Influence of Drying Protocol with Isopropyl Alcohol on the Bond Strength of Resin-based Sealers to the Root Dentin

Kléber Campioni Dias, MSc,[*] Carlos José Soares, PhD,[†] Liviu Steier, Dr med dent,[‡] Marco Aurélio Versiani, PhD,[*] Fuad Jacob Abi Rached-Júnior, PhD,[§] Jesus Djalma Pécora, PhD,[*] Yara Terezinha Correa Silva-Sousa, PhD,[§] and Manoel Damião de Sousa-Neto, PhD[*]

Abstract

Introduction: This study compared the bond strength, interfacial ultrastructure, and tag penetration of resin-based sealers applied to smear-free radicular dentin using 70% isopropyl alcohol as the active final rinse. **Methods:** Eighty root canals were prepared and assigned to 2 groups (n = 40) according to the drying protocol: paper points or 70% isopropyl alcohol. Then, roots were divided into 4 subgroups (n = 10) with respect to the sealer and obturation material: AH Plus (Dentsply De Trey GmbH, Konstanz, Germany) and gutta-percha (AH/GP), Hybrid Root SEAL (Sun Medical, Tokyo, Japan) and gutta-percha (HR/GP), Epiphany SE (Pentron Clinical Technologies, Wallingford, CT) and gutta-percha (EP/GP), and Epiphany SE and Resilon (EP/RS). Roots were sectioned, and the push-out test was performed. Failure modes were examined under stereomicroscopy and sealer penetration into the dentinal tubules under scanning electron microscopy. Data were statistically analyzed by 2-way analysis of variance post hoc Tukey tests with a significant level of 5%. **Results:** Overall, canals dried with isopropyl alcohol showed significantly higher bond strength values (2.11 $\pm$ 1.74 MPa) than with paper points (1.81 $\pm$ 1.73 MPa) ($P < .05$). The HR/GP group showed lower bond strength than the AH/GP group ($P < .05$) but higher than the EP/GP and EP/RS groups ($P < .05$). The most frequent type of failure was cohesive in the AH/GP and HR/GP groups and adhesive in the EP/GP and EP/RS groups. Scanning electron microscopic evaluation revealed better adaptation of the adhesive interface in the AH/GP and HR/GP groups in comparison with the EP/GP and EP/RS groups. **Conclusions:** A final rinse with EDTA and 70% isopropyl alcohol improved the bond strength and penetration of the sealers into dentinal tubules of the root. *(J Endod 2014;40:1454–1458)*

Key Words

Bond strength, isopropyl alcohol, push-out test, resin-based sealer, root dentin

Primary infection or infection secondary to root filling procedures is the main cause of apical periodontitis and endodontic failure. It follows that the root filling functions, such as entombment and prevention of bacterial penetration, are paramount (1). Conventional root fillings consist of a core material, usually gutta-percha or Resilon, that should be closely adapted to the canal wall and a sealer that fills voids and gaps between the core and the dentin (2). In endodontic research, epoxy resin–based sealers, such as AH Plus (Dentsply De Trey GmbH, Konstanz, Germany), are frequently used as a control material (1) because of their reduced solubility, long-term dimensional stability, and adequate microretention to dentin (3–7). However, its sealing ability remains controversial partly because AH Plus does not bond to gutta-percha (8).

Improvements in adhesive technology have fostered attempts to incorporate adhesive dentistry in endodontics by introducing methacrylate-based sealers focusing on forming a single cohesive unit between the core material, sealing agent, and root canal dentin (9). Recently, acidic resin monomers were incorporated into these sealers to render them self-adhesive to dentin substrates, aiming to reduce the application time and errors that might occur during bonding steps (9). However, sealer adhesion to dentin may be affected by the moisture condition of the root canals before filling procedures (2, 10). Thus, making smear-free dentin more wettable may improve sealer penetration (11).

According to the manufacturers, keeping the root canals in a moist state after the removal of the smear layer with EDTA is recommended to improve the dentin hybridization of methacrylate-based sealers (10). Considering that no clear instructions have been provided for achieving such an ideal degree of residual moisture (12), various chemicals, including alcohol in different concentrations (2, 11, 13–15), have been tested to improve dentinal wettability. Recent studies have shown that excessive desiccation may remove the water residing in the dentinal tubules, which may in turn hamper effective penetration of hydrophilic sealers, compromising the quality of adhesion (2, 12). Conversely, a final rinse with 70% isopropyl alcohol has shown promise to improve zinc oxide–based sealer penetration into the dentinal tubules (11), but its effect is still unclear when using resin-based sealers in the obturation procedure.

Therefore, this study aimed to compare the bond strength, interfacial ultrastructure, and tag penetration of AH Plus and 2 self-adhesive methacrylate resin–based

From the *Department of Restorative Dentistry, Dental School of Ribeirão Preto, University of São Paulo, Ribeirão Preto, Brazil; †Department of Restorative Dentistry, Dental School of Uberlândia, Federal University of Uberlândia, Uberlândia, Brazil; ‡Department of Endodontics, Warwick Dentistry, The University of Warwick, Coventry, United Kingdom; and §Department of Endodontics, School of Dentistry, University of Ribeirão Preto, Ribeirão Preto, Brazil.

Address requests for reprints to Dr Manoel Damião de Sousa-Neto, Rua Célia de Oliveira Meirelles 350, 14024-070, Ribeirão Preto, SP, Brazil. E-mail address: sousanet@forp.usp.br

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sealers (Hybrid Root SEAL; Sun Medical, Tokyo, Japan; and Epiphany SE; Pentron Clinical Technologies, Wallingford, CT) applied to smear-free radicular dentin using 70% isopropyl alcohol as the active final rinse. The null hypothesis tested was that different drying protocols of root dentin would not affect the bond strength and the penetration of dentinal tubules of different resin-based endodontic sealers.

Materials and Methods

Sample Selection

This study was approved by the local ethics committee (protocol #0086.0.138.000-09). Eighty straight single-rooted maxillary canines with fully formed apices and similar root morphology were obtained from a pool of extracted teeth and stored in 0.1% thymol solution at 5°C. The specimens were decoronated by transversally sectioning the roots at 17 mm from the apex with a double-faced diamond disc (#6911H; Brasseler Dental Products, Savannah, GA) at a low speed with air/water spray coolant. Preliminary periapical radiographs were exposed in both buccolingual and mesiodistal directions for each tooth. All teeth presenting more than 1 root canal, isthmus, resorption, calcifications, or apical curvature were excluded. Teeth not patent to the canal length with a size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) were also discarded. Within 3 months after extraction, teeth were washed under running water for 24 hours, blot dried, stored in normal saline, and transferred to a chamber maintained at 37°C and 95% relative humidity.

Root Canal Preparation

Conventional access cavities were made, and apical patency was confirmed by inserting a 10 K-file through the apical foramen before and after completion of root canal preparation. The working length (WL) was established at 1 mm from the canal length, and a single experienced operator performed all experimental procedures. The canals were prepared using a crown-down technique with hand K-files (Dentsply Maillefer) up to size 60, flushed with 2 mL 1% sodium hypochlorite between each file size, and delivered in a syringe with a 30-G needle placed 1 mm short of the WL. After preparation, the canals were irrigated with 5 mL 17% EDTA (pH = 7.7) for 5 minutes followed by a final 5-minute 5-mL rinse with bidistilled water.

Experimental Groups

The specimens were randomly assigned to 2 experimental groups ($n = 40$) according to the drying protocol. In group 1, the canals were blot dried with size 60 paper points (Dentsply Maillefer) until complete dryness of the last point was confirmed visually. In group 2, after the removal of excess normal saline with size 60 paper points, as in group 1, the canals were filled with 70% isopropyl alcohol (Pizzani Química Industrial, São José dos Campos, SP, Brazil) using a syringe with a 30-G blunt-tip needle carried to the WL. The alcohol was left in the canal for 5 seconds and immediately aspirated with a size .014 capillary tip (Ultradent, South Jordan, UT) at a low vacuum with a gentle up-and-down motion for 5 seconds. For each drying protocol, the specimens were further assigned to 4 subgroups ($n = 10$) with respect to the sealer and obturation material: AH Plus and gutta-percha (AH/GP), Hybrid Root SEAL and gutta-percha (HR/GP), Epiphany SE and gutta-percha (EP/GP), and Epiphany SE and Resilon (EP/RS).

The sealers, shown in Supplemental Table S1 (available online at www.jendodon.com) were prepared according to the manufacturer's recommendations and introduced at large amounts into the canal orifice with a Lentulo spiral (Dentsply Maillefer) rotated at 500 rpm in a clockwise direction with a slow-speed handpiece inserted up to 1 mm short of the WL. Thereafter, a prefitted size 60, 0.02 taper cone (Dentsply Maillefer) was inserted into the full WL, and nickel-titanium finger spreaders (Dentsply Maillefer) were used to conduct the lateral compaction using 3 fine-medium accessory cones (Dentsply Maillefer) per canal. A heated instrument was used to cut the coronal surplus, after which the filling was vertically compacted with a size 10 plugger (Dentsply Maillefer). The coronal root surfaces of the specimens obturated using Hybrid Root SEAL and Epiphany SE sealers were light cured (Curing Light 2500; 3M ESPE, St Paul, MN) for 20 and 40 seconds, respectively. The roots were radiographed from buccolingual and mesiodistal directions to check the length of the filling material and the presence of voids, and samples were stored (37°C and 95% humidity) for 7 days to allow the complete setting of the sealers. If voids were observed in the obturation mass, the specimen was replaced.

After this period, each root third (coronal, middle, and apical) was sectioned perpendicularly to its axis into three 1-mm-thick serial slices using a low-speed saw (Isomet 1000; Buehler, Lake Forest, IL) rotating at 300 rpm with a 75-g load with water coolant. Thus, 9 slices were obtained from each specimen, with a total of 90 sections per group. Each slice was marked on its apical side with an indelible marker.

Push-out Bond Strength Test and Failure Analysis

The first slice obtained from each root canal third was submitted to the push-out test in a universal testing machine (Instron 4444; Instron, Canton, MA), operating at a crosshead speed of 1.0 mm/min. Four-millimeter-long shafts with tip diameters of 0.4 mm, 0.6 mm, and 1.0 mm were used for the apical, middle, and coronal sections, respectively, until bond failure. The apical surface displaying the ink dot was placed facing the punch tip, ensuring that loading forces were introduced from an apical to coronal direction, to push the filling material toward the larger part of the root slice, thus avoiding any limitation to the material movement. This method ensured the alignment of the specimen in an accurate and reproducible manner, maintained the shaft centralized, and avoided its contact with the dentin when the material was pushed and dislodged from the canal wall. Bond strength data were converted to MPa by dividing the load (in kN) by the adhesion area of the filling material in millimeters squared. The adhesion area was calculated as the lateral surface area of a truncated cone using the formula $\pi(R + r)[h^2 + (R - r)^2]^{0.5}$, where π is the constant 3.14, R is the mean radius of the coronal canal, r is the mean radius of the apical canal, and h is the thickness of the slice. The widest and narrowest diameters of the filling material and the thickness of the slice were individually measured by a digital caliper with 0.001-mm accuracy (Mitutoyo Messgerate GmbH, Neuss, Germany).

The failure mode of each debonded specimen after the push-out test was assessed with a stereomicroscope (Stemi 2000-C; Zeiss, Jena, Germany) at a magnification of 25×. Failures were classified as follows:

1. Adhesive between dentin and sealer (no sealer visible on dentin walls)
2. Cohesive in sealer (dentin walls totally covered with sealer)
3. Mixed when both adhesive and cohesive failures could be observed

Scanning Electron Microscopic Analyses

The second slice from each canal third was selected and prepared for scanning electron microscopic (SEM) analysis (JSM 5410; JEOL Ltd, Tokyo, Japan), as previously described (5). The specimens were mounted to observe the dentin/filling interface regarding the presence of a hybrid layer and resin tag formation at magnifications of 50×, 500×, and 1,000×.