapy.

EndoRez (Ultradent Products Inc, South Jordan, UT), a radiopaque hydrophilic auto-curing methacrylate-based endodontic sealer, has been on the market for about 7 years. Its main component is a urethane dimethacrylate (16). This root-filling system is used without a self-etching primer and achieves adhesion by means of intratubular penetration (17), which is enhanced by its hydrophilic properties (18).

The aim of this study was to compare Resilon in conjunction with either a bonding (Epiphany; Pentron Clinical Technologies, Wallingford, CT) or a nonbonding endodontic sealer (Pulp Canal Sealer; Kerr Corporation, Orange, CA) to EndoRez and gutta-percha with regards to the physical properties and flexural stress in standardized dentin cylinders. In addition, the flexural stress of the Resilon and the gutta-percha was tested. The null hypotheses were formulated as follows. There is no difference in the flexural properties of dentin cylinders filled with different root-filling materials. There is no difference in the flexural properties of Resilon and gutta-percha filling materials, and adhesive techniques have no influence on the flexural properties of dentin cylinders filled with the Resilon system.

From the *Department of Endodontics, Catholic University of Sacred Heart, Rome, Italy; †Italian National Institute of Health, Technology and Health Department, Rome, Italy; and ‡School of Dental Medicine, University of Connecticut, Farmington, Connecticut.

Address requests for reprints to Dr. Gianluca Plotino, Via Eleonora Duse, 22–00197 Rome, Italy. E-mail address: gplotino@fastwebnet.it.
0099-2399/$0 - see front matter

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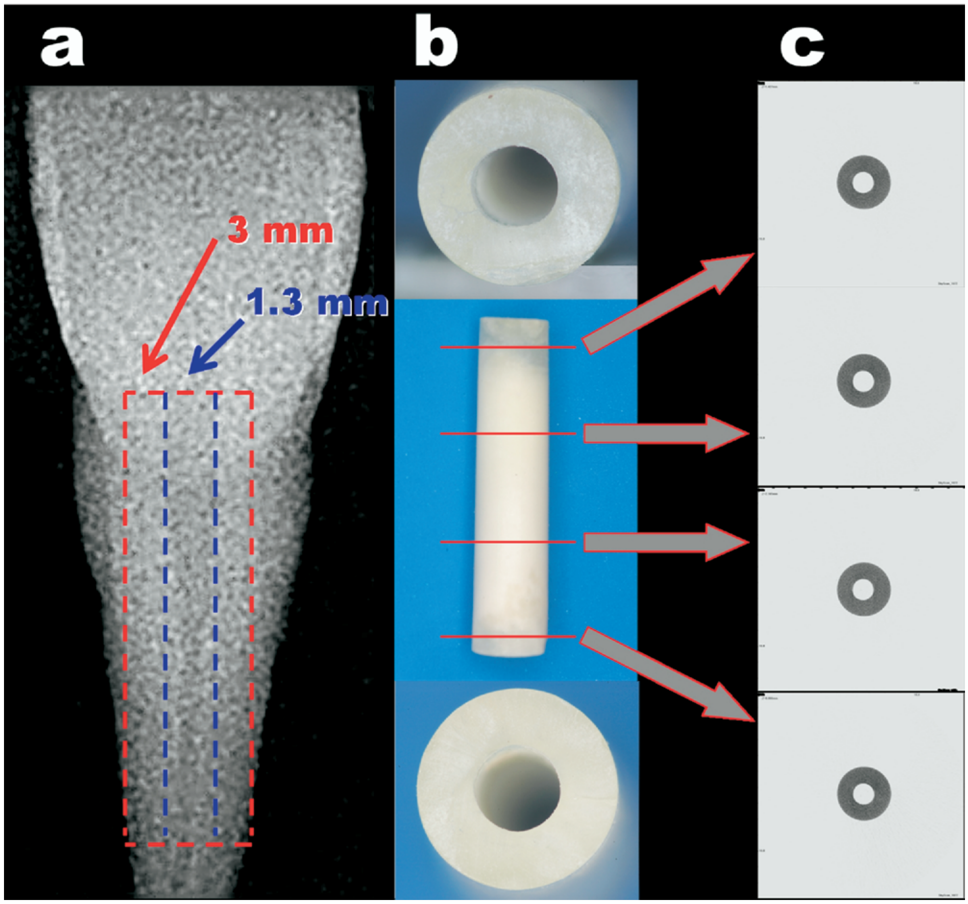

Figure 1. (a) Radiograph of a maxillary central incisor and dentin specimen dimensions, (B) dentin cylinder specimen, and (C) four cross-sections obtained by means of μCT scanning and reconstruction procedures corresponding to the different levels as showed in 1b.

Materials and Methods

Fifty sound freshly extracted completely formed human maxillary central incisors with similar root dimension and morphology were selected for this study from a pool of teeth extracted for periodontal reasons. Roots that exhibited resorption, fractures, open apices, or radiographically invisible canals were excluded from the study. After extraction, the teeth had been cleaned by immersion in 5.25% NaOCl solution for 2 hours, debrided of periodontal tissue and calculus with a scaler, washed under running water, blot dried, and stored in normal saline until used for testing.

With a diamond bur using a high-speed hand piece under water irrigation, 2 mm of the apex and the coronal enamel were removed from each tooth. After a standard access preparation, the canal was cleansed of debris by irrigation with 5 mL of 5.25% NaOCl, after which canal patency was evaluated by using a size 10 K-Flexofile (Dentsply Maillefer, Baillagues, Switzerland). Root canals were prepared by using ample water cooling with Largo burs (Dentsply Maillefer) subsequently sized 1, 2, 3, and 4 to obtain a standardized cylindrical preparation of 1.3 mm in diameter at the center of the root. During preparation, the root canals were irrigated between each successive instrument with 2.5 mL of 5.25% NaOCl.

The external surface of each root was reduced by means of mechanical milling (Vertex Machinery Works Co, Ltd Precision Machine Tool, Feng-Yuan City, Taiwan) under continuous water cooling to obtain dentin cylinders with an external diameter of 3 mm and minimum length of 12 mm (Fig. 1A, B). Milling was performed by means of a circular honing stone with fine 400 grit at a speed of 5,730 rpm.

After machining, the dentin cylinders were evaluated for cracks and defects under a stereomicroscope (Stemi SV6; Carl Zeiss S.P.A., Arese, Italy) at 30× and measured at three locations (coronal, middle, and apical) to ensure accuracy of dimensions by using an electronic caliper (Mitutoyo, Tokyo, Japan). Measurements were accurate to .01 mm. Samples that did not meet the criteria were replaced. Two specimens of each group were randomly selected to evaluate the accuracy of the cylinders by means of microcomputed tomographic (μCT) analysis (Skyscan 1072; Assing S.P.A, Aartselaar, Belgium) (Fig. 1C). Removal of the smear layer was accomplished with a final flush of 5 mL 17% EDTA solution for 2 minutes, followed by rinsing with a 5-mL saline solution. NaOCl was not used for final irrigation because it may negatively affect the bond of the sealer to the dentinal wall.

The cylinders were dried with paper points and then randomly divided into the following 5 groups of 10 samples each ($n = 10$).

Group 1: obturation with gutta-percha and Pulp Canal Sealer by thermoplasticizing the material in an Obtura II (Spartan, Fenton, MO) at a temperature of 200°C. The sealer was placed on the dentinal walls with a paper point, and the softened gutta-percha was gently condensed in layers of 2 to 3 mm by using a plugger.

Group 2: obturation with Resilon, Epiphany primer, and Epiphany Sealer. The Epiphany self-etching primer was applied with a paper point to the dentin surface for 20 seconds and then air blown for 5 seconds. A second layer of primer was applied with the same protocol to ensure adequate primer placement. Excess primer was removed with a dry paper point. Placement of the Epiphany sealer and Resilon-filling material was performed as in group 1 by thermoplasticizing the materials