The efficacy of ultrasonic irrigation to remove artificially placed dentine debris from human root canals prepared using instruments of varying taper

L. W. M. van der Sluis, M-K. Wu & P. R. Wesselink

Department of Cariology Endodontology Pedodontology, Academic Centre for Dentistry Amsterdam (ACTA), Amsterdam, The Netherlands

Abstract

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Aim To investigate the influence of the taper of root canals on the effectiveness of ultrasonic irrigation to remove artificially placed dentine debris.

Method Forty-four maxillary and mandibular canines were selected after bucco-lingual and mesio-distal radiographs indicated that their internal diameters were smaller than the diameters of a size 20, .06 taper System GT instrument (Dentsply Maillefer, Ballaigues, Switzerland). These canines were divided into three groups and prepared using either size 20, .06 taper System GT instruments, size 20, .08 taper or size 20, .10 taper System GT instruments. Each root was then split longitudinally through the canal, forming two halves. In one canal wall, a standard groove was cut 2–6 mm from the apex, to simulate uninstrumented canal extensions. Each groove was filled with dentine debris mixed with 2% NaOCl to simulate a situation when dentine debris accumulates in the uninstrumented canal extensions. Each canal was reassembled by joining the two halves of the teeth by means of wires and sticky wax. In each canal ultrasonic irrigation was performed with a size 15 K file using 2% NaOCl as an irrigant. 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. The scores before and after irrigation were compared. The differences in percentage of score reduction between the three groups were analysed by means of one-way ANOVA.

Results After ultrasonic irrigation, the debris score reduced by 74, 81 and 93%, respectively, in the size 20, .06, 20, .08 and 20, .10 taper groups. However, the difference amongst groups was not statistically significant ($P = 0.078$).

Conclusion There was a tendency that ultrasonic irrigation was more effective in removing artificially placed dentine debris from simulated canal extensions from canals with greater tapers.

Keywords: dentine debris, irrigation, natural teeth.

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Introduction

During root canal treatment the use of sodium hypochlorite (NaOCl) as an irrigant solution is indispensable because of its tissue-dissolving capacities (Moorer & Wesselink 1982) and its antibacterial effect (Siqueira *et al.* 2000). The flushing action of the irrigant solution may be more important during the cleaning process than the ability of the irrigant solution to dissolve tissue (Baker *et al.* 1975). Most of the dentine debris is inorganic matter that cannot be dissolved by NaOCl. Therefore, removal of dentine debris relies mostly on the flushing action of irrigant.

Correspondence: L. W. M. van der Sluis, Department of Cariology Endodontology Pedodontology, ACTA, Louwesweg 1, 1066 EA Amsterdam, The Netherlands (Tel.: +31 20 5188651; fax: +31 20 6692881; e-mail: l.vd.sluis@acta.nl).

The enhancement of the flushing action of an irrigant solution by using ultrasound is well documented (Cunningham & Martin 1982, Cunningham *et al.* 1982a,b, Stock 1991, Lumley *et al.* 1993, Lee *et al.* 2004a,b). Cunningham & Martin (1982) and Cunningham *et al.* (1982a,b) reported that more bacterial spores and dentine debris were removed during ultrasonic irrigation than hand irrigation.

However, narrow canals may compromise the efficacy of ultrasonic irrigation (Krell *et al.* 1988, Krell & Johnson 1988, Druttman & Stock 1989, Stock 1991). Therefore, such canals may need to be enlarged and their taper increased to allow effective ultrasonic irrigation. NiTi rotary instruments with different tapers have been used to enlarge the small root canal and are available from a variety of manufacturers. It is important to know the minimum diameter and/or taper a root canal should have to allow good ultrasonic irrigation and which diameter and/or taper restricts its effectiveness.

In a recent study (Lee *et al.* 2004a), simulated canals were split longitudinally, forming two halves and a standard groove was cut in one canal wall, to simulate uninstrumented canal extensions. Each groove was filled with dentine debris to simulate a situation when such debris accumulates in uninstrumented canal extensions. After reassembling the canals, ultrasonic irrigation was performed. The quantity of the debris in the groove before and after irrigation was scored and compared. It was found that after irrigation the remaining debris was significantly greater in size 20, .04 taper canals than in size 20, .06 and 20, .08 canals.

The advantage of the method used by Lee *et al.* (2004a,b) is that the amount of debris present both before and after irrigation could be compared, whereas in other previous studies the amount of debris was evaluated only after preparation and irrigation (Abbott *et al.* 1991, Lumley *et al.* 1993, Wu & Wesselink 1995). Because it was not clear how much debris was present before irrigation in those studies, it could not be established how much was removed using the different irrigation procedures. On the other hand, Lee *et al.* (2004a) conducted their experiment in simulated plastic canals; dentine, due to its porous nature (by having dentinal tubules), may act differently than a solid plastic material. Therefore, it would be interesting to repeat the same study in natural teeth to evaluate the differences between the plastic model and natural teeth.

The purpose of this study was to repeat the experiment conducted by Lee *et al.* (2004a) in natural teeth to investigate the influence of the taper of root canals on the effectiveness of ultrasonic irrigation to remove artificially placed dentine debris from natural root canals.

Materials and methods

Maxillary and mandibular canines were radiographed bucco-lingually and mesio-distally. The internal diameters of each root were measured on both radiographs 3, 7 and 11 mm from the apex. The diameters of a size 20, .06 rotary System GT instrument (Dentsply Maillefer, Ballaigues, Switzerland) were 0.38, 0.62 and 0.86 mm at 3, 7 and 11 mm from the tip of instrument. In 44 canines the internal diameters were smaller than the diameters of the size 20, .06 instrument at 3, 7 and 11 mm from the apex. However, it was not possible to find a canine with a single canal that was smaller than the size 20, .04 instrument.

The 44 canines were randomly divided into three groups ($n = 14$, 14 and 16). The canals were accessed and prepared. Each canal was prepared to the apical foramen which was determined by inserting a size 15 file into the canal until the tip of the file was just visible. The coronal aspect of each canal was flared, using Gates Glidden drills (Dentsply Maillefer); sizes 2–4 were used for the canal orifice only. The three groups were prepared using either size 20, .06 taper, size 20, .08 taper or size 20, .10 taper rotary System GT instruments (Dentsply Maillefer). Between the instruments, each canal was irrigated with 2 mL of a freshly prepared 2% solution of NaOCl, using a syringe and a 27-gauge needle that was placed 1 mm short of the working length, resulting in a total volume of 50 mL. The NaOCl solution was prepared by diluting a 10% NaOCl solution (Merck, Darmstadt, Germany). Its pH was adjusted to 10.8 with 1 N HCl. The concentration of the NaOCl solution was measured iodometrically (Moorer & Wesselink 1982).

The experiment was conducted using the methodology described by Lee *et al.* (2004a). Briefly, after root canal preparation each root was split longitudinally through the canal, forming two halves (Fig. 1). A standard groove of 4 mm in length, 0.2 mm in width and 0.5 mm in depth was cut in one canal wall 2–6 mm from the apex, to simulate uninstrumented canal extensions in the apical half. Each

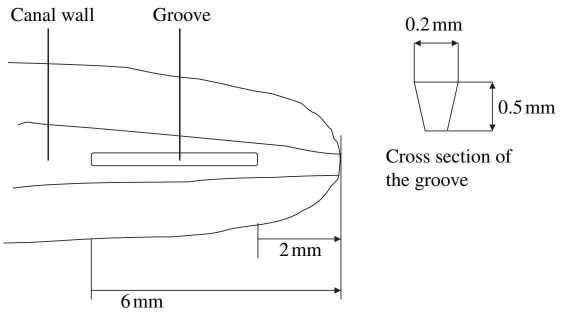

Figure 1 Schematic representation of specimen preparation. In one half of the instrumented root canal a groove was cut 2–6 mm from the apex.

groove was filled with dentine debris mixed with 2% NaOCl to simulate a situation when dentine debris accumulates in the uninstrumented canal extensions. After reassembling the two root halves by means of wires and sticky wax, ultrasonic irrigation was performed with a piezoelectronic unit (PMax; Satelec, Meriganc, France) in each canal for 3 min using 2% NaOCl as irrigant. After switching on the ultrasound device, an activated size 15 file was placed within 1 mm of the working length, thus, oscillation of the file and irrigation began almost at the same time. The oscillation in the direction of the groove at speed 3 lasted for 3 min. According to the manufacturer, the frequency employed under these conditions was approximately 30 kHz. The root halves were separated after the irrigation procedure in order to evaluate the removal of dentine debris. Images of each halve of the canal with the groove were taken before and after irrigation, using a Photomakroskop M400 microscope with digital camera (Wild, Heerbrugg, Switzerland) at ×40 magnification; the pictures were scanned into a PC as Tagged Image File Format (TIFF) images. The quantity of the debris in the groove before and after irrigation was scored, the higher the score, the larger the amount of debris. With the scores before and after irrigation, the percentage of score reduction was calculated as follows:

$$\text{Percentage of score reduction} = \frac{\text{Score before irrigation} - \text{Score after irrigation}}{\text{Score before irrigation}} \times 100\%$$

The differences in percentage of score reduction between the three groups were analysed by means of one-way ANOVA. The level of significance was set at $\alpha = 0.05$.

Results

The results of the study are shown in Table 1. There was a tendency for ultrasonic irrigation to be more effective in more tapered canals, but the difference amongst the groups was not statistically significant ($P = 0.078$).

Discussion

The results show that the ultrasonic irrigation has a tendency to remove more artificially placed dentine debris from more tapered root canals.

It has been reported that uninstrumented extensions or irregularities were totally or partially filled with debris following conventional hand irrigation (Cunningham *et al.* 1982a, Goodman *et al.* 1985, Wu & Wesselink 2001). In this study, a standard groove of 4 mm was cut, 2–6 mm from the apex and each groove was filled with dentine debris mixed with 2% NaOCl to simulate a situation where dentine debris accumulates in the uninstrumented canal extensions. This methodology has the potential to score the debris in the groove twice, and could therefore show how much debris had been removed by ultrasonic irrigation.

In a study by Albrecht *et al.* (2004), apical debris removal using various tapers of ProFile GT instruments (Dentsply Maillefer) was evaluated. When the taper was relatively small, significantly more debris was found when the apical preparation size was 20 compared with size 40 apical preparations. When a taper of .10 was produced, however, there was no difference in apical debris removal between apical preparations size 20 and 40. The results of the present study are in line with those results, and demonstrate a trend for better cleaning in canals prepared to a size 20, .10 taper in natural teeth (Table 1).

Table 1 Reduction of debris score

Size and taper of root canal	Percentage of score reduction
20, .06	73.9 ± 26.0
20, .08	80.9 ± 33.3
20, .10	92.7 ± 20.2

Table 2 Reduction of debris score after ultrasonic irrigation in different-sized root canals

	Percentage of score reduction	
Size and taper of root canal	In root canals in natural teeth (the present study)	In simulated plastic canals (Lee *et al.* 2004a)
20, .04	No data	58.3 ± 21.4
20, .06	73.9 ± 26.0	83.3 ± 26.7
20, .08	80.9 ± 33.3	94.4 ± 13.0
20, .10	92.7 ± 20.2	No data

Because it was not possible to find canines with a canal size smaller than the System GT instrument size 20, .04, in the present study a group of teeth of that taper was not included. The 44 canals selected on the basis of the diameter on radiographs were smaller than the size 20, .06 instrument, making it possible to create three different groups consisting of sizes 20, .06, 20, .08 and 20, .10. Therefore, the present study and the study by Lee *et al.* (2004a) shared the 20, .06 and 20, .08 groups (Table 2).

The results of both natural and plastic root canals showed the same tendency namely that ultrasonic irrigation was more effective in removing artificially placed dentine debris from extensions in wide canals than from small canals (Table 2). However the percentage of debris score reduction was lower in natural root canals than in the corresponding-sized simulated plastic canals (Table 2), indicating that it was more difficult to remove dentine debris from natural canals than plastic canals probably due to the complicated morphology of the natural root canals and the porous dentinal wall. The data in the present study with natural root canals had a higher SD/mean ratio when compared with the data for canals in plastic blocks (Table 2), also indicating that the results of the natural root canals were influenced by the morphology of the natural root canals and the porous dentinal wall. This may partly explain why in plastic canals, the difference amongst the groups ($n = 12$) was significant ($P = 0.012$) (Lee *et al.* 2004a,b), whereas in natural root canals the difference amongst the groups ($n = 14$–16) was not significant ($P = 0.078$).

Conclusion

The taper of prepared root canals influenced the effectiveness of ultrasonic irrigation in removing artificially placed dentine debris from uninstrumented canal extensions.

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