Comparison of Passive Ultrasonic Debridement Between Fluted and Nonfluted Instruments in Root Canals

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Abstract

The purpose of this study was to determine if passive ultrasonic irrigation using finger spreaders was more effective than standard files in removing debris after root canal instrumentation. Eighty-five straight canals were instrumented and then passively ultrasonically irrigated with either fluted files or nonfluted finger spreaders for 3 minutes or 1 minute. Images of split canal lumens were imported into Adobe Photoshop CS2 (Adobe Systems, San Jose, CA), and percentage of debris remaining was calculated. Analysis of variance and Student Newman-Keuls post hoc tests ($p < 0.05$) showed that when comparing the entire canal, 3 minutes of activation with a file had significantly less debris remaining than 1 minute of activation with a spreader. There was a trend for 1 minute of activation with a file to have less debris than either 3 minutes or 1 minute of activation with a spreader. When comparing apical, middle, or coronal thirds between groups, no significant differences were found. The use of a nonfluted spreader did not improve debris removal. *(J Endod 2007;33:578–580)*

Key Words

Acoustic streaming, debris removal, finger spreaders, ultrasonic irrigation, ultrasonics

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Proper biomechanical preparation of the root canal space is considered to be essential for success in endodontic therapy. Removal of vital tissue, necrotic debris, and microorganisms from within the root canal system is necessary for microbial control. This goal is attempted by using chemomechanical root canal preparation consisting of mechanical debridement and canal enlargement combined with thorough irrigation with bactericidal solutions. However, the complex nature of the root canal system makes complete debridement very difficult and a continuous challenge (1–4).

The use of sonics and ultrasonics in canals has evolved from primary instrumentation to a passive cleaning technique. Although there have been significant advances in canal preparation and debridement, the fact remains that dentinal debris is still routinely found within canal preparations and that clinicians have been slow to adopt ultrasonic or sonic instrumentation as an important adjunct in canal debridement (5, 6).

Acoustic streaming is the creation of intense circular fluid movement or flow patterns around files known as eddies. When files are activated with ultrasonic energy in a passive manner, the acoustic streaming enhances the cleaning effect of the irrigant in the pulp space through hydrodynamic shear stress. Passive activation implies that no attempt is made to instrument, plane, or contact the canal walls with the file (7).

Contact with the root canal wall may significantly inhibit free oscillation of an activated file. When a file is introduced into the root canal, it will touch the dentin wall at different points along its length and become loaded at these points. This will influence its amplitude of oscillation and hence its clinical performance (8). Canals instrumented with the file oscillating freely after hand instrumentation were significantly cleaner than when the file contacted the canal wall (9). To maximize the effects of acoustic streaming, smaller files should be used within the canal space. Ahmad et al. (9) showed that smaller files generate greater acoustic streaming because of the increased amplitude of the file, and the amplitude has been shown to be the greatest at the tip (10).

In addition to reduced acoustic streaming, canal wall contact with ultrasonic and sonic instruments can potentially damage the canal walls or finished canal preparations. Tronstad et al. (11) found longitudinal parallel grooves on the canal walls that had been apparently caused by the tips of the files. Walmsley et al. (12) found that during the process of ultrasonic instrumentation, a distinct pattern or marking was left in the dentin of the canal walls and that the longitudinal marks suggested the file tip may have been working as a hand file and not oscillating properly. This may have been because the file was constrained in the narrow apical region of the canal. Both sonic and ultrasonic instruments produced similar marks, but it was unknown whether they influence the long-term prognosis of root canal therapy. Even when following the passive technique of Jensen et al. (7), file contact with the canal walls may be unavoidable. If this is the case, a nonfluted instrument may engage the canal wall less and produce more acoustic streaming and better debridement.

van der Sluis et al. (13) found no significant difference between a size 15 K-file and a smooth wire of the same dimension in removing dentinal debris from artificially created grooves in the apical halves of straight canal preparations in plastic blocks. Although a smooth size 15 wire may be ideal for comparison with a size 15 K-file, no such product is available on the market. The closest commercially available substitute is a narrow, minimally tapered, nonfluted finger spreader.

To date, no study has compared the passive ultrasonic irrigation debridement efficiency of fluted files versus nonfluted finger spreaders. The purpose of this study was to determine if passive ultrasonic irrigation using finger spreaders was more effective than standard files in removing debris after root canal instrumentation.

Materials and Methods

Single canals from 85 anterior and posterior extracted human teeth stored in 0.2% sodium azide were decoronated to a standardized root length of 15 mm. A #10 FlexoFile (Dentsply Maillefer, Johnson City, TN) was placed until just visible at the apex and 1 mm was subtracted to establish working length. Rotary instrumentation was performed with ProFile 0.04 nickel-titanium rotary instruments (Dentsply Tulsa Dental, Tulsa, OK) in a crown down technique to a standardized master apical file #40, 0.04 taper, while irrigating with 1 mL of 6% sodium hypochlorite (NaOCl) (The Chlorox Company, Oakland, CA) between files. The teeth were randomly divided into a negative control group and 4 experimental groups with 20 teeth in each. The negative control group consisted of 5 canals that received no further treatment except for a final rinse with 5 mL of 6% NaOCl and drying with coarse paper points (Henry Schein, Melville, NY). A pilot study determined that a power setting of 3 using a P5 ultrasonic unit (Dentsply Tulsa Dental) was the most effective in removing canal debris.

All experimental groups were irrigated with 5 mL of 6% NaOCL and then passively ultrasonically activated for the indicated times with either a #15 FlexoFile or a yellow stainless-steel finger spreader (Henry Schein). This instrument had an approximate D_0 of 0.15 mm and a .04 taper. Both instruments were marked with a permanent black marker at 13 mm (1 mm short of working length) and had thick rubber stops placed at 13 [1/2] mm. Passive activation meant that every attempt was made to keep the file centered in the canal so that it would not touch the canal walls. During activation, the file/spreader was moved continuously up and down 2 to 3 mm with the apical extent ending 1 mm short of working length. Great care was taken so that only the black reference mark on the file/spreader ever became level with the orifices of the preparations. The rubber stops never touched the specimens and therefore did not affect the irrigation process.

Groups 1 and 2 received passive activation for 3 minutes or 1 minute, respectively, with the file. Groups 3 and 4 received passive activation for 3 minutes or 1 minute, respectively, with the finger spreader. After random passive ultrasonic irrigation of the teeth, the canals received a final rinse with 5 mL of 6% NaOCl and were dried with coarse paper points. For all rinses, 10-mL syringes (Terumo Medical Corporation, Elkton, MD) and 30-gauge Max-I-Probe irrigation tips (Dentsply Rinn, Elgin, IL) were placed 1 mm from working length. One operator who was experienced with this method of instrumentation prepared all canals.

With the aid of a dental operating surgical microscope (Global Surgical Corporation, St. Louis, MO), teeth in the control and experimental groups were longitudinally grooved with a diamond disc and split buccolingually. The longitudinal section of each tooth with $\leq 180°$ of the canal circumference was selected for study. The sections with $> 180°$ of canal circumference would possibly interfere with total canal visualization during photography. The chosen sections were photographed by using a 4-megapixel Nikon Coolpix 4500 (NIKON, USA, Melville, NY) at X4 optical zoom and saved as TIFF images with maximum resolution of 2,272 × 1,704 pixels. The images were then imported into Adobe Photoshop CS2 (Adobe Systems, San Jose, CA) and magnified ×10 with the digital zoom tool. Four different aspects of the tooth were evaluated: the apical, middle, and coronal thirds and the entire canal space. Data for the entire canal space were determined by totaling the data from the apical, middle, and coronal thirds. The magnetic lasso tool was used to outline each of the aforementioned areas and then the histogram function was used to calculate the total number of pixels within each space. In the same manner, areas of debris were selected, and the debris pixel content for each space was determined. The debris pixel content for each space was divided by the total pixels for that space to determine the percentage of debris remaining in each. The level of significance was set at $p < 0.05$. Statistical analysis was performed by using one-way analysis of variance and Student-Newman-Keuls post hoc tests to compare the percent of remaining debris among the 4 treatment groups.

Results

The results for debris remaining in the canals overall are presented in Figure 1. When comparing the entire canal, group 1 (the 3-minute file group) had significantly less remaining debris than group 4 (the 1-minute spreader group), and there was a trend for group 2 (the 1-minute file group) to have less debris than both spreader groups (groups 3 and 4). The control group behaved as expected with more debris than any of the experimental groups.

Comparing the debris scores of individual canal thirds within experimental groups, all had significantly more debris increasing from coronal to apical, with the exception of the middle thirds and apical thirds in group 3 (the 3-minute spreader technique). However, when comparing apical, middle, and coronal thirds among experimental groups (Fig. 2), there were no significant differences. The control group behaved as expected with more debris than any of the experimental groups, regardless of the canal third evaluated.

Discussion

The positive controls had the most remaining debris, which was greatest in the apical direction. This observation follows the pattern of previous studies by Jensen et al. (7) and Sabins et al. (14) who found that a passive ultrasonic or sonic activation technique resulted in cleaner canals than hand instrumentation alone. In this study, the addition of 1 minute of ultrasonic activation improved overall canal cleanliness at all levels evaluated. When comparing apical, middle, or coronal thirds between groups, no significant differences in debris removal were noted. This finding may be because of the inability to deliver continuous intracanal irrigation throughout the procedure. The transparency of some of the experimental tooth models allowed the operator to witness the vibratory effects of the ultrasonically activated files and spreader tips. It was speculated that continuous irrigation/increased

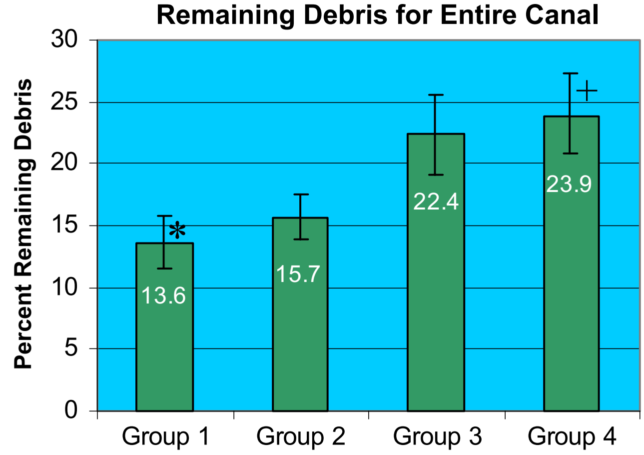

Figure 1. Group 1* with 3 minutes of file activation had significantly less remaining debris than group 4^+ with 1 minute of spreader activation ($p < 0.05$). Standard error bars are shown.

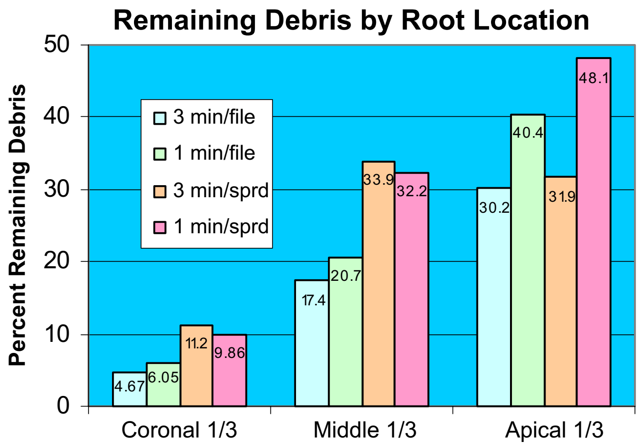

Figure 2. There were no significant differences between groups when comparing coronal, middle, and apical thirds of the teeth ($p < 0.05$). Error bars are omitted.

volume of irrigant may have improved removal of canal debris. Gutarts et al. (15) developed an ultrasonically activated 25-gauge irrigating needle that could be connected to a piezoelectric ultrasonic unit and activated at the highest power setting without needle breakage. In their study, 6% NaOCl was delivered at a rate of 15 mL/min through the needle. The results showed that 1 minute of ultrasonic irrigation after hand/rotary instrumentation resulted in significantly cleaner canals and isthmuses at all 10 apical levels. The effect of increased volumes of solution during ultrasonic activation requires more research.

Among the conditions of this study, a standard fluted file used for 3 minutes with passive ultrasonic irrigation was superior at debris removal when considering the entire canal space. Nonfluted finger spreaders did not improve debris removal. The order of effectiveness was 3 min/file >1 min/file >3 min/spreader >1 min/spreader. When considering apical, middle, and coronal thirds separately, there were no significant differences among the techniques.

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