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

Luciana Magrin Blank-Gonçalves, DDS, MDSc, Cleber Keiti Nabeshima, DDS, Guilherme Henrique Rosa Martins, DDS, MDSc, and Manoel Eduardo de Lima Machado, DDS, MDSc, PhD

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

From the Department of Restorative Dentistry, School of Dentistry, University of São Paulo, São Paulo, São Paulo, Brazil.

Address requests for reprints to Dr Manoel Eduardo de Lima Machado, Av. Prof. Lineu Prestes, 2227, Cidade Universitária, 05508-000 São Paulo, SP, Brazil. E-mail address: professormachado@hotmail.com

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The biomechanical instrumentation of the root canal produces a smear layer containing dentin debris, organic remains such as pulp tissue, odontoblastic processes, necrotic debris, and microorganisms and their metabolic products (1).

The irrigation of the root canal is an essential procedure in the endodontic treatment for the removal of the smear layer. Currently, a final irrigation with chemicals such as ethylenediaminetetraacetic acid (EDTA) and sodium hypochlorite (NaOCl) is recommended to remove the inorganic and organic components of the smear layer (2–4). Syringe irrigation is the standard procedure, although it is ineffective in the apical part of the root canal (3–7). However, other systems have been suggested (8), and the activation of the irrigant should be considered because it results in cleaner areas when compared with conventional irrigation (9–11), increases tissue dissolution (12), and significantly reduces the number of bacteria present inside the root canal system (13, 14).

This study focused on passive ultrasonic irrigation (PUI) and sonic systems (8, 11, 12, 15, 16). Ultrasound systems such as Satelec are based on low-amplitude and high-frequency vibrations transmitted along the instrument. The sonic system has high-amplitude but low-frequency vibrations, represented mainly by EndoActivator (Dentsply, Tulsa, OK) (17).

When these systems are compared with conventional techniques, they show better results in the removal of the smear layer from the canal walls (4, 15). However, it should be noted that the samples used for these evaluations have been straight canals (15, 16). Therefore, there is lingering doubt regarding the performance of these systems in curved canals.

The greatest difficulty in endodontic instrumentation involves the apical third of the canal. Studies demonstrating the removal of the smear layer in this area showed remaining debris with both conventional and activated irrigation techniques (6, 7, 9, 11, 18).

The purpose of this study was to evaluate the effectiveness of different irrigant agitation techniques on smear layer removal in curved root canals.

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, no smear layer on the root canal surface, with all the tubules clean and open;1, moderate smear layer;2, 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.

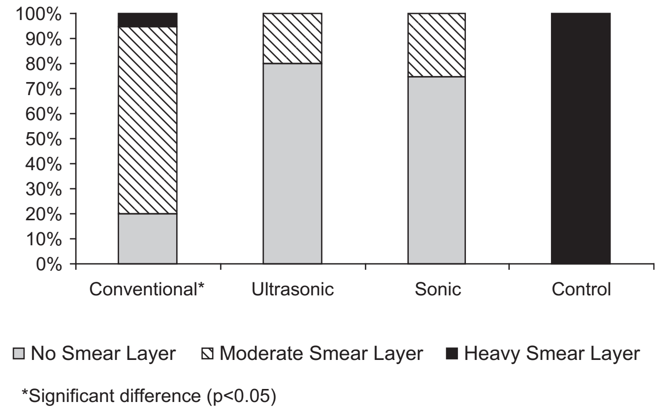

Figure 1. Comparison between groups according to smear layer on the dentinal surface.

In the control group, a thick smear layer covering the entire surface was observed, and there was a lack of open dentinal tubules (Fig. 2*A*).

Conventional irrigation showed more samples with a moderate smear layer (Fig. 2*B*), whereas the sonic and ultrasonic groups showed more samples with clean and open dentinal tubules (Fig. 2*C* and *D*).

A comparison of the groups showed a significant difference between the groups with activation (ultrasonic or sonic) and the conventional irrigation group (P = .0007), but there was no significant difference between the ultrasonic and sonic activation groups.

Discussion

The most commonly used irrigant in endodontics is sodium hypochlorite because it has bactericidal properties and causes tissue dissolution (12, 21). Among other substances used for this purpose, EDTA has been superior in the removal of the smear layer in comparison with other substances in the final irrigation (2, 3, 15, 22, 23), justifying its use in the present study.

In this study, the results showed that PUI and sonic activation removed more smear layer than did conventional irrigation, which is in agreement with the pertinent literature and reaffirms the advantages of the ultrasonic (4, 15) and sonic activation methods (10).

The cleaning found in the activated groups was satisfactory (80% ultrasonic group, 75% sonic group), which can be attributed to the vibration produced by the activating systems. However, the large volume of irrigating solution and the adequate taper of the preparation, which allowed hydrodynamic flow, also contributed to the findings. The differences between the systems with respect to frequency and amplitude were not determinants in the removal of the smear layer.

The results are in contrast to other studies, in which methodologic differences can be pointed out. Chopra et al (22) used wide and straight root canals, whereas Uroz-Torres et al (7) chose to use a reduced volume of EDTA. Recently, Rödig et al (24) found that sonic and ultrasonic systems improved smear layer removal only in the straight coronal portion of curved root canals. The use of the #15/0.02 yellow tip was selected to match the tip used in ultrasonic activation, which differed from that used by Rödig et al, who chose the #25/0.04 tip. A smaller insert allowed free movement in the apical region, with a consequent increase in hydrodynamic flow. In the present study, the tip and the activation time used were the same as the proposed protocol for the sonic system used for comparison because there is no defined standard protocol for ultrasonic activation (17). Therefore, it is important to emphasize the need for a standard ultrasonic irrigation protocol to allow future comparisons.

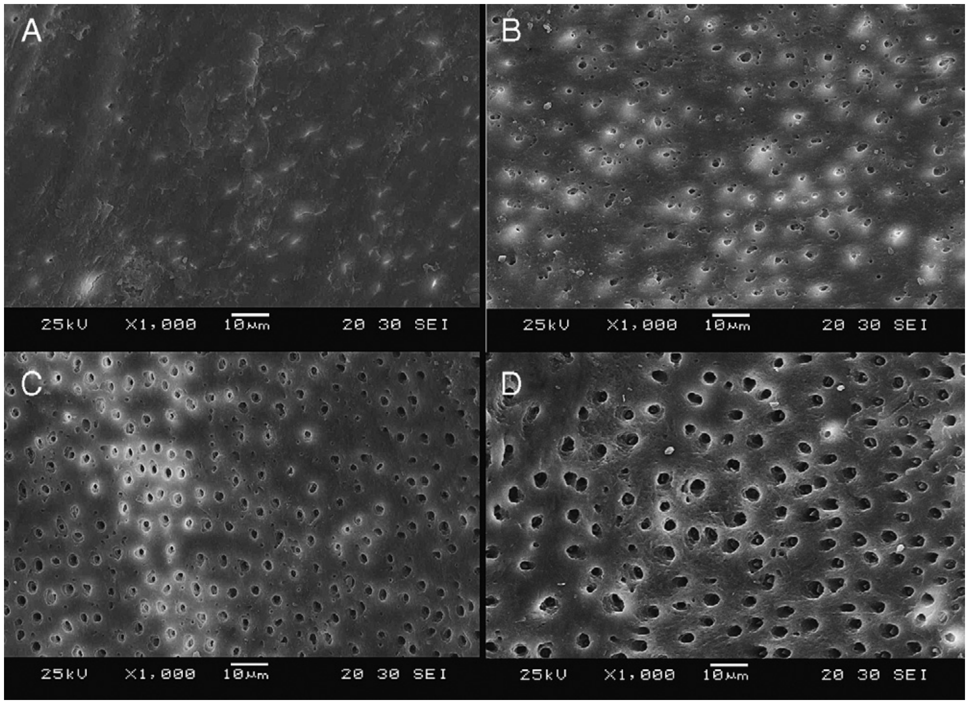

Figure 2. (*A*) Control group, heavy smear layer (score 2); (*B*) conventional irrigation group, moderate smear layer (score 1); (*C*) ultrasonic activation group, no smear layer (score 0); (*D*) sonic activation group, no smear layer (score 0).

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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