A quantitative and qualitative analysis of ultrasonic versus sonic endodontic systems on canal cleanliness and obturation

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Objective. The purpose of this study was to compare 2 irrigation techniques by evaluating canal cleanliness and obturation of lateral/accessory canals.
Study design. Seventy-five extracted canines were instrumented to a size #40/0.06 taper. The EndoActivator (EA) was compared with an ultrasonic unit for final irrigation. Each unit was used for 1 minute each with 6.15% NaOCl and 17% EDTA. A control group received syringe irrigation. Thirty teeth were sectioned and evaluated for debris removal and open dentinal tubules at 3/5 mm from the apical foramen with a scanning electron microscope. Forty-five teeth were examined for obturation of lateral canals.
Results. The EA was significantly better in removing debris at all levels when compared with other treatment groups ($P < .05$) and resulted in obturation of significantly more numbers of lateral canals ($P < .01$.)
Conclusions. The EA provided better obturation of lateral and accessory canals and resulted in less remaining debris.
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The complexity of the canal anatomy makes it very difficult to efficiently clean and seal all ramifications of the root canal system. Different devices and techniques have been proposed to improve canal cleanliness. Proper chemo-mechanical debridement is an important predictor of endodontic success.

Sodium hypochlorite (NaOCl) is used as an irrigating solution in endodontics because it interferes with cellular metabolism, inactivates bacterial enzymes, and causes lipid and fatty acid degradation.[1] Possibly the most important property is its ability to digest vital and necrotic pulp tissue.[2] When NaOCl is used as an intracanal irrigant, a mixture of organic and inorganic material is left coating canal walls up to 2 μm thick, and packed up to 40 μm deep into the dentinal tubules.[3] Ethylenediaminetetraacetic acid (EDTA) is a chelator used in endodontics to eliminate the smear layer by reacting with calcium in hydroxyapatite and removing it from dentin.[4] The combination of NaOCl and EDTA used alternately removes the smear layer from the instrumented root canal surfaces and pulpal remnants from the uninstrumented surfaces.[5,6]

Ultrasonic (US) activation increases the efficacy of irrigation solutions in removing organic and inorganic debris from root canal walls.[7] An irrigant activated with ultrasonic vibration is directly associated with effective cleaning of the root canal space.[8] Files activated ultrasonically produced streaming patterns close to the file, continuously moving irrigants around. This produces shear stress, which can damage biological cells and disrupt debris.[9] One minute of ultrasonic irrigation with NaOCl significantly reduced the count of colony-forming units and is 7 times more likely to yield negative cultures than hand or rotary instrumentation alone.[10] Separation of the ultrasonic files can be a concern during this phase of the root canal treatment.

The oscillation of an endosonic file produces the greatest displacement at the unconstrained tip.[9] Ahmad et al.[11] found that root canals need to be enlarged to a size #40 to allow free oscillation of a #15 file, although it was found that the imposition of file-wall contact did inhibit the production of transient cavitation.[12] While negotiating the apical third of a curved root canal, the oscillating tip is more susceptible to constraint. This explains occasional inefficiency of the ultrasonic device, especially in the apical third of curved canals.[9] According to Vertucci,[13] 30% of canines have lateral canals. Most are found in the apical third where the ultrasonic tip is less effective.

Ultrasonic devices operate at a higher frequency (25-40 kHz) than that of sonics (2-3 kHz). Lower

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frequency produces lower shear stresses, which cause less modification to the tooth surface. The EndoActivator (EA; Advanced Endodontics, Santa Barbara, CA) system safely cleans the canal system, including lateral canals, fins, and apical deltas by energizing the root canal irrigants with a flexible, noncutting polymer tip.[2] In a fluorescence microscopy study assessing the efficiency of irrigant activation in the apical third of curved canals, Paragliola et al.[14] concluded that final activation of irrigants after mechanical preparation improves debridement of the root canal systems.

The EA is recommended to enhance debridement and promote the disruption of the smear layer and biofilm.[2] The irregular agitation of the solution creates an effective scrubbing and cleaning mechanism. However, despite clinicians' greatest efforts to clean the canal system, some surfaces may still remain untouched.[15]

The purpose of this study was twofold: (1) to analyze canal cleanliness by the use of scanning electron microscopy (SEM) and (2) to evaluate the efficacy of sonic and ultrasonic instruments on the obturation of lateral canals.

MATERIAL AND METHODS

Canal preparation

Seventy-five extracted human maxillary canines were sterilized and decoronated using a diamond disk with the NSK Z500 brushless motor (Brasseler USA, Savannah, GA). The canals were located with a #10 stainless steel Flex-o-file (Dentsply Maillefer, Tulsa, OK). Once patency was confirmed, the coronal portion of the canal was flared with #2 through #4 Gates Glidden burs (Dentsply Maillefer). Working length was determined by placing a size 10 file into the canal until visualized at the apex, and subtracting 1 mm from this measurement. Canals were instrumented with EndoSequence files (Brasseler USA) using a crown-down technique. The canals were enlarged to an apical size of 40/0.06. NaOCl 6.15% (Clorox, The Clorox Co., Oakland, CA) was used for irrigation between files.[1,6,16-18] A 28-gauge max-i-probe (Dentsply RINN, Elgin, IL) was used to dispense 1 mL of solution at a distance 1 mm short of the working length.

Sonic and ultrasonic irrigation

After instrumentation, samples were divided into 3 groups of 25. Group 1: EA was used according to manufacturer's recommendations. For each sample, the canal was flooded with 1 mL of 6.15% NaOCl. Using a pumping action, the activator was moved in 2- to 3-mm vertical strokes for 60 seconds. A capillary tip (Ultradent Products, Inc., South Jordan, UT) was used to suction loose debris and fluid from the canal. These steps were repeated with a solution of 17% EDTA (Roth International, Ltd., Chicago, IL).[4,19] Group 2: Ultrasonic Suprasson P5 Newtron (Acteon Group, Mount Laurel, NJ) was used according to manufacturer's recommendations. For each sample, the canal was flooded with 1 mL of 6.15% NaOCl. The device was set to power setting 6 and a K 15/21-mm endodontic irrigation file (Acteon Group) was inserted in the center of the canal, 1 mm short of the working length. It was activated for 60 seconds and then slowly withdrawn without exerting any pressure apically or parietally. A capillary tip was used to suction loose debris and fluid. These steps were repeated with a solution of 17% EDTA. Group 3: Control was irrigated without sonic or ultrasonic. For each sample, the canal was flooded with 1 mL of 6.15% NaOCl with a 28-gauge slotted needle for 60 seconds, and then an intracanal suction tip was used to eliminate loose debris and fluid. This was repeated with a solution of 17% EDTA. All teeth had a final rinse with alcohol and the canals were dried with paper points (Henry Schein, Inc., Melville, NY).

Obturation assessment

Fifteen teeth from each group were randomly selected. These teeth were obturated using fine-medium gutta percha cones (Dentsply, Johnson City, TN) with the tip adjusted to size #40. The tip of the cone was coated with AH plus sealer (Dentsply, Johnson City, TN) and placed in the canal. The continuous wave technique of obturation was used with the System B (SybronEndo, Glendora, CA) and Obtura (Obtura Spartan, Fenton, MD). A fine-medium tip (SybronEndo) was used and the gutta percha was burned out to a level 3 mm short of the apex. A #60 S-Kodenser (Obtura Spartan) was then placed in the canal to compress the gutta percha. The canals were then backfilled with the Obtura gun.

Clearing process

The 45 teeth were decalcified at room temperature for 2 days in fixation decalcifying solution (Richard-Allan Scientific, Kalamazoo, MI), dehydrated, and then rendered transparent by soaking in methyl salicylate (Fisher Chemicals, Fair Lawn, NJ). The presence of filled lateral canals was analyzed using a Zeiss OPMI Pico diagnostic microscope (Carl Zeiss Meditech, Dublin, CA). The obturation of lateral/accessory canals was assessed by 2 examiners using a standardized 3-point score. A score of 0 was given if no lateral/accessory canals were obturated. A score of 1 was given if 1 lateral/accessory canal was obturated. A score of 2 was given if 2 or more lateral/accessory canals were obturated and analyzed with a Kruskal-Wallis and Dunn