Evaluation of a Sonic Device Designed to Activate Irrigant in the Root Canal

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Abstract

Introduction: The aims of this study were to evaluate the removal of dentin debris from the root canal by sonic or ultrasonic activation of the irrigant and the physical mechanisms of sonic activation by visualizing the oscillations of the sonic tip, both inside and outside the confinement of the root canal. **Methods:** Roots of 18 canines were embedded, split, and prepared into standardized root canals. A standard groove was cut on the wall of one half of each root canal and filled with the same amount of dentin debris before irrigation procedures. The removal of dentin debris was evaluated after different irrigation procedures. The oscillations of the sonic tip were visualized *ex vivo* by using high-speed imaging at a time scale relevant to the irrigation process, and the oscillation amplitude of the tip was determined under 20× magnification. **Results:** After irrigation, there was a statistically significant difference between the experimental groups ($P < .0001$). Without irrigant activation, the grooves were still full of dentin debris. From the ultrasonic activated group, 89% of the canals were completely free of dentin debris, whereas from the sonic group, 5.5%–6.7% were ($P = .0001$). There was no significant difference between the sonic activation groups. **Conclusions:** Activation of the irrigant resulted in significantly more dentin debris removal; ultrasonic activation was significantly more efficient than sonic activation. The oscillation amplitude of the sonically driven tips is 1.2 ± 0.1 mm, resulting in much wall contact and no cavitation of the irrigant. *(J Endod 2010;36:143–146)*

Key Words

Activation, irrigation, root canal, sonic, ultrasonic

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Irrigation of the root canal space is a fundamental aspect of root canal treatment. Techniques for acoustic and hydrodynamic activation of the irrigant have been developed (1–3), because syringe irrigation is not effective in the apical part of the root canal (4, 5).

It has been shown that acoustic streaming and cavitation contribute to the cleaning efficiency of root canal irrigation (2, 3, 6). Acoustic streaming can be defined as a rapid movement of fluid in a circular or vortex-like motion around a vibrating file (7). Cavitation can be defined as the creation of vapor bubbles or the expansion, contraction, and/or distortion of preexisting bubbles (so-called cavitation nuclei) in a liquid; the process is coupled to acoustic energy (8). Studies have shown that passive sonic activation of irrigant is inferior to its counterpart in ultrasonic (9, 10). However, the details concerning those mechanisms have not been clarified.

The EndoActivator system (Advanced Endodontics, Santa Barbara, CA), a sonic device, has recently been developed for root canal irrigation. Special polymer tips can be driven sonically at 3 different frequencies to activate the irrigant. No data are currently available to support its use.

The aims of this study were (1) to determine the removal of dentin debris from the root canal by sonic or ultrasonic activation of the irrigant and (2) to evaluate the physical mechanisms of sonic activation by visualizing the oscillation amplitude of EndoActivator tips.

Materials and Methods

High-speed Imaging Experiments

An optical set-up was constructed to visualize the effect of sonic activation in a glass model of the root canal containing water. The canal was 10 mm in length, with an apical diameter of 0.30 mm and a taper of approximately 0.06. Imaging was performed by using a high-speed camera (Shimadzu Corp, Kyoto, Japan) at a frame rate of 4000 frames per second. From these recordings the oscillation amplitude of the tip was measured by using a calibrated reference grid (Edmund Optics, Barrington, NJ)

A microscope with 1.25–20× magnification was used (BX-FM; Olympus, Tokyo, Japan) for magnification. The root canal was illuminated in bright-field by a continuous wave light source (ILP-1; Olympus).

Dentin Debris Removal Model

Straight roots from 18 extracted human maxillary canines were decoronated to obtain uniform root sections of 15 mm. The roots were embedded in self-curing resin (GC Ostron 100; GC Europe, Leuven, Belgium) and then bisected longitudinally through the canal in mesiodistal direction with a saw microtome (Leica Microsystems SP1600, Wetzlar, Germany). The surfaces of both halves were ground successively with 240-, P400-, and 600-grit sandpaper, resulting in smooth surfaces on which only little of the original root canal lumen was left. Four holes were drilled in the resin part, and the 2 halves could be reassembled by 4 self-tapping bolts through the holes (Fig. 1*A*).

New root canals were prepared by K-files #15/.02 (Dentsply Maillefer, Ballaigues, Switzerland) and HERO 642 (MicroMega, Besançon, France) nickel-titanium rotary instruments to a working length (WL) of 15 mm, ISO size 30, and taper 0.06, resulting in standardized root canals. During preparation, the canals were rinsed with 1 mL of 2% NaOCl after each file and delivered by a 10-mL syringe (Terumo, Leuven, Belgium) and a 30-gauge needle (Navitip; Ultradent, South Jordan, UT).

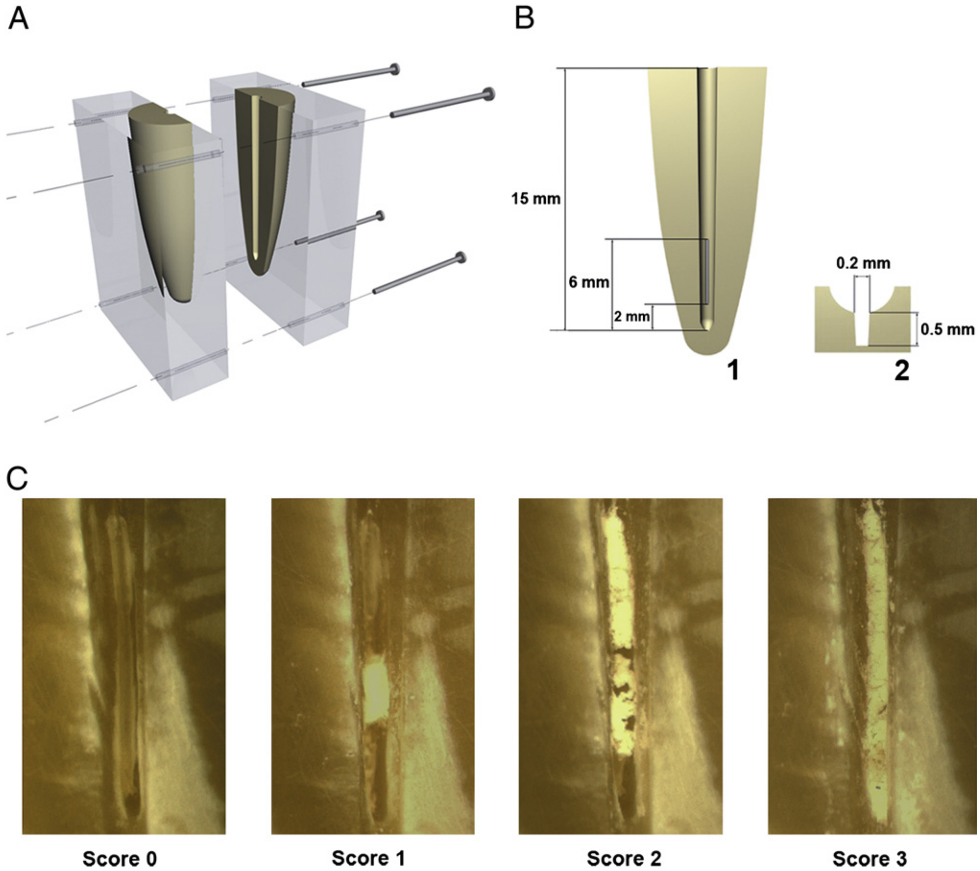

Figure 1. (*A*) Schematic representations of the standardized root canal model, its groove (*B-1*) and cross section (*B-2*). (*C*) Examples of the different score scales.

A standard groove of 4 mm in length, 0.5 mm deep, and 0.2 mm wide, situated at 2–6 mm from WL (11) (Fig. 1*B-1, B-2*), was cut in the wall of one half of each root canal with a customized ultrasonic tip. A periodontal probe with an adapted 0.2-mm-wide tip was used to verify the dimension of each groove during and after preparation. The dimension of the groove is comparable to an apical oval root canal (12). Each groove was filled with dentin debris, which was mixed with 2% NaOCl for 5 minutes, to simulate a situation in which dentin debris accumulates in uninstrumented canal extensions (11). This model was introduced to standardize the root canal space and the amount of dentin debris present in the root canal before the irrigation procedure, to increase the reliability of the dentin debris removal evaluation. The methodology is sensitive, and the data are reproducible (13). A pilot study has shown that a single model could be reused up to at least 8 times without any visible defect on the surface of the canal wall. Therefore, the 18 models were used repeatedly in the 6 experimental groups, which are the ultrasonic activated group, sonic activated groups by different frequencies or tips or irrigants, and control group (Table 1).

Irrigation Procedure

Specimens in all the experimental groups were rinsed with 2 mL irrigant (2% NaOCl or water) by using 10-mL syringes with 30-gauge needles placed 1 mm from WL. Then the residue of irrigant was passively activated for 20 seconds sonically or ultrasonically. In group 6, the sonic tip was inserted but not activated. Passive activation meant that every attempt was made to keep the file centered in the canal to minimize contact with the canal walls. This sequence was repeated twice, resulting in a total irrigation volume of 6 mL and a total irrigation time of 1 minute.

The ultrasonic activation was performed with a stainless steel #20/.00 file (IrriSafe; Satelec Acteon, Merignac, France) energized by a piezoelectronic unit (Suprasson PMax; Satelec Acteon) at power setting "blue" 4. The sonic activation was performed with the EndoActivator system.

TABLE 1. Experimental Groups and Number of Specimens at Each Score Rank after Irrigation Procedure

					Score			
Group (n = 18)	Activation system	Frequency (Hz)	Size/taper	Irrigant	0	1	2	3
1	Ultrasonic	30,000	#20/.00	NaOCl	16 (90%)	1 (5%)	1 (5%)	0 (0%)
2	Sonic	190	#15/.02	NaOCl	3 (17%)	4 (22%)	9 (50%)	2 (11%)
3	Sonic	190	#25/.04	NaOCl	3 (17%)	6 (33%)	0 (0%)	9 (50%)
4	Sonic	160	#15/.02	NaOCl	1 (5%)	2 (11%)	12 (67%)	3 (17%)
5	Sonic	190	#15/.02	Water	0 (0%)	5 (28%)	12 (67%)	1 (5%)
6 (control)	No activation	0	#15/.02	NaOCl	0 (0%)	0 (0%)	0 (0%)	18 (100%)

Score 0, the groove is empty; score 1, less than half of the groove is filled with debris; score 2, more than half of the groove is filled with debris; score 3, the complete groove is filled with debris.