The capability of two hand instrumentation techniques to remove the inner layer of dentine in oval canals

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Abstract

Wu M-K, van der Sluis LWM, Wesselink PR. The capability of two hand instrumentation techniques to remove the inner layer of dentine in oval canals. *International Endodontic Journal*, **36**, 218–224, 2003.

Aim To evaluate the capability of two hand instrumentation techniques, namely balanced force and circumferential filing, to remove the inner layer of dentine in oval canals.

Methodology Thirty mandibular incisors with a single oval canal were selected and divided into two equal groups on the basis of their radiographic bucco-lingual internal diameters measured at a level 5 mm from the apex. Two different hand instrumentation techniques, i.e. balanced force and circumferential filing, were used in each group. A modification of the Bramante muffle mould was used to examine the root canal before and after instrumentation at a level 5 mm from the apex. The two images of the root cross-section before and after instrumentation were superimposed on one another. The perimeter of the canal and the length of the arc where the inner layer of dentine had been removed by the instrumentation were measured by means of an image analysis program. The percentage of this arc was calculated.

Results The balanced force method removed the inner layer of dentine from 38.6% of the circumference of the canal wall, as opposed to 57.7% using circumferential filing. The difference was not statistically significant ($P = 0.101$).

Conclusion In oval canals, both the balanced force and circumferential filing techniques left large portions of the canal wall uninstrumented.

Keywords: inner layer of dentine, instrumentation.

Received 3 July 2002; accepted 11 November 2002

Introduction

In infected root canals, the inner layer of dentine may contain microorganisms (Peters *et al.* 2001). One aim of root canal instrumentation is to remove the inner layer of dentine from all aspects of the root canal wall (Walton & Torabinejad 1996). However, in many cases bacteria have penetrated deeply into the dentine (Armitage *et al.* 1983, Ando & Hoshino 1990, Peters *et al.* 2001), making it difficult to completely remove them from the dentinal tubules using instruments. Moreover, it would be more difficult to remove the entire inner layer of dentine in long oval root canals than in round (Wu & Wesselink 2001).

In many dental schools, students are taught that the apical root canal should be enlarged to three sizes larger than the first file that binds at the working length (the first binding file) (Weine 1996). The aim of this procedure is to remove the entire inner layer of dentine from the apical canal wall. The first binding file is the smallest instrument that enables dentists to feel resistance at or before reaching the working length. It is thought that this file can gauge the apical diameter, so that after enlargement using three larger files, the inner layer of dentine together with the microorganisms can be removed from the entire wall.

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In a recent study (Wu *et al.* 2002), however, it was found that at its working length the first binding file touched only one side of the wall in 75% of curved canals, and failed to touch any wall in the other 25%. This indicates that after further enlargement the inner layer can be removed from one side of the wall only. Whether the inner layer can be removed from the entire canal wall remains questionable.

Large master files have been recommended in the past to scrape the entire circumference of the root canal wall (Tronstad 1991). For instance, sizes 70–90 have been recommended for all maxillary central incisors. The internal diameter of maxillary central incisors may vary from 0.19 to 0.94 mm, 2 mm from the apex (Wu *et al.* 2000b); at this level the diameter of a size 90 master file is 0.92 mm. Clinically, dentists do not know whether the canal is 0.19 or 0.94 mm, and using large files in all maxillary central incisors could unnecessarily result in a severe weakening of those small roots (Trope & Ray 1992). Furthermore, using large files in curved roots can lead to apical lacerations and ledging (Tang & Stock 1989, Briseno & Sonnabend 1991, Nagy *et al.* 1997, Buchannan 2000, Wu *et al.* 2000a). Some textbooks say that curved canals should not be prepared apically beyond a size 20 or 25 (Ingle *et al.* 1994, Walton & Torabinejad 1996). The use of Ni–Ti rotary instruments can reduce, but not completely prevent, the occurrence of apical transportation (Wu *et al.* 2000a, Hülsmann *et al.* 2001). This means that using large files can weaken the root and increase the risk of apical transportation.

Oval-shaped canals, most of which have long bucco-lingual but short mesio-distal diameters, exist in 25% of roots (Wu *et al.* 2000b). Using a larger file in long oval canals in order to include the entire oval canal in the preparation can result in perforation of the mesial or distal wall, as suggested by Wu & Wesselink (2001). It has been supposed that a circumferential filing technique with a small file will prevent this, while completely scraping the wall. However, several studies have shown that circumferential filing is not capable of contacting the entire canal wall (Reynolds *et al.* 1987, Zuolo *et al.* 1992, Siqueira Jr *et al.* 1997, Evans *et al.* 2001). Access cavity location and design may influence the percentage of the wall surface that is contacted by the instruments. However, Mannan *et al.* (2001), who used different cavity designs in maxillary anterior teeth, found that regardless of access cavity design, mechanical preparation using stepback filing did not allow instrumentation of the entire wall.

The balanced force technique (Roane *et al.* 1985) has been used in the preparation of curved root canals (Wu & Wesselink 1995). However, it has been found that in two-thirds of oval canals use of the balanced force method left a portion of the root canal wall uninstrumented (Wu & Wesselink 2001).

Different methods have been used to evaluate the cleaning efficacy of root canal preparation. Histological cross-sections have been used and the capability of different techniques to remove predentine evaluated (Reynolds *et al.* 1987, Zuolo *et al.* 1992, Siqueira Jr *et al.* 1997, Evans *et al.* 2001). However, predentine was not always visible (Evans *et al.* 2001). Longitudinal sectioning allows for an evaluation of the entire root surface (Lumley *et al.* 1993, Wu & Wesselink 1995). However, the root surface can be evaluated only once, after the root canal preparation. The muffle model introduced by Bramante *et al.* (1987) made it possible to examine the root canal both before and after instrumentation, at any level within the same canal system. Since then, various modified versions of this model have been used to evaluate the effects of root canal instrumentation (Calhoun & Montgomery 1988, McCann *et al.* 1990, Sydney *et al.* 1991, Hülsmann *et al.* 1999, 2001).

The purpose of this study was to use a muffle model to evaluate the capability of two hand instrumentation techniques, i.e. balanced force and circumferential filing, to remove the inner layer of dentine in oval canals.

Materials and methods

From a pool of extracted human permanent teeth stored in 5% formol-saline, 30 mandibular incisors with a single canal were selected after mesio-distal radiographs indicated a bucco-lingual internal diameter of 0.6–1.2 mm at a level 5 mm from the apex. Since the average mesio-distal internal diameter was found to be 0.3 mm at the same level (Wu *et al.* 2000b), all these teeth had a single oval-shaped root canal. These 30 teeth were of approximately the same length. They were divided into two equal groups ($n = 15$) on the basis of their bucco-lingual internal diameters. One of two different hand instrumentation techniques, i.e., balanced force or circumferential filing, was used in each of these groups.

A modified version of the muffle mould technique (Bramante *et al.* 1987) was used in which the root of each tooth was embedded in acrylic resin (Vertex, Dentimex, the Netherlands). Grooves in the walls of the mould allowed removal and exact repositioning of the complete tooth-block or sectioned portions of the tooth (Fig. 1). The bottom of the mould was milled after which it was fixed on the microscope table with putty (Fig. 2). Each tooth-block was sectioned 5 mm from the root apex.

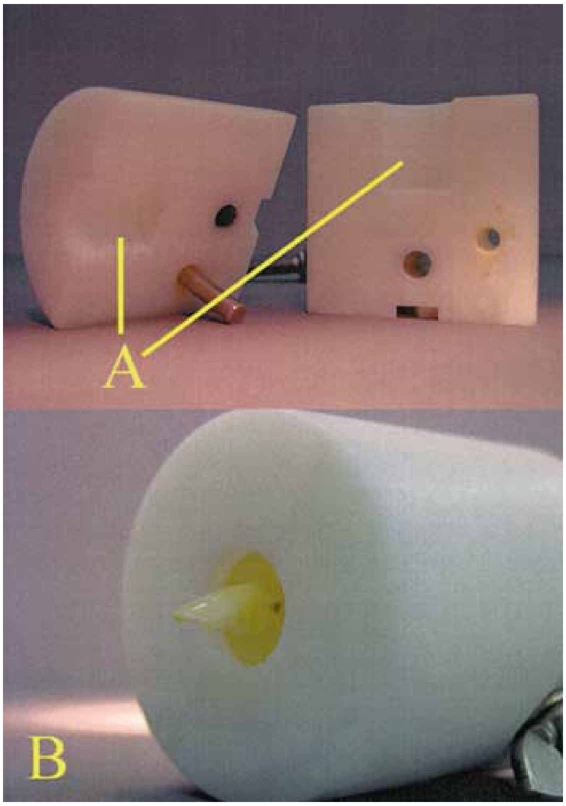

Figure 1 Grooves in the walls of the muffle mould (A) allowed removal and exact repositioning of the complete tooth-block or sectioned parts of the tooth. A mandibular incisor was embedded in acrylic resin in the muffle mould (B).

After the apical canal had been irrigated with 2% NaOCl, the sectioned surface of the apical root with the apical root canal was photographed using a microscope with digital camera (Photomakroskop M400 microscope, Wild, Heerbrugg, Switzerland) at ×40 magnification. It was confirmed that the canal outline was clearly visible. The tooth was then remounted in the mould and root canal instrumentation was performed. After instrumentation, the mould was opened and the sectioned surface was photographed again. These images were then saved as Tagged Image File Format (TIFF) images. Using a KS100 Imaging system 3.0 (Carl Zeiss Vision GmbH, Hallbergmoos, Germany), the two images of the sectioned surface of the apical root before and after instrumentation were superimposed on one another. The second canal outline (after instrumentation) was compared to the first canal outline (before instrumentation). If the first outline was not in contact with the second one at any point along the circumference, it was deemed that the inner layer of dentine had been removed from the entire canal wall (=100%). If the second outline was in contact with the first outline in one or more places, indicating that the inner layer had not been removed from that part of the canal wall, the length of both the contact portion and the noncontact portion was measured (Figs 3 and 4). The canal perimeter and the length of the arc where the inner layer of dentine had been removed were also measured. The percentage of this arc was calculated (<100%). One investigator measured all specimens without knowing which instrumentation technique had been performed.

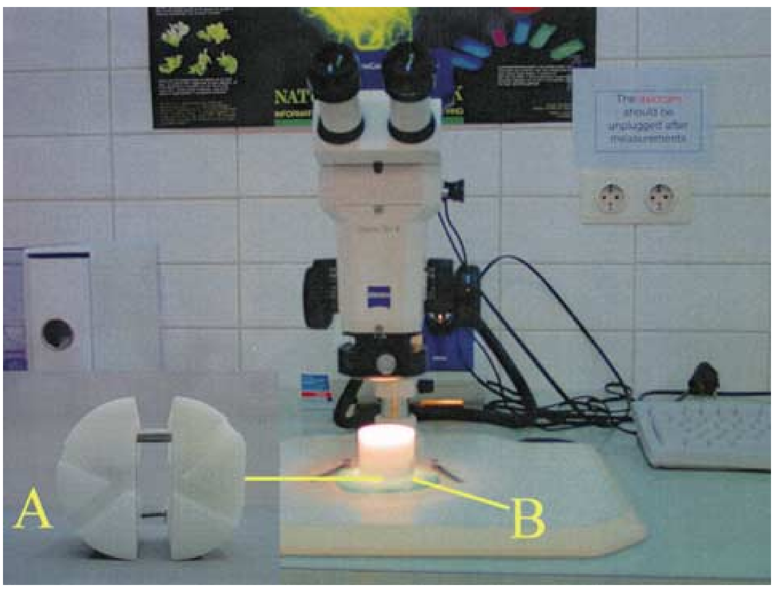

Figure 2 The bottom of the mould was milled (A) and it was fixed to the microscope table with putty (B).

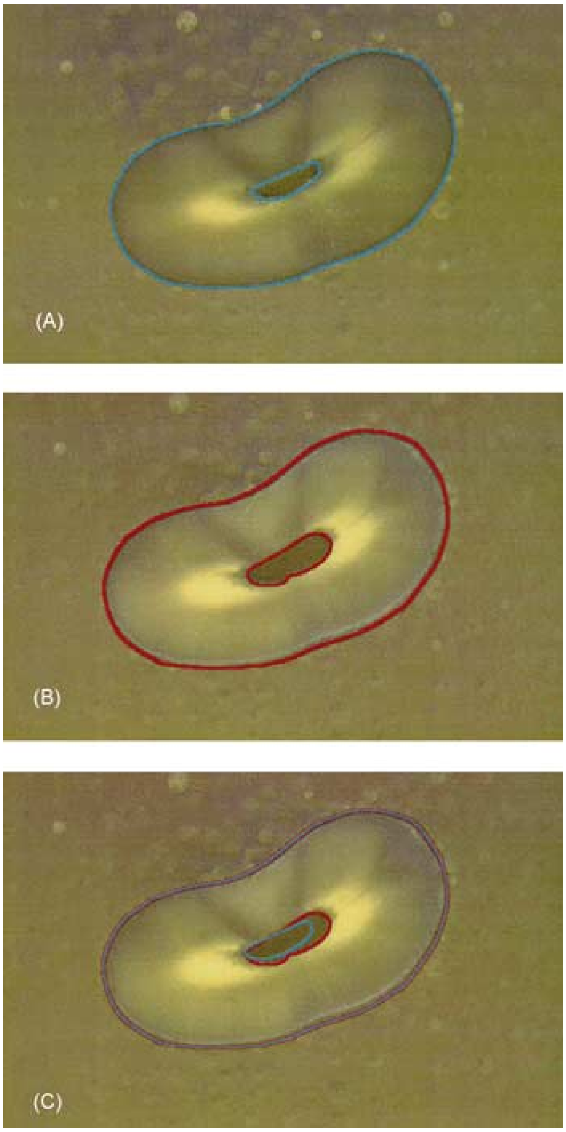

Figure 3 Two images of a sample from the circumferential filing group. (A) The image before instrumentation. The outlines of the root and the canal were both drawn in blue. The canal perimeter was 2.49 mm. (B) The image after instrumentation. The outlines of the root and the canal were both drawn in red. (C) The outlines in (A) were superimposed on the outlines in (B). The two root outlines (blue and red) were completely superimposed while the two canal outlines were partly superimposed. The inner layer of dentine had been removed from 65.9% of the canal wall.

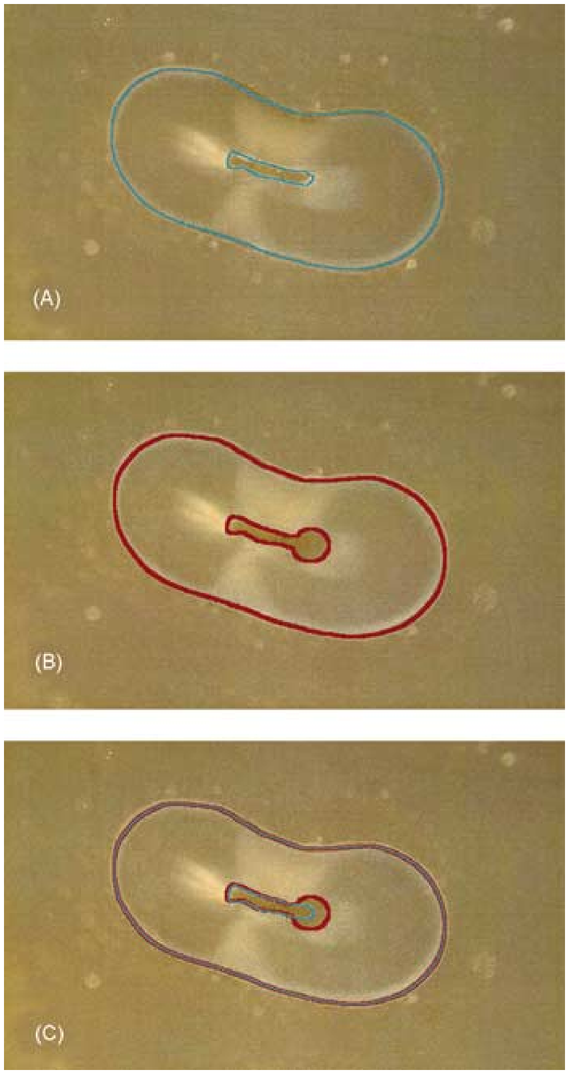

Figure 4 Two images of a sample from the balanced force group. (A) The image before instrumentation. The outlines of the root and the canal were both drawn in blue. The canal perimeter was 2.90 mm. (B) The image after instrumentation. The outlines of the root and the canal were both drawn in red. (C) The outlines in (A) were superimposed on the outlines in (B). The two root outlines (blue and red) were completely superimposed, while the two canal outlines were partly superimposed. A round preparation (red) was created at the right end of the long oval canal, leaving 67.2% of the canal wall unprepared.

Before the second photograph was taken, the canals were instrumented using two different techniques. In all the teeth a so-called lingual conventional access cavity (Mannan *et al.* 2001) was made. The working length was established by deducting 1 mm from the actual canal length, which had been previously determined by inserting a size 15 file into the canal until the tip of the file was just visible at the apical foramen. The coronal part of each canal was preflared using Gates–Glidden drills (Dentsply Maillefer, Ballaigues, Switzerland), sizes

50 and 70 (sizes 1 and 2) to a depth of 7 mm short of the working length, and ISO size 90 (size 3) to a depth of 8 mm short of the working length. Regardless of which technique was used, each canal was irrigated between each instrument with 2 mL of a freshly prepared 2% solution of NaOCl, using a syringe and a 27-gauge needle. After completion of the preparation, the canal was irrigated with 10 mL of 2% NaOCl.

Balanced force technique

Each canal was instrumented with Flexofiles (Dentsply Maillefer) using the balanced force technique (Roane *et al.* 1985). Briefly, a size-10 file was introduced into the canal until binding, and rotated 90 to 180 degrees clockwise with light apical pressure. Next, the file was rotated in a counterclockwise direction 120 to 360 degrees at an inward apical pressure that was light for small files (≤size 25) and heavier for large files (>size 25). Debris was removed by means of a slight outward pull with clockwise rotations. Such preparation was continued until the working length – 1 mm short of the apex – was reached. The same procedures were followed for all the subsequent instruments, sizes 15–40, finishing with a size-40 master apical file.

Circumferential filing technique

Each canal was prepared using Flexofiles (Dentsply Maillefer) and a size 10 was inserted up to the working length, i.e., 1 mm short of the apex, using circumferential filing, until the file was loose. Sizes 15–40 were then taken to the working length in sequence, ending with a size-40 master apical file. Each file was moved around the long oval canal at least twice until the file was loose.

The differences between the two groups with respect to canal perimeter and the percentage of the arc where the inner layer of dentine had been removed were analysed using a Mann–Whitney *U*-test. The level of significance in the test was set at $P < 0.05$.

Results

The results are shown in Table 1. There was no significant difference in canal perimeter between the two groups ($P = 0.576$), confirming that both were balanced in respect of anatomy. The circumferential filing technique removed the inner layer of dentine from a greater proportion of the perimeter of the canal wall than the balanced force technique (Table 1; Figs 3 and 4). However, the difference was not statistically significant ($P = 0.101$).

Table 1 The capability to remove the inner layer of dentine at a level 5 mm from the apex

Techniques	Mean and SD of canal perimeter (mm)	Mean and SD of the percentage of the arc from which the inner layer was removed (%)
Balanced force	2.11 ± 0.84	38.6 ± 17.5
Circumferential filing	2.18 ± 0.62	57.7 ± 29.4

Discussion

Most rotary instrumentation produce a round preparation (Hülsmann *et al.* 2001, Wu & Wesselink 2001). When the balanced force technique was performed in oval canals, the round preparation did not include the recesses, with the result that a portion of the canal wall was unprepared (Wu & Wesselink 2001). In this study, the balanced force technique again prepared less than 40% of the canal wall (Fig. 4; Table 1). The use of larger files in order to scrape more canal walls is not to be recommended, because these unnecessarily weaken the mesial and/or distal walls.

The concept behind circumferential filing is that a small file can move around the oval canal on the outstroke. Thus, it was speculated that the file could contact the whole canal wall without the risk of mesial or distal perforation. In this study, a size 90 Gates–Glidden drill had been used to 8 mm from the apex to facilitate the action of circumferential filing in deeper root canals and the circumferential filing did indeed prepare more aspects of the wall than the balanced force technique (Table 1). However, 40% of canal wall was not instrumented even after the use of circumferential filing. There is no evidence to prove that using a technique to remove dentine from 60% of the canal wall will lead to a higher success rate than using a technique that removes dentine from 40% only.

In the study by Reynolds *et al.* (1987), circumferential filing scraped 29, 60 and 64% of the wall in the apical, middle and coronal portions of root canals, respectively. It is unclear why this technique scraped more aspects of the wall in the middle and coronal portions than in the apical portion. The results of this study are in line with those of others (Reynolds *et al.* 1987, Zuolo *et al.* 1992, Siqueira Jr *et al.* 1997, Evans *et al.* 2001), demonstrating that thus far no technique has proved capable of scraping the whole circumference of the wall.

In this study, no stepback procedure was performed. Clinically, larger files are used during the stepback, but large files cannot prepare the narrow recesses in oval canals. However, including stepback may widen the canals in both groups and increase the percentage of prepared wall.

The capability of instrumentation to remove the inner layer of dentine was evaluated using only one section in this study. In cross-section the shape of root canals is not always oval at each level within a root (Wu *et al.* 2000b). Because the presence of oval canal was confirmed at the level 5 mm from the apex in this study, evaluation at the same level guaranteed observation of the effect of instrumentation in oval canals, which was the purpose of this study.

In this study, regardless of which technique was used, the instruments did not succeed in contacting 40% or more of the root canal wall. As yet, no technique has proved capable of removing dentine from the entire wall. This indicates that it is not possible to remove the inner layer of dentine from the entire canal wall of oval canals. Nevertheless, clinically high success rates have been recorded, even in the absence of strong disinfectants designed to kill microorganisms in the dentinal tubules (Peters *et al.* 1995). The hypothesis that the mechanical removal of heavily infected dentine is vital to the success of the treatment is being challenged. Therefore, it is not advisable to enlarge canals unnecessarily by means of large-sized instruments; rather the canals should be widened to allow effective irrigation and filling.

Conclusions

In oval canals, both balanced force and circumferential filing left large portions of canal wall uninstrumented.

Acknowledgements

The authors wish to thank Dr E.W. van Wijk and Dr M. Talma for their laboratory work.

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