Sealer Penetration into Dentinal Tubules in the Presence or Absence of Smear Layer: A Confocal Laser Scanning Microscopic Study

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Abstract

Introduction: The aim of this study was to test the dentinal tubule penetration of AH26 (Dentsply DeTrey, Konstanz, Germany) and MTA Fillapex (Angelus, Londrina, PR, Brazil) in instrumented root canals obturated by using cold lateral compaction or warm vertical compaction techniques in either the presence or absence of the smear layer. **Methods:** Forty-five extracted single-rooted human mandibular premolar teeth were used. The crowns were removed, and the root canals were instrumented by using the Self-Adjusting File (ReDent-Nova, Ra'anana, Israel) with continuous sodium hypochlorite (2.6%) irrigation. Final irrigation was either with 5% EDTA or with sodium hypochlorite. The canals were dried and obturated by using rhodamine B–labeled AH26 or MTA Fillapex in combination with the cold lateral compaction or the warm vertical compaction technique. After setting, the roots were sectioned horizontally at 4-, 8-, and 12-mm distances from the apical tip. On each section, sealer penetration in the dentinal tubules was measured by using confocal laser scanning microscopy. **Results:** Regardless of the usage of EDTA, MTA Fillapex, compared with AH26, was associated with greater sealer penetration when used with the cold lateral compaction technique, and, conversely, AH26, compared with MTA Fillapex, was associated with greater sealer penetration when used with the warm vertical compaction technique ($P < .05$). Removal of the smear layer increased the penetration depth of MTA Fillapex used with the cold lateral compaction technique ($P < .05$); however, it had no significant effect on the penetration depth of AH26. **Conclusions:** Greater sealer penetration could be achieved with either the MTA Fillapex–cold lateral compaction combination or with the AH26–warm vertical compaction combination. Smear layer removal was critical for the penetration of MTA Fillapex; however, the same did not hold for AH26. *(J Endod 2014;40:1627–1631)*

Key Words

Butterfly effect, epoxy resin, lateral condensation, mineral trioxide aggregate, thermoplastic, warm gutta-percha

Endodontic treatment involves the removal of the vital and necrotic contents of the root canal through chemomechanical means followed by obturation of the prepared root canal to prevent ingress of fluids and avoid bacterial infection or regrowth. Mechanical preparation of the root canal has been traditionally performed using stainless steel hand files and, within the past 2 decades, using rotary nickel-titanium (NiTi) files. A more recent advancement has been the introduction of the Self-Adjusting File (SAF; ReDent-Nova, Ra'anana, Israel), a compressible, thin-walled lattice made from a hollow 1.5- to 2.0-mm-sized NiTi cylinder, which is assumed to provide 3-dimensional cleaning/shaping of the canal system through an oscillating mode of action (1).

Among a variety of obturation techniques, cold lateral compaction stands as a practical and reliable technique; by using this technique, root canals can be filled effectively without sophisticated armamentarium, and length control can be successfully managed during compaction (2). On the other hand, warm gutta-percha (thermoplasticizing) techniques involve softening of the gutta-percha by using a heat source followed by either compacting inside or injecting into the canal of the softened gutta-percha material. Warm vertical compaction, an example of a thermoplasticizing technique, allows placement of a greater mass of gutta-percha in the canal, allowing for irregularities and accessory canals to be better filled compared with the cold lateral compaction technique (3, 4).

Root canal sealers vary in composition and are used in conjunction with core filling materials (eg, gutta-percha cones) in order to fill the voids or irregularities in the root canal and to fill the space between the gutta-percha cones and between the core material and the dentinal wall. AH26 (Dentsply DeTrey, Konstanz, Germany) is a widely used epoxy resin–based sealer and possesses positive handling characteristics and superior physical properties (1). MTA Fillapex (Angelus, Londrina, PR, Brazil) is a new calcium silicate–based sealer containing mineral trioxide aggregate (MTA), salicylate resin, natural resin, bismuth oxide, and silica. The formulation is intended to benefit the advantages of MTA, a material known to possess favorable biocompatibility, antimicrobial activity, and good sealing ability (5).

The smear layer is the organic and inorganic debris that forms after cavity preparation or root canal instrumentation and coats the dentin and clogs the orifice of the dentinal tubules (6). Theoretically, this layer is assumed to prevent the penetration of

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disinfectants and root canal sealers into the dentinal tubules; therefore, its removal, by using agents such as EDTA, should be preferred for better adaptation of sealers. However, the corresponding literature presents conflicting results on the benefits of smear layer removal and sealer adaptation and microleakage (6–8). The aim of this study was to test the dentinal tubule penetration of the sealers AH26 and MTA Fillapex in instrumented root canals obturated by using the cold lateral compaction and warm vertical compaction technique, either in the presence or absence of the smear layer.

Materials and Methods

Preparation of the Teeth

Forty-five extracted single-rooted human mandibular premolar teeth were used in the study. After extraction, all teeth were stored in physiological saline solution until use.

The crowns were removed at the cementoenamel junction with a high-speed fissure bur under water cooling. A #10 K-file was introduced into the canal and advanced until it was just visible at the apex and then retracted 1 mm to establish the working length. A glide path was verified or established using K-files #10 to 25. A 1.5-mm SAF file mounted on a vibrating handpiece head (RDT3-NX, ReDent-Nova; 5,000 vibrations/min, 0.4-mm vibration amplitude) was operated in each canal for 4 minutes with continuous sodium hypochlorite irrigation (NaOCl, 2.6%) delivered through the hollow file. The irrigant was provided by a VATEA irrigation pump (ReDent-Nova) at a volume of 5 mL/min. An in-and-out manual motion was continuously performed by the operator.

Experimental Design

Five of the roots were reserved as controls without doing any further application. Then, root canals of half of the remaining teeth (20/40) were irrigated with 2 mL 5% EDTA (Wizard; Rehber Kimya, Ankara, Turkey; pH = 7.4) for 3 minutes in order to remove the smear layer. A final rinse was performed by irrigating with 1 mL 2.6% NaOCl for 1 minute. This protocol was found to remove the smear layer substantially in scanning electron microscopy analyses (JSM 6060LV; JEOL, Tokyo, Japan; Fig. 1*A* and *B*). The canals were then dried with paper points.

Root canals irrigated with or without the use of EDTA were randomly divided into 4 subgroups of 5 roots each and obturated either with MTA Fillapex or with AH26. Both sealers were mixed according to the manufacturers' instructions. However, in order to allow for analysis under confocal laser scanning microscopy, each sealer was fluorescent labeled by adding rhodamine B (Alfa Aesar, Karlsruhe, Germany) at an approximate ratio of 0.1% (weight). The sealer was delivered to the canal by using a #25 finger spreader. The roots were further divided into 2 subgroups; 1 group was filled with the cold lateral compaction technique and the other with the warm vertical compaction technique. In the cold lateral compaction group, a #25 master gutta-percha cone (DiaDent-Dentplus, Seoul, South Korea) was inserted into the root canal, a finger spreader was inserted 2–3 mm short of the working length, and accessory cones (0.02 taper) were placed until the entire length of the root canal was filled. In the warm vertical compaction group, a #25 master gutta-percha cone was placed into the root canal, and then the tip of the activated heat carrier of System B (Model 1005; Analytic Technology, Redmond, WA) was inserted until 5–6 mm short of the working length, the coronal gutta-percha was removed, and the apical part of the gutta-percha was condensed by using a finger plugger. Backfilling of the rest of the canal space was achieved by injecting warm gutta-percha using the Obtura II system (Obtura Corporation, Fenton, UK), each time injecting 2- to 3-mm segments and vertically condensing with a hand plugger. Excess gutta-percha in all teeth was cut using the activated tip of System B at 1-mm depth below the canal orifice. Radiographs were taken from buccal and mesial aspects to verify the quality of the root canal fillings, and then the access cavities were sealed with glass ionomer cement (Kavitan Plus; Spofa Dental, Prague, Czech Republic). The specimens were kept in an incubator at 37°C and 100% humidity for 2 days.

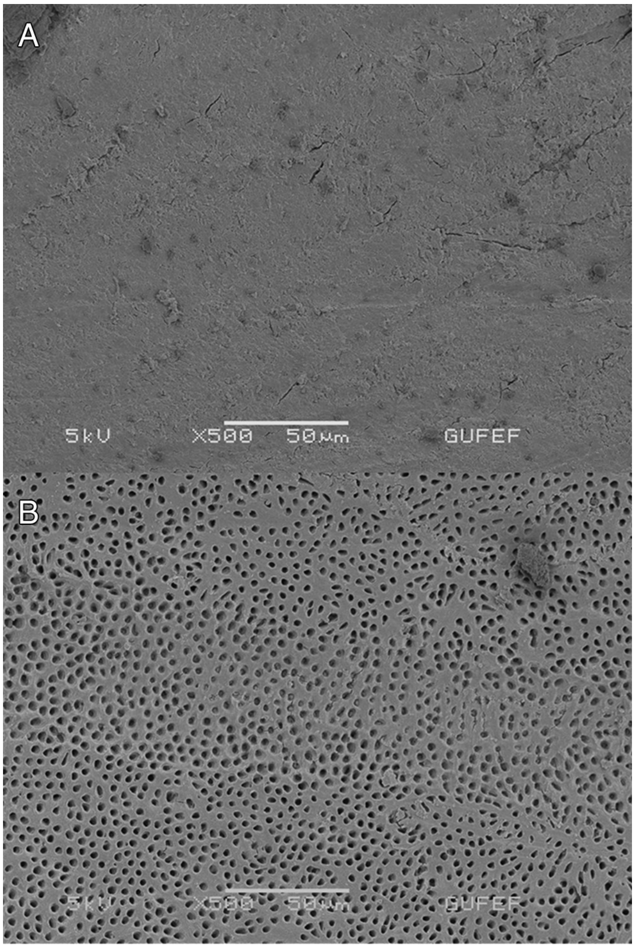

Figure 1. Scanning electron microscopic photographs showing that irrigating with 5% EDTA solution substantially removed the smear layer. (*A*) The control surface (instrumented and irrigated with NaOCl only) and (*B*) instrumented and EDTA-treated surface. Scale bars = 50 μm. Magnification $\times$500.

In summary, the study included 8 experimental groups denoted by letters from A–H and depicted as follows where each group received specific applications (n = 5):

1. *Group A:* EDTA/NaOCl treated and filled with AH26 using the cold lateral compaction technique
2. *Group B:* EDTA/NaOCl treated and filled with MTA Fillapex using the cold lateral compaction technique
3. *Group C:* EDTA/NaOCl treated and filled with AH26 using the warm vertical compaction technique
4. *Group D:* EDTA/NaOCl treated and filled with MTA Fillapex using the warm vertical compaction technique
5. *Group E:* NaOCl treated and filled with AH26 using the cold lateral compaction technique
6. *Group F:* NaOCl treated and filled with MTA Fillapex using the cold lateral compaction technique
7. *Group G:* NaOCl treated and filled with AH26 using the warm vertical compaction technique
8. *Group H:* NaOCl treated and filled with MTA Fillapex using the warm vertical compaction technique