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Efficacy of three rotary NiTi instruments in removing gutta-percha from root canals

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Abstract

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Aim To investigate the ability of three rotary nickel–titanium instruments and hand instrumentation to remove gutta-percha and sealer.

Methodology Sixty freshly extracted human single-rooted teeth, each with one root canal, were instrumented with K-files and filled using cold lateral compaction of gutta-percha and AH Plus (Dentsply Detrey, Konstanz, Germany) sealer. The teeth were randomly divided into four groups of 15 specimens each. Removal of gutta-percha was performed with the following devices and techniques: ProTaper, R-Endo, Mtwo and Hedström files. The specimens were rendered transparent and the area of remaining filling material on the root canal wall was measured using a computer image analysis program. Statistical analysis was accomplished by Kruskal–Wallis and Mann–Whitney *U*-tests with Bonferroni correction for the analysis of residual root filling material and working time.

Results The ProTaper group had less filling material inside the root canals than the other groups, but a significant difference was found between only the ProTaper and Mtwo groups ($P < 0.05$). The retreatment time for Mtwo and ProTaper was significantly shorter compared with R-Endo and manual instrumentation with Hedström files ($P < 0.001$). R-Endo was significantly faster than manual instrumentation ($P < 0.001$).

Conclusions Under the experimental conditions, ProTaper left significantly less gutta-percha and sealer than Mtwo instruments. Complete removal of materials did not occur with any of the instrument systems investigated.

Keywords: gutta-percha, root canal retreatment, rotary instruments.

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Introduction

Residual necrotic tissue or bacteria beneath gutta-percha or sealer can be responsible for periapical inflammation or pain (Schirrmeister *et al.* 2006a). Thus, the main objective of nonsurgical retreatment is to remove all material filling from the root canal and to regain access to the apical foramen (Stabholz & Friedman 1988, Barrieshi-Nusair 2002). The techniques used to remove gutta-percha are varied and included the use of hand or rotary instruments with or without heat and solvents and/or ultrasound (Hülsmann & Bluhm 2004, Schirrmeister *et al.* 2006b).

Various nickel–titanium (NiTi) rotary endodontic instruments have been developed to facilitate cleaning and shaping of root canals. To improve safety preparation and to prepare more appropriate shapes, new instrument designs with noncutting tips, radial lands, varying tapers and rake angles, and changing pitch lengths have been developed. Rotary NiTi instruments have also been proposed for the removal of filling materials from root canal walls, and various studies reported their efficacy, cleaning ability and safety (Imura *et al.* 2000, Betti & Bramante 2001, Kosti *et al.* 2006, Zmener *et al.* 2006, Saad *et al.* 2007).

Recently, two new NiTi rotary instruments have been introduced commercially: the Mtwo (Sweden &

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Martina, Padova, Italy) and R-Endo (Micro-Mega, Besançon, France) systems. According to the manufacturer, R-Endo instruments are specifically designed to be used in retreatment. To date, their efficacy in removing gutta-percha root filling has not been reported. The aim of the present study was to investigate the efficacy of three rotary NiTi systems and one hand instrumentation sequence to remove gutta-percha root fillings.

Materials and methods

Sixty freshly extracted human single-rooted teeth, each with a single root canal, were used. Preoperative mesiodistal and buccolingual radiographs were taken of each root to confirm the canal anatomy. The teeth were verified radiographically as having patent canals with curvatures <10° (Schneider 1971). Only root canals in which apical diameter was size 15 were selected.

Access cavities into each pulp chamber were prepared using high-speed diamond burs with copious water spray. A size 10 K-file was placed in the canal until it was visualized at the apical foramen. The working length was determined by subtracting 1 mm from this measurement. The root canal was prepared using K-files with the step-back technique. Instrumentation was standardized with a size 30 K-file reaching the full working length, a size 55 file 5 mm coronally, and final coronal flaring with Gates-Glidden burs sizes 2 and 3. A size 10 K-file was used during root canal preparation to maintain patency of the canal. At each instrument change, 2 mL of 2.5% NaOCl was used. When instrumentation of the root canal was complete, 17% EDTA was applied for 1 min to remove the smear layer, and the canal was flushed again with 2.5% NaOCl. The root canals were then dried with paper points and filled with laterally compacted gutta-percha (Meta Dental Co. Ltd, Korea) and sealer that was mixed according to the manufacturer's instructions. The teeth were radiographed in the buccolingual and mesiodistal directions to confirm the adequacy of root filling. Regardless of tooth length, the extent of the root filling was uniformly limited to 14 mm from the apex so that the volume of the gutta-percha filling was approximately equal for all teeth. The access cavities were sealed with a temporary filling material (Cavit G; 3M Espe, Seefeld, Germany), and the teeth stored at 37 °C in 100% humidity for 2 weeks.

Retreatment technique

The samples were divided randomly into four groups of 15 specimens each. All roots had 6 mm of filling material removed from the cervical part of the canal using Gates-Glidden burs sizes 2 and 3. Then, 0.05 mL of chloroform solvent was introduced into each canal to soften the gutta-percha. Two or three additional drops of solvent were applied as required to reach the working length. During retreatment, the root canals were constantly irrigated with 2.5% NaOCl. All rotary instruments were used at a constant speed of 300 rpm and torque recommended by the manufacturers. After the working length was reached, rotary instruments were used to remove gutta-percha in a brushing circumferential motion whilst pressing against the root canal walls.

Group 1 (ProTaper group)
ProTaper (Dentsply Maillefer, Ballaigues, Switzerland) instruments were used in a handpiece with adjustable torque (NiTi Anthogyr Control, Dentsply Maillefer, Ballaigues, Switzerland) according to the manufacturer's instructions. The gutta-percha was removed in the following sequence using light apical pressure: F3 (size 30, 0.09–0.05 taper), F2 (size 25, 0.08–0.055 taper) and F1 (size 20, 0.07–0.055 taper) files were used with a crown-down technique with an input motion to remove the gutta-percha until the working length was reached. F2 and F3 were used again to the working length with a brushing circumferential motion to complete gutta-percha removal and cleaning of the canal walls.

Group 2 (R-Endo group)
R-Endo instruments were used with an inget type contra-angle handpiece (Inget® 06 contra-angle; Micro-Mega, Besançon, France) and manipulated in a gentle in-and-out motion according to the manufacturer's instructions. The R2 instrument (size 25, 0.06 taper) was used to two-third of the working length. The R3 (size 25, 0.04 taper) and Rs instruments (size 30, 0.04 taper) were used to the full length of the canal.

Group 3 (Mtwo group)
Mtwo instruments were used with an air-driven torque-limited rotary handpiece (Mtwo Direct VDW, Munich, Germany). The torque setting was selected with a turning ring and chosen for each file according to the manufacturer's instructions. Four instruments were used to the full length of the canals using a gentle in-and-out motion: Mtwo size 15, 0.05 taper; Mtwo size

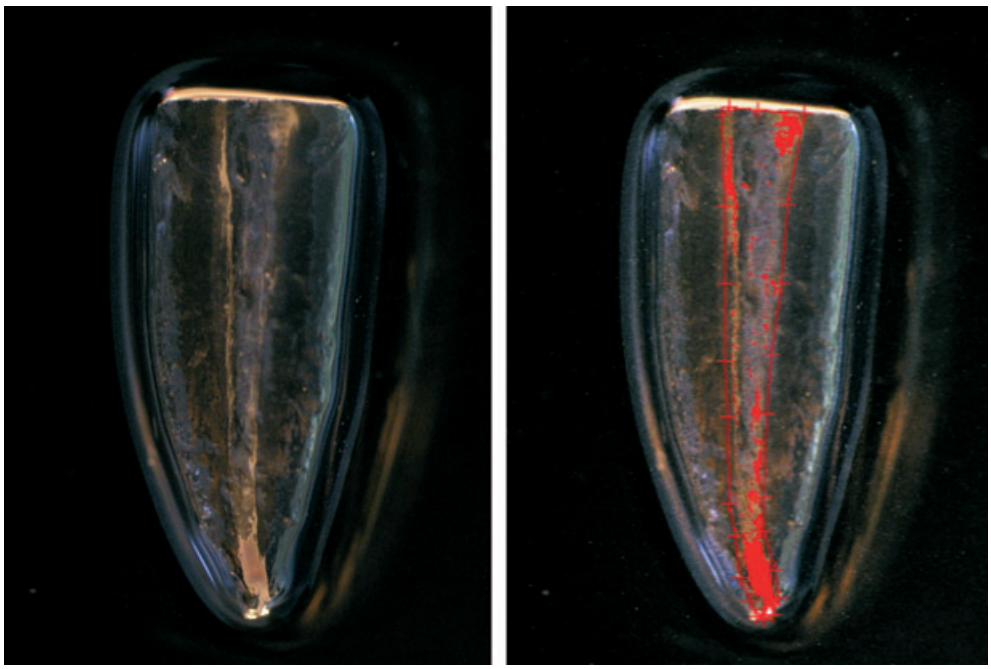

Figure 1 Images of gutta-percha and sealer remaining on the root canal walls and the calculation of the area of gutta-percha and sealer using an imaging programme after repreparation of a cleared specimen.

20, 0.06 taper; Mtwo size 25, 0.06 taper and Mtwo size 30, 0.05 taper.

Group 4 (hand instrument group)
Hand instrumentation was carried out with Hedström (VDW Antaeos, Munich, Germany) files (sizes 20–30) in a circumferential motion. A step-back procedure with Hedström files was then completed coronally in 1-mm increments to file size 55.

All instruments were used in two root canals and were then discarded. Any deformed instruments were discarded. Gutta-percha removal was judged to have been completed when the working length was reached and no more gutta-percha could be removed with the instruments used. To standardize procedures throughout the study, only one operator (TT) conducted the experiments to avoid variables during specimen preparation. The time needed for the procedure was measured with a stopwatch for each sample.

Evaluation

The teeth were rendered transparent according to the technique described by Robertson *et al.* (1980). The specimens were decalcified in 5% nitric acid for 3 days, rinsed for 4 h and dehydrated in increasing concentrations of ethyl alcohol (80% for 12 h, 90% for 1 h and 100% for 3 h). The roots were then placed in methyl salicylate which made them transparent after approximately 2 h. Specimens were photographed using a microscope with a digital camera at ×6 magnification, and the amount of gutta-percha/sealer on the canal walls was measured in mm^2 using image analyser software (Comef 4.3; OEG Messtechnik, Frankfurt, Germany) in the buccolingual and mesiodistal directions according to the technique described by Schirrmeister *et al.* (2006a,b) (Fig. 1).

Statistical analysis

Statistical analysis for remaining root filling material and working time involved the use of Kruskal–Wallis and Mann–Whitney *U*-tests with the Bonferroni correction.

Results

All instruments left filling material inside the root canal (Table 1). Imaged in the buccolingual and mesiodistal directions, the specimens retreated with the ProTaper instruments left less filling material inside the root

Table 1 The amount of remaining filling material and the time required to remove the filling material with each technique

Method	Mesiodistal (mm^2)	Buccolingual (mm^2)	Time (s)
ProTaper	3.02 ± 2.95	2.72 ± 2.77	310 ± 24
R-Endo	3.81 ± 2.95	3.75 ± 2.33	369 ± 56
Mtwo	6.15 ± 3.52	5.90 ± 3.00	282 ± 39
Hedström	5.71 ± 4.31	5.18 ± 3.83	528 ± 72

Values are expressed as mean ± SD.

canals than the other groups but significant difference was found between only ProTaper and Mtwo groups ($P < 0.05$).

The retreatment time with the Mtwo and ProTaper instruments was significantly shorter than manual instrumentation with Hedström files ($P < 0.001$). R-Endo was significantly slower than Mtwo ($P < 0.001$) and ProTaper ($P < 0.05$) but significantly faster than manual instrumentation ($P < 0.001$).

Discussion

The major factors associated with endodontic failure are the persistence of microbial infection in the root canal system and/or the periradicular area (Siqueira 2001). Thus, root canal retreatment has largely replaced periradicular surgery for the management of persisting or emerging disease. It is therefore important to remove as much sealer and gutta-percha as possible during retreatment, to uncover remnants of necrotic tissue or bacteria that might set as the antigenic source (Saad *et al.* 2007).

Conventionally, the removal of gutta-percha using hand files with or without solvent can be a tedious, time-consuming process, especially when the root filling material is well condensed (de Oliveira *et al.* 2006). Therefore, the use of rotary NiTi instruments in root canal retreatment may decrease patient and operator fatigue. In the present study, chloroform was used during the instrumentation because it is more efficient in dissolving gutta-percha than other chemicals (Tamse *et al.* 1986, Wilcox 1995). However, possible adverse health effects from exposure to chloroform should not be overlooked (Tamse *et al.* 1986).

In previous studies, the amount of filling material remaining inside the canal after the retreatment procedure was assessed radiographically (Masiero & Barletta 2005, de Carvalho Maciel & Zaccaro Scelza 2006) or the roots were split longitudinally and the residual gutta-percha and sealer were measured linearly (Imura *et al.* 2000, Zmener *et al.* 2006, Saad *et al.* 2007) or using a scoring system (Hülsmann & Stotz 1997, Hülsmann & Bluhm 2004, Kosti *et al.* 2006). In addition, computed tomography (Barletta *et al.* 2007) and operating microscopes (Schirrmeister *et al.* 2006c) have been used for this purpose. Ideally, three-dimensional visualization of the root canal system would provide a better understanding of the distribution of the debris after retreatment (Ferreira *et al.* 2001). Schirrmeister *et al.* (2006a,b) reported that residual material might be lost by splitting the roots longitudinally. In the present study, the roots were cleared to allow measurement of the area of residual filling material.

In the present study, all retreatment techniques left filling material inside the canal. This confirms previous reports by numerous investigators using different retreatment instruments, techniques and solvents (Tamse *et al.* 1986, Kaplowitz 1990, Barrieshi-Nusair 2002, Hülsmann & Bluhm 2004, Zmener *et al.* 2006, Saad *et al.* 2007). These results demonstrated that the use of ProTaper instrumentation combined with chloroform was significantly more effective than Mtwo in terms of the residual material, whilst no difference was found amongst the ProTaper, R-Endo and manual instrumentation groups. Earlier studies found that ProTaper was more effective than manual instrumentation in terms of the amount of remaining filling material inside the canal after retreatment (Hülsmann & Bluhm 2004, de Carvalho Maciel & Zaccaro Scelza 2006, Saad *et al.* 2007). By contrast, Schirrmeister *et al.* (2006b,d) observed similar amounts of residual gutta-percha and sealer after ProTaper and manual instrumentation in straight and curved root canals. R-Endo instruments are machined into a round blank and their cross-section is characterized by three equally spaced cutting edges; the instrument has neither radial lands nor an active tip. The present results indicate that the R-Endo system, which the manufacturer claims is assigned specifically for retreatment, left a similar amount of filling material in the canal walls compared with the other rotary systems (ProTaper, Mtwo) and manual instruments in canals with a curvature of <10° prepared to size 30.

The Mtwo instruments have an S-shaped cross-section, an increasing pitch length in the apical–coronal direction and a noncutting safety tip. Therefore, these instruments are characterized by a positive rake angle with two cutting edges, which are claimed to cut dentine effectively (Schäfer *et al.* 2006a). The initial reports concluded that Mtwo was found to be successful in root canal preparation (Foschi *et al.*

2004, Veltri *et al.* 2005, Schäfer *et al.* 2006a,b). As they have sharp blades, it is possible to cut through the canal and reach the apical end-point whilst bypassing gutta-percha. Furthermore, unlike the other NiTi instruments, the Mtwo rotary instruments do not require a crown-down instrumentation sequence. Using the Mtwo instruments with the single-length preparation might leave more filling material in the canal during repreparation. In addition, although there are size 35 (0.04 taper) and size 40 (0.04 taper) instruments in the Mtwo system, they were not used in the present study to standardize the canal size and taper.

In some previous studies, rotary NiTi instruments required less time for gutta-percha removal than hand instruments (Hülsmann & Bluhm 2004, Schirrmeister *et al.* 2006b, Saad *et al.* 2007). By contrast, Imura *et al.* (2000), when evaluating mandibular premolars, reported a significant difference amongst the groups for the mean retreatment time, with the Hedström instrument group requiring significantly less time than the Quantec rotary group. The reason given was the removal of gutta-percha in larger pieces. In the present study, all types of rotary NiTi instruments were significantly faster than hand files in removing gutta-percha, whilst Mtwo and ProTaper instrument systems required significantly less time for retreatment than R-Endo instruments.

No instrument fractures occurred during gutta-percha removal. The speed of the rotary NiTi instruments was adjusted according to the manufacturer's recommendation. The low-torque handpiece approved to increase tactile sensitivity, give better control of rotary instrumentation, and reduced the risk of instrument separation (Yared *et al.* 2001). In addition, using each set of instruments to prepare two root canals only, plus the use of chloroform as a solvent, might be an additional reason for the lack of instrument fracture in this study.

Conclusions

All instruments left filling material inside the root canal. Under the experimental conditions, ProTaper left significantly less gutta-percha and sealer than Mtwo instruments.

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