Ex vivo study of the efficacy of H-files and rotary Ni–Ti instruments to remove gutta-percha and four types of sealer

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Abstract

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Aim To compare the efficacy of ProFile rotary Nickel–Titanium (Ni–Ti) instruments and Hedstroem-files (H-files) combined with Gates-Glidden (GG) drills during removal of gutta-percha root fillings used in combination with one of the four representative sealers.

Methodology Forty-eight single-rooted human teeth, with fully formed apices and straight root canals were used. The root canals were accessed and instrumented using a stepback technique with H-files. They were randomly assigned to four groups and subsequently filled with a combination of lateral and vertical condensation of gutta-percha and one of the following sealers: Roth 811, AH26, Endion and Roekoseal. The root fillings were removed 1 year later, using either H-files in combination with GG drills or the ProFile Ni–Ti system. Teeth were then grooved longitudinally and split. The amount of gutta-percha and sealer remaining on the root canal walls was traced and scored visually with the aid of a stereomicroscope. The scores were analysed and statistically compared with the Kruskal–Wallis test between the ProFile and H-file groups, as well as among the four sealer subgroups. Two samples from each group were studied under the scanning electron microscope to enhance inspection of canal walls and remaining material.

Results Sealer remnants were observed with both techniques mainly in the middle and apical third of the root canal. The ProFile system and the H-files were associated with similar amounts of remaining filling material ($P > 0.05$). In the cervical third of the root canal all sealer remnants were removed with both techniques. In the middle and apical third AH26 was associated with a statistically significant greater quantity of remnants on the root canal walls with both removal techniques ($P < 0.05$). Endion, Roth 811 and Roekoseal were associated with approximately the same amount of filling material in the middle third of the root canal ($P > 0.05$), whereas in the apical third Endion was associated with significantly more remnants of filling material than the other two sealers with either ProFile or H-files ($P < 0.05$).

Conclusions None of the methods used for the removal of root fillings was totally effective, especially in the apical third of the root canal.

Keywords: AH26, Endion, gutta-percha removal, Hedstroem-file, nickel–titanium rotary instrument, ProFile System, Roekoseal, root canal retreatment, root canal sealer, Roth 811.

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Introduction

Nonsurgical root canal retreatment is the treatment of choice when root-filled teeth are associated with disease. An important step in retreatment is the removal of existing filling material to regain access to the entire canal, expose remnants of necrotic tissue and microorganisms and facilitate their removal.

Several techniques, employing various instruments have been proposed for removing root filling materials (Wilcox 1989, Friedman *et al.* 1992, Moshonov *et al.* 1994, Hülsmann & Stotz 1999, Farge *et al.* 1998, Betti

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& Bramante 2001, Barrieshi-Nusair 2002, Vidučić *et al.* 2003). Heat and a variety of solvents such as, chloroform, eucalyptol, orange oil, xylol and halothane, have also been used to soften gutta-percha and facilitate its removal. However, it has been reported that none of the retreatment methods produces completely clean root canal walls (Wilcox *et al.* 1987, Imura *et al.* 2000, Ferreira *et al.* 2001, Barrieshi-Nusair 2002).

The difficulty in gutta-percha removal is directly related to canal preparation and filling techniques, the type of sealer used as well as the time elapsed since the original treatment (Lambrianidis 2001). The majority of the laboratory studies examined teeth with root fillings performed a short time before retreatment, without investigating all representative types of sealers (Friedman *et al.* 1992, Imura *et al.* 2000, Barrieshi-Nusair 2002).

The aim of this study was to compare the efficacy of ProFile rotary nickel–titanium (Ni–Ti) endodontic instruments (Dentsply Maillefer, Baillagues, Switzerland) and Hedstroem-files (H-files; Antaeos, Vereinigte Dentalwerke GmbH & Co., Munich, Germany), used in combination with Gates-Glidden drills (GG; Antaeos) during the removal of root fillings comprising of gutta-percha and one of the four representative sealers.

Materials and methods

Forty-eight single-rooted human teeth were used. The teeth were stored for 2 days immediately after extraction at room temperature in 3% sodium hypochlorite to dissolve organic debris. Subsequently, they were cleaned with an ultrasonic scaler and washed with distilled water to remove calculus and soft-tissue debris and then immersed in 10% formalin solution until use.

Criteria for tooth selection were: existence of a single root canal, no visible root caries, fractures or cracks on examination with a ×4 magnifying glass, no signs of internal or external resorption or calcification and a fully formed apex. Only roots with less than 5° of curvature according to Schneider (1971) were included. Preoperative mesiodistal and buccolingual radiographs of each root were taken to confirm the existence of a single straight canal. Only root canals in which the first file that fitted at the apex was a size 15 were included.

Instrumentation was performed by a single operator. Access cavities were prepared and a size 10 H-file was introduced into the canal until it was visible at the apical foramen. The working length was determined by subtracting 1 mm from this measurement. This same file was used during the root canal preparation to maintain patency of the canal. Root canal preparation was performed using H-files with a stepback technique (Ingle *et al.* 2002). Instrumentation was standardized with a size 30 H-file reaching full working length, a size 55 file 5 mm coronally and a final coronal flaring with GG sizes 3 and 2. A 15% EDTA gel was used as a chelating agent. The canals were irrigated between successive instruments with 5 mL of 2.5% NaOCl delivered with 27-gauge needle tips placed passively into the canal, as far as 3 mm from the apical foramen without binding.

Samples were wrapped in aluminium foil, embedded in acrylic blocks and randomly divided into four groups A, B, C and D, comprising 12 teeth each. The sealers were prepared according to the manufacturer's instructions. The root canal walls were dried with paper points and then coated with sealer using a lentulo to 1–2 mm from the apical constriction. The root filling was performed with a combination of lateral and vertical condensation techniques using gutta-percha and either Roth 811 (Roth International, Chicago, IL, USA), AH26 (Dentsply Maillefer), Endion (Voco Dental Products, Cuxhaven, Germany) or RS Roekoseal Single Dose (Roeko Dental Products, Langenau, Germany) for groups A, B, C and D respectively (Table 1).

The quality of the root filling was evaluated with mesiodistal and buccolingual radiographs and was considered satisfactory when no voids could be detected. The access cavity was sealed temporarily (Cavit-G, Espe, Seefeld, Germany) and teeth were stored in a humidity chamber (100% humidity and 37 °C) for 1 year. The teeth in all four groups were then randomly divided in two subgroups comprising six teeth each. In subgroups A_1, B_1, C_1 and D_1, the filling was removed using H-files in combination with GG drills, whereas in subgroups A_2, B_2, C_2 and D_2, the ProFile system was used for gutta-percha removal.

In subgroups A_1, B_1, C_1 and D_1, GG size 3 and subsequently 2 were used to remove the coronal gutta-percha and create a reservoir for solvent. Increments of chloroform (0.1 mL) were placed in the canal to soften the gutta-percha; only up to two applications were used. The gutta-percha was removed using H-files, with a circumferential filling motion and copious irrigation with 2.5% NaOCl. Each stainless steel file was used five times and then discarded. The last instrument introduced to the full working length was a size 35 H-file, one size larger than the master apical file used in the original instrumentation.

Table 1 Composition of tested sealers as given by the manufacturer

Trade name	Manufacturer	Composition
Roth 811	Roth International, Chicago, IL, USA	Staybelite resin, ZnO, bismuth subcarbonate USP, barium sulphate USP, sodium borate anhydrous, catalyst: eugenol
AH26 (silver-free)	DeTrey, Zurich, Switzerland	Powder: bismuth oxide, methenamine, resin: epoxy resin
Endion	Voco Dental Products, Cuxhaven, Germany	Ca-Al-F-silicate-glass, polyacrylic acid, X-ray contrast medium, catalyst: water
Roekoseal Single Dose	Roeko Dental Products, Langenau, Germany	Polymethylsiloxane, silicone oil, paraffin-base oil, hexachloroplatinic acid (catalytic agent), zirconium dioxide

In subgroups A_2, B_2, C_2 and D_2, gutta-percha was removed using the ProFile system in a crowndown technique. Orifice Shapers No. 4 (size 50, taper 0.07) and No. 3 (size 40, taper 0.06) were used to remove the coronal gutta-percha and create a reservoir for solvent. Increments of chloroform (0.1 mL) were placed in the canal to soften gutta-percha; only up to two applications were used. ProFile instruments sizes 30 and 25, with a 0.06 taper were introduced up to two-third within the root canal followed by sizes 30 and 25, with a 0.04 taper, each progressing to the full working length; 15% EDTA gel was used as a chelating agent and copious irrigation with 2.5% NaOCl was performed during the procedure. Ni–Ti instruments were used with a speed-reduction handpiece (KaVo Dental Gmbh & Co., Biberach, Germany) and a torque control motor (ATR Tecnika, Pistoia, Italy). The instruments were used with a continuous axial motion, with a range of 2–3 mm, exerting slight apical pressure. Each Ni–Ti instrument was used five times, and then discarded. The last instrument introduced to the full working length was a size 30, with a 0.04 taper.

Criteria for the assessment of removal of the root filling material were the detection of smooth canal walls and absence of gutta-percha or sealer on the last instrument to be used. Magnifying loupes ×4.5 (Carl Zeiss, Oberkochen, Germany) were used to enhance vision.

The teeth were grooved buccolingually with a diamond disc and sectioned longitudinally. Each half was divided into coronal, middle and apical thirds. The scoring was carried out visually by three independent pre-calibrated examiners under the stereomicroscope at ×4 magnification for each half in the coronal, middle and apical third separately. In case of disagreement, all three examiners repeated the scoring together. Evaluation scales used were: score 0, no gutta-percha and no sealer; score 1, debris of sealer; score 2, debris of sealer and gutta-percha; score 3, severe debris of sealer and gutta-percha. Mean values were calculated from the scores gathered for all 12 halves of each group (A_1, B_1, C_1, D_1, A_2, B_2, C_2 and D_2) in the cervical, middle and apical thirds and in the total root canal surface (Table 2).

Table 2 Mean scores of residual debris following retreatment

Group	Cervical	Middle	Apical	Total
A_1 (Roth 811/H-file)	0.25	0.5	0.83	0.53
B_1 (AH26/H-file)	0.92	2.25	2.83	2
C_1 (Endion/H-file)	0.58	0.92	1.58	1.03
D_1 (RS/H-file)	0.08	0.50	0.83	0.47
A_2 (Roth 811/ProFile)	0.17	0.50	0.75	0.47
B_2 (AH26/ProFile)	0.92	1.92	2.42	1.75
C_2 (Endion/ProFile)	0.67	0.83	1.75	1.08
D_2 (RS/ProFile)	0.08	0.25	0.67	0.33

Statistical analysis of the scores was performed with the Kruskal–Wallis test.

Results

Sealer remnants were found with both techniques mainly at the middle and apical third of the root canal (Table 2). The ProFile system was similar when compared with H-files in the removal of the filling material and statistical analysis of the mean debris score showed no statistically significant difference ($P > 0.05$) for each of the four types of sealer removed with either technique at all canal levels. In the cervical third there was no statistically significant difference ($P < 0.05$) between the sealers studied. In both middle and apical thirds of the root canal more AH26 remnants remained on the root canal walls (Fig. 1) with both removal techniques (Table 2). Overall, AH26 was associated with significantly greater debris scores ($P < 0.05$) when compared with the other three sealers. In the middle third of the canal Roth 811 (Fig. 2) was associated with significantly less debris when compared with AH26

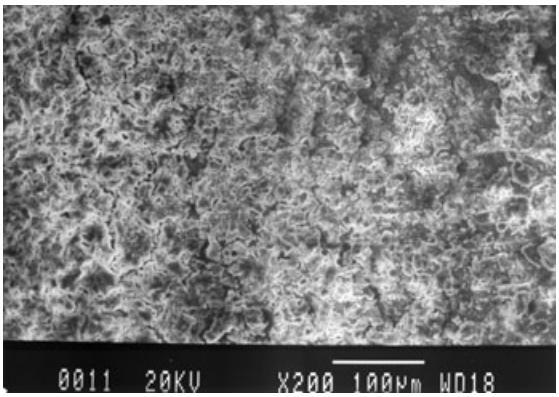

Figure 1 Middle third of the root canal after the removal of gutta-percha and AH26 sealer using Hedstroem-files (×200). Severe amount of sealer.

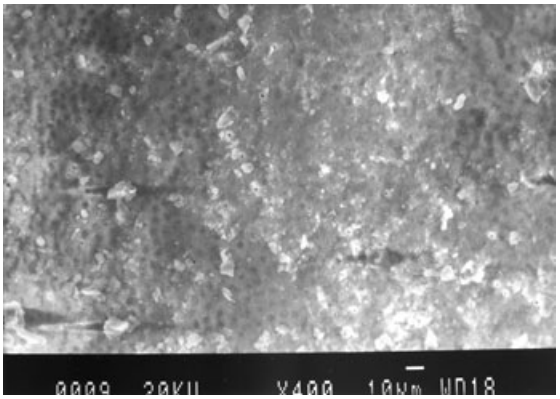

Figure 2 Middle third of the root canal after the removal of gutta-percha and Roth 811 sealer using the ProFile system (×400). Relatively clean root canal walls.

with either removal technique ($P = 0.00$ and 0.00 respectively), whereas no statistically significant difference ($P > 0.05$) was found between Roth 811 and either Endion or Roekoseal when removed with either technique. In the apical third Endion removed with H-files (Fig. 3) or ProFile (Fig. 4) was associated with significantly more debris when compared with Roth 811 ($P = 0.037$ and 0.001 for the two removal techniques respectively) and RS ($P = 0.011$ and 0.001 respectively) (Figs 5 and 6). Roth 811 and Roekoseal left almost the same amount of debris in the apical third with both removal techniques ($P > 0.05$).

Discussion

All canals had some sealer residue on the root canal walls. Overall Ni–Ti instruments were not more effect-

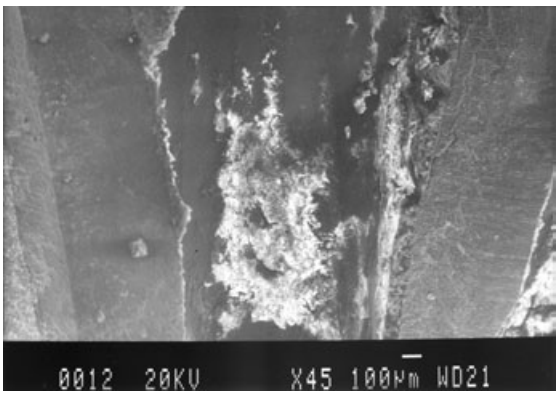

Figure 3 Middle third of the root canal after the removal of gutta-percha and Endion using Hedstroem-files (×45). Considerable amount of root canal sealer.

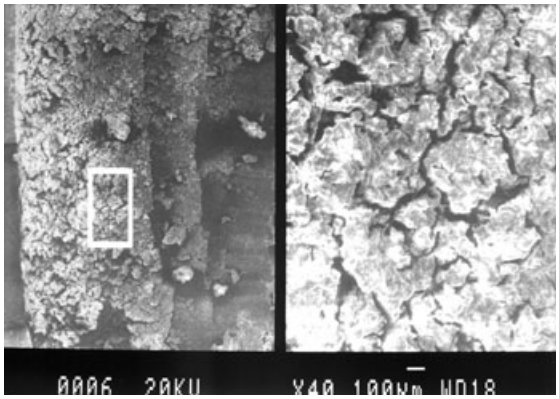

Figure 4 Apical third of the root canal after the removal of a gutta-percha and Endion sealer using the ProFile system (×40). Severe amount of root canal sealer.

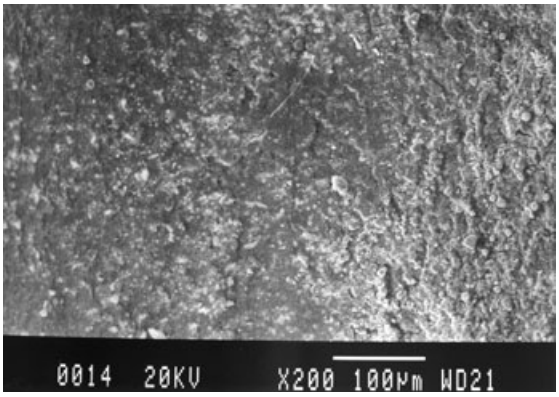

Figure 5 Middle third of the root canal after the removal of gutta-percha and Roekoseal sealer using Hedstroem-files (×200). Relatively clean root canal walls.

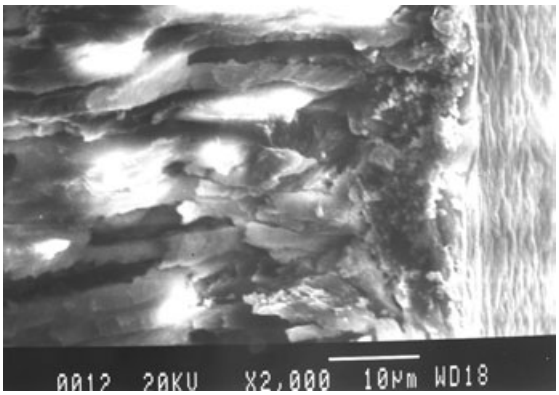

Figure 6 Middle third of the root canal after the removal of gutta-percha and Roekoseal sealer using the ProFile system (×2000). Penetration of sealer in the dentinal tubules.

ive when compared with stainless steel H-files in the removal of root filling material. Consistent with these results, several studies have shown that removal of the root fillings with Ni–Ti rotary instruments, although not more effective, is more rapid than with hand files (Teplitsky *et al.* 1992, Sae-Lim *et al.* 2000, Ferreira *et al.* 2001). On the contrary, several studies have concluded that stainless steel hand files remove filling material more effectively than Ni–Ti rotary instruments (Betti & Bramante 2001), whilst other studies (Imura *et al.* 2000, Barrieshi-Nusair 2002) reported that stainless steel hand files were faster and attributed this finding to the changing of instruments in the handpiece.

All sealers were virtually eliminated from the cervical part of the root canal with either retreatment technique, confirming the finding that rotary instruments GG drills and Orifice Shaper instruments of the ProFile system are effective in cleaning that part of the canal (Imura *et al.* 2000). On the contrary, the degree of root canal cleanliness was less satisfactory in the apical third of the canal, which is in agreement with other investigators (Teplitsky *et al.* 1992, Zuolo *et al.* 1996, Ferreira *et al.* 2001). This has been attributed to the increased anatomical variability as well as the difficulty of instrumentation in this region (Ferreira *et al.* 2001).

In this study, direct visual scoring with the aid of a stereomicroscope, as proposed earlier (Sae-Lim *et al.* 2000), was adopted for the evaluation of residual gutta-percha and sealer on the canal walls, as it was considered a simple and efficient assessment method. The examination under the scanning electron microscopy enhanced the inspection of the root canal walls.

Four types of sealer were evaluated: a ZnO-based sealer (Roth 811), a resin containing sealer (AH26), a glass–ionomer sealer (Endion) and a polydimethylsiloxane-based sealer (RS). From the materials studied AH26 was associated with the largest amount of remnant cement on the root canal walls, followed by Endion; Roth 811 and RS were associated with less residual material.

Concurring with the results of this study, other observers (Wilcox *et al.* 1987) concluded that AH26 was more difficult to remove from canal walls than Roth cement. On the contrary, others have reported that the amount of material remaining on root canal walls after the removal of root fillings with AH26 and Roth 811 was similar, and higher when a glass–ionomer sealer was used (Friedman *et al.* 1992).

The sealer properties most probably related to the ease of removal are adhesion to dentine and gutta-percha, degree of penetration into the dentinal tubules, film thickness, dimensional changes, as well as solubility.

As each sealer had different constituents and adhesive behaviours it is not surprising that varying amounts of materials remained. In a study conducted by Economides *et al.* (1999) it was shown that AH26 is more dense and compact compared with a zinc oxide-based sealer. Epoxy resin sealers are also strongly adhesive to both dentine and gutta-percha when compared with other types of cement *in vitro* (Lee *et al.* 2002).

Endion is a glass–ionomer sealer for which good adherence to dentine has been shown (Ray & Seltzer 1991, Weiger *et al.* 1995, Lee *et al.* 2002). In a laboratory adhesion test, glass–ionomer-based sealers have demonstrated five times stronger adhesion to dentine than to gutta-percha when compared with other types of cement (Lee *et al.* 2002). Furthermore it should be remembered that adhesion of glass–ionomer sealers, as well as resin-based sealers, to dentine depends on the pre-treatment of dentine (Miletic *et al.* 1999). Thus, the results of the present study could have been affected by the removal of the smear layer that had taken place with the use of 15% EDTA gel and 2.5% NaOCl solution, probably by increasing penetration of the sealer into the dentinal tubules (Saunders *et al.* 1992).

Roekoseal is a sealer containing dimethylpolysiloxane, with limited data available on its clinical performance (Huumonen *et al.* 2003) and sealing ability (Bartuskova & Perinka 2001, Wu *et al.* 2002). In a laboratory study (Çobankara *et al.* 2002) after 21 days

of observation, the sealing ability of root fillings with Roekoseal in combination with the lateral condensation technique was better than those with a glass–ionomer sealer, a resin-based sealer and a zinc oxide sealer; after 1 week the situation was reversed. The slow setting properties of this material could be an explanation for its diminished leakage. Silicone-based sealers are inert and biocompatible, yet no information is available on their adhesion to dentine.

In this study, removal of Roth 811 was comparatively effective. In a laboratory study (Lee *et al.* 2002) a zinc oxide-based sealer had very low bond strength to dentine, corroborating previous results (Grossman 1976, McComb & Smith 1976). However, its bond to gutta-percha was significantly high.

In this study, a lentulo spiral filler was used for the application of the various sealers. The method of application of the sealer may affect its distribution on the canal walls and ultimately the ease and thoroughness of removal. The results of this study might have been different if the method of sealer application was different.

Conclusions

Both ProFile and Hedstroem files left root filling material on the root canal walls, mostly in the middle and apical third of the canal, irrespective of the type of sealer used.

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