A comparison between a smooth wire and a K-file in removing artificially placed dentine debris from root canals in resin blocks during ultrasonic irrigation

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Abstract

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Aim To compare the efficacy of a smooth wire with a conventional K-file, in removing dentine debris from grooves in root canals made in resin blocks, during ultrasonic irrigation.

Methodology Each resin block containing a standard simulated canal was split longitudinally through the canal, forming two halves. In one canal wall, a standard groove 4 mm in length, 0.2 mm in width and 0.5 mm in depth was cut 2–6 mm from the apical end of the canal, to simulate uninstrumented canal extensions. Each groove was filled with fresh dentine debris mixed with 2% NaOCl to simulate a situation when dentine debris accumulates in uninstrumented canal extensions. Each canal was reassembled by joining the two halves of the resin block by means of wires and sticky wax. In each canal ultrasonic irrigation was performed for 3 min using 2% NaOCl as irrigant. In one group ($n = 20$) a conventional K-file size 15 was used. In the other group ($n = 20$) a smooth wire was used which had the same length and diameter as the size 15 K-file. Before and after irrigation, images of each half of the canal with a groove were taken, using a microscope and a digital camera, after which they were scanned into a PC as TIFF images. The quantity of dentine debris in the groove was evaluated using a scoring system: the higher the score, the larger the amount of debris remaining. The score data were analysed by means of the Mann–Whitney *U*-test.

Results After ultrasonic irrigation, the debris was completely removed from the groove in 35 canals (87.5%), and there was no significant difference between the groups ($P = 0.429$).

Conclusions Using a smooth wire during ultrasonic irrigation is as effective as a size 15 K-file in removal of artificially placed dentine debris in grooves in simulated root canals in resin blocks.

Keywords: smooth wire, ultrasonic irrigation.

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Introduction

Ultrasound is sound energy with a frequency above the limit of human hearing (>20 kHz). Ultrasonic devices have been used in dentistry mainly in Periodontics until Richman introduced ultrasound into Endodontics as a means of canal debridement (Richman 1957). In Endodontics ultrasound can be used for preparing root canals because of its cutting action, and/or irrigation because it can induce acoustic streaming of irrigant solutions. Because it is difficult to control the cutting of dentine during ultrasonic preparation, canal transportation can occur and the root canal wall is not smooth after preparation (Stock 1991, Sundqvist & Figdor 1998). This uncontrolled action of the file during

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ultrasonic preparation is the reason why ultrasound is not routinely used for shaping.

The cleaning efficacy of ultrasound appears to be promising when it is used only for irrigation after the root canal has been instrumented (Ahmad *et al.* 1987). Compared with hand irrigation, ultrasonic irrigation is effective (Cunningham *et al.* 1982, Goodman *et al.* 1985, Haidet *et al.* 1989, Lee *et al.* 2004a,b). In laboratory studies (Lee *et al.* 2004a,b) standard grooves or holes were made in root canals in prepared extracted teeth or resin blocks to simulate oval canal extensions or canal irregularities. These grooves or holes were filled with dentine debris and after hand- or ultrasonic irrigation the amount of dentine debris still present in the grooves or holes was evaluated. Using this method it was clear that ultrasound irrigation was more effective than syringe irrigation and that artificially made root canals in resin blocks with a diameter of 0.20 mm and 06 and 08 taper were significantly cleaner than root canals with a diameter of 0.20 mm and 04 taper.

Acoustic streaming is the most acceptable explanation for the cleaning efficacy of ultrasonic irrigation (Ahmad *et al.* 1987). The stronger the streaming the better the result (Lumley *et al.* 1991). The streaming velocity produced by ultrasonic irrigation produces hydrodynamic shear stresses, which are more than capable of disaggregating clumps of bacteria or debris contained within the canal (Lumley *et al.* 1991). Acoustic streaming is defined as the generation of time-independent, steady unidirectional circulation of fluid in the vicinity of a small vibrating objects (Nyborg 1965). The prerequisite of an effective acoustic streaming is the free vibration of the instrument in the root canal (Ahmad *et al.* 1987). The streaming velocity is described by the formula $\mathrm{Um} = \omega\varepsilon_0^2/\mathrm{a}$ in which Um is the liquid streaming velocity, ω is 2π times the driving frequency, ε_0^2 is the displacement amplitude and a the radius of the wire (Ahmad *et al.* 1987). According to the formula: (1) the diameter of the file (a), (2) the amplitude displacement (ε_0) and (3) the frequency (f) are important for the efficacy of the ultrasonic irrigation. The best effect is obtained when the wire is small, the amplitude displacement is large and the frequency is high. The diameter of the canal is important because it can influence the amplitude displacement.

Another factor of importance is the heat generated by ultrasound. Ultrasound can increase the temperature of a 2.5% solution of sodium hypochlorite to a level comparable with the tissue dissolving effectiveness of a 5% solution of sodium hypochlorite (Cunningham & Balekjian 1980). The frequency and the displacement amplitude will have an effect on the heating of the sodium hypochlorite. By increasing the frequency and the displacement amplitude the temperature of the sodium hypochlorite will rise and the tissue dissolving effectiveness of the sodium hypochlorite will be enhanced.

According to the formula the diameter of the root canal is critical and for this reason it was important to use resin blocks to standardize the diameter of the root canal. It is not possible to standardize the diameter of root canal preparation in natural teeth because the difference in diameter is too large (Stock 1991).

Normally in ultrasonic irrigation a size 15 K-file is used but the action of the file can result in a canal wall which is not smooth, in canal transportation or apical perforation. According to the formula it would be possible to replace the K-file with a smooth wire without reducing the cleaning efficacy as long as the diameter of the wire is the same as the file. For this reason the purpose of the study was to compare the efficacy of a smooth wire, in removing artificially placed dentine debris from straight root canals made in resin blocks, with a normal K-file, during ultrasonic irrigation.

Materials and methods

Forty resin blocks (Endo Training Block, REFA0177; Dentsply Maillefer, Ballaigues, Switzerland) were used. The original straight root canal was enlarged using a size 20,0.8 rotary GT instrument (Dentsply Maillefer) in a handpiece rotating at approximately 300 rpm. Two grooves were then cut in each block along the long axis of the canal, before splitting longitudinally through the canal using a chisel, forming two halves.

The working portion of a hand spreader (A60; Dentsply Maillefer) was removed and the end of the shank was sharpened. In the wall of one half of each canal, a standard groove 4 mm in length was created 2–6 mm from the apex using this modified hand spreader (Fig. 1); the groove simulated an uninstrumented canal extension. The groove was 0.2 mm wide and 0.5 mm deep, the width of the groove is comparable with the width of the short diameter of narrow oval canals (Wu *et al.* 2000).

To produce dentine debris, a number of freshly extracted teeth were split longitudinally and debris was ground from the canal wall with round burs from the pulpal side to the cementum side. Five minutes before use, the dentine debris was mixed with 2% NaOCl and a

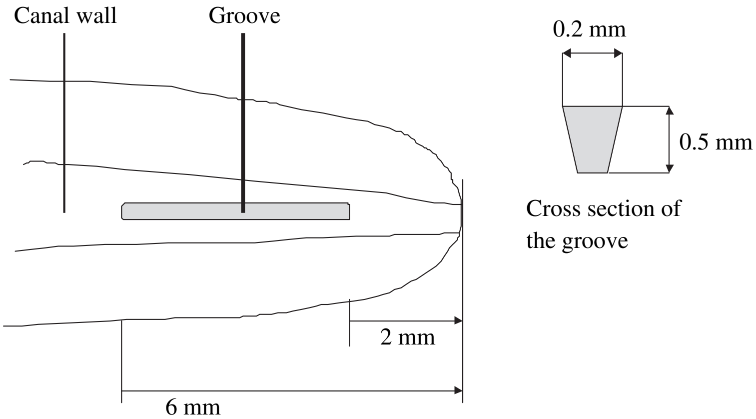

Figure 1 Schematic representation of specimen preparation. On one half of the instrumented root canal a groove was cut 2 mm to 6 mm from the apex.

wet sand-like mixture was prepared. Using a paper point, each groove was filled with debris taking care not to compact it.

To reassemble the tooth, the two halves of each block were reconnected using wires and sticky wax. Two groups of 20 canals were used. Ultrasonic irrigation was performed in each canal with a piezo-electronic ultrasonic unit (P MAX; Satelec, Meriganc Cedex, France) using 2% NaOCl as the irrigant. The concentration of the NaOCl solution was measured iodometrically (Moorer & Wesselink 1982). In group 1, each canal was then irrigated with approximately 200 mL of 2% NaOCl along an ultrasonically activated size 15 K-file to 1 mm short of the apical end of the canal, and oscillating in the direction towards the groove at speed 3 for 3 min. According to the manufacturer, the frequency employed under the above-mentioned conditions was approximately 30 kHz. In group 2, the same procedure was followed as in group 1, only a smooth wire size 15 was used, with the same properties as the size 15 K-file, during the ultrasonic irrigation. The smooth wire was made by grinding and polishing a size 25 K-file until it was smooth and had the same dimensions as the size 15 K-file.

Before and after irrigation, photographs of the two halves of the canal were taken using a Photomakroskop M 400 microscope with a digital camera (Wild, Heerbrugg, Switzerland) at ×40 magnification; the photos were then scanned as tagged-image file format images. The amount of debris in the grooves was evaluated prior to treatment, using a scoring system, in order to examine whether all grooves were filled with debris at the time of irrigation. The second scoring was performed after irrigation. A higher score indicated a greater amount of debris: score 0: the entire groove was free of debris; score 1: less than half of the groove was filled with debris; score 2: half and more than the half of the groove was filled with debris; score 3: the entire groove was filled with debris. For the statistics the Mann–Whitney *U*-test was used. The level of significance was set at $P = 0.05$.

Results

Before the ultrasonic irrigation, the groove score was 3 for each specimen.

After irrigation in group 1 there were four samples (20%) with score 1, the others (80%) had score 0: free of debris. In group 2 one sample (5%) had score 1, the others (95%) had score 0. There was no significant difference between the two groups ($P = 0.429$).

Discussion

Because the frequency, displacement amplitude and radius of the file and the wire were the same in both groups the smooth wire was as effective as the K-file. The only difference between the two instruments is the grooving of the K-file, which is very superficial. There was no significant difference in cleaning efficacy between the smooth wire and a K-file during ultrasonic irrigation indicating that the shallow grooves of the K-file did not significantly influence the cleaning effect.

These findings correspond with Goodman *et al.* (1985) and Cameron (1987) who found that a smooth wire did indeed clean the root canal during ultrasonic irrigation. Ultrasonic irrigation with a smooth wire and a 2 or 4% sodium hypochlorite solution resulted in canal walls without a smear layer (Cameron 1987) and the isthmuses of the root canals contained significantly less debris after ultrasonic irrigation than the control group (Goodman *et al.* 1985). The studies were performed on freshly extracted teeth so the effectiveness of using a smooth wire was proven in natural teeth.

In a study where a comparison was made between a smooth wire and a size 15 K-file, during ultrasonic irrigation, less cutting of the canal wall was seen when the smooth wire was used (Mayer *et al.* 2002). This demonstrates the advantage of using a smooth wire to limit the cutting effect of the K-file.

In the above-mentioned studies the smooth wires were not compared with a conventional K-file or were compared with a K-file that did not have the same properties or dimensions as the K-file (Mayer *et al.* 2002). For this reason it was not clear if a smooth wire would be as effective in cleaning the root canal as a K-file under the same conditions.

This study was performed with straight root canals. In the study by Goodman *et al.* (1985) roots with a Schneider curvature between 15 and 35° were used indicating that a smooth wire is effective in both straight and curved canals.

Dentine is porous, for that reason it could be more difficult to remove dentine from natural teeth than from resin blocks. This will be the same for the K-file as for the smooth wire because they create the same amount of acoustic streaming, which is responsible for the cleaning effect.

From the results of the study of Lumley *et al.* (1993) it can be concluded that ultrasonic irrigation is more effective when the direction of the oscillation of the file is towards the oval recesses. For this reason in this study the oscillation of the file was also towards the grooves.

Conclusion

Using a smooth wire during ultrasonic irrigation is as effective in the removal of artificially placed dentine debris in root canals in resin blocks as a size-matched conventional K-file.

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