Qualitative Analysis of the Removal of the Smear Layer in the Apical Third of Curved Roots: Conventional Irrigation versus Activation Systems

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Abstract

Introduction: The aim of this study was to evaluate the effectiveness of different irrigant agitation techniques on smear layer removal in curved root canals. Methods: Mesiobuccal canals of 62 extracted lower molars with a curvature of 33 degrees were used and instrumented up to ProTaper F2. The samples were divided into 3 experimental groups according to the final irrigation: conventional irrigation, ultrasonic irrigation, and sonic irrigation by using the EndoActivator system. The control group was composed of 2 specimens without any final irrigation. In all of the experimental groups, 5 mL of 17% ethylenediaminetetraacetic acid was used for 1 minute, and 5 mL of 2.5% NaOCl was used for 30 seconds. The analysis of the apical region was performed via scanning electron microscopy by 3 examiners. The data were submitted to the Kruskal-Wallis and Dunn tests (P < .05). Results: The activation systems removed significantly more smear layer than did conventional irrigation. Conclusions: Sonic and ultrasonic irrigation resulted in better removal of the smear layer in the apical third of curved root canals than did conventional irrigation. (J Endod 2011;37:1268–1271)

Key Words

Irrigation, root canal, smear layer

Materials and Methods

This study involved 62 mesiobuccal canals of extracted lower molars with a similar mean root canal curvature of 33 degrees as determined by the method of Schneider (19), completely formed apexes, and no previous endodontic treatment.

The working length (WL) was performed by using a #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland), which was introduced less than 1 mm from the foramen. The roots were sealed with C-Silicone impression material (Clonage, DFL, Rio de Janeiro, Brazil) to avoid apical extrusion during irrigation. Root canals that allowed the introduction of an instrument exceeding ISO size 20 to the apical foramen were not used.

The canals were instrumented according to Machado et al (20) with Gates Glidden 1, 2, and 3 drills and the ProTaper (Dentsply Maillefer) rotary system up to the F2 file. After each instrument was used, the canals were flushed with 2 mL of 2.5% NaOCl (Fórmula e Ação, São Paulo, Brazil). At the end of the procedure, the canals were flushed with 6 mL of 2.5% NaOCl by using a syringe and a 30-gauge needle (NaviTips; Ultradent Products, South Jordan, UT).
The specimens were divided into 3 experimental groups (n = 20). In all of the groups, a final irrigation with 5 mL of 17% EDTA (Fórmula e Ação) and 5 mL of 2.5% NaOCl was performed by using a disposable syringe with a 30-gauge needle to within 2 mm of the WL.

**Conventional Irrigation Group**

The canal was flushed with 2.5 mL of 17% EDTA, the solution was left in place for 60 seconds with no agitation, and the canal was flushed again with 2.5 mL of 17% EDTA. After aspiration, the canal was flushed with 2.5 mL of 2.5% NaOCl, which was left in place for 30 seconds and then flushed with 2.5 mL of 2.5% NaOCl.

**Ultrasonic Group**

The canal was flushed with 2.5 mL of 17% EDTA, followed by ultrasonic activation (P5 Satelec; Dentsply) at a power setting of 3, with a stainless steel K-type file, size 15, inserted 2 mm short of the WL for 60 seconds, and then flushed with 2.5 mL of 17% EDTA. After aspiration, the canal was flushed with 2.5 mL of 2.5% NaOCl with similar activation for 30 seconds, followed by flushing with 2.5 mL of 2.5% NaOCl.

**Sonic Group**

Irrigation was carried out with a similar protocol as in ultrasonic group but with sonic activation (EndoActivator) by using a yellow tip #15/0.02 at a speed of 10,000 rpm according to the manufacturer’s instructions (17).

The control group was composed of 2 specimens without any irrigation after instrumentation.

The root canals were dried with paper points. A diamond disk was used to make a horizontal groove between the apical third and the middle third as well as a longitudinal groove in a buccolingual direction. Colored gutta-percha cones were fitted and used as markers to best gauge the groove depths and to avoid the intrusion of the cutting disk into the canals (10). The apical third was separated by applying slight pressure with a chisel in the horizontal groove. Subsequently, the apical third of the mesial roots was split longitudinally.

The samples were fixed in 2% glutaraldehyde, dehydrated by immersion in a graded ethanol series, coated with gold, and observed with a scanning electron microscope (JSM 5900; JEOL, Tokyo, Japan) at 25 kV. Each fragment was viewed at low magnification (×25) for a total view of the mesiobuccal canal and centered on the screen; the magnification was then adjusted to ×1000, and photographs were taken for analysis.

The images were analyzed by 3 previously calibrated examiners according to the scoring system proposed by Torabinejad et al (5): 0, no smear layer, 1, smear layer on the root canal surface, with all the tubules clean and open; 2, moderate smear layer; 3, heavy smear layer, smear layer covers the root canal surface and the tubules. The examiners were blinded to the group membership of the specimens. In case of disagreement between the examiners for a particular image, a consensus agreement was to be used.

The data obtained were analyzed with the kappa test to determine concordance among the examiners. Kruskal-Wallis and Dunn tests were used to compare the groups at 5% level of significance.

**Results**

The kappa test results showed good interexaminer agreement, with values ≥0.6 for the various categories.

The results of smear layer scores as a percentage distribution of each group are shown in Figure 1.

![Figure 1](image-url)
The EndoActivator was selected in the present study because it is a recently introduced sonic irrigation system. Whereas the insert in the ultrasound system is made of metal alloys, EndoActivator has polymer-based tips (17) that do not damage the canal wall (25). Moreover, the high frequency generated by ultrasound can result in the greater extrusion of debris (26).

There is no consensus with respect to the optimal volume (7, 9, 27, 28), time of application (4), or the activation method of irrigating solutions (4, 22). In this study, the use of final irrigation with 17% EDTA (5 mL) and 2.5% NaOCl (5 mL) divided into 2 steps and with activation between the 2 steps could have provided better cleaning results because of the removal of the remaining debris.

None of the protocols tested in this study showed 100% removal of the smear layer. These results reflect the difficulty associated with cleaning the apical third of curved root canals, in agreement with the literature (3–7, 24, 29, 30).

Although the scoring method involved qualitative analysis, the use of a simple and direct scoring system, as proposed by Torabinejad et al (5), by multiple calibrated examiners with concordance between them (kappa test), as well as the large number of observations made in the present study, clearly increase the reliability of the results (4, 15).

Regarding the importance of the canal taper in curved canals, Khademi et al (31) observed that the total removal of the smear layer occurred only in preparations with an apical diameter of at least 0.30 mm. The last file used for the preparation in the present study was F2 of the ProTaper system by using the technique described by Machado et al (20). This appears to be adequate for hydrodynamic flow without weakening of the walls.

Within the limitations of this study, it can be concluded that the irrigation of curved root canals by using sonic activation or ultrasonic systems appears to be more efficacious in the removal of the smear layer than that using conventional methods.

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The authors deny any conflicts of interest related to this study.

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