The efficacy of gutta-percha removal using ProFiles

J. J. Ferreira, J. S. Rhodes & T. R. Pitt Ford
Department of Conservative Dentistry, Guy's, King's and St. Thomas' Dental Institute, Kings College, London, UK

Abstract

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Aim The purpose of this study was to compare the efficacy *in vitro* of gutta-percha removal from obturated root canals using ProFiles.

Methodology Forty-eight human root canals with curvatures ranging between 25 and 45° were instrumented by a standardized method to an apical ISO size 30 and 0.04 taper. They were obturated with vertically condensed gutta-percha. Retreatment was performed with the following techniques: K-Flexofiles with chloroform; Hedstrom files with chloroform; ProFiles 0.04 taper with chloroform; ProFiles 0.04 taper alone. The time for each method was measured. A microfocal macroradiographic technique was used to evaluate the amount of debris remaining within the root canals after the retreatment procedure. Roots were divided into apical, middle and coronal parts and scored on a scale of 0 (no debris) to 3 (>50% of walls covered with debris) by trained observers on two separate occasions.

Results The scores for debris remaining within root canals for K-Flexofiles with chloroform and ProFiles with chloroform were the lowest and not significantly different at all three levels of the roots examined ($P > 0.05$), and Hedstrom files with chloroform and ProFiles with chloroform were not significantly different in the apical part. In general, coronal parts were cleaner than apical parts. The difference in scores at the three levels between ProFiles with chloroform and ProFiles alone were each significant ($P < 0.01$). Instrumentation using ProFiles with chloroform (mean 6.42 min) was significantly faster than using hand files (mean 11.67 min) ($P < 0.01$).

Conclusion The results indicated that ProFiles or hand files with chloroform produced similarly clean canals, but that ProFiles were faster.

Keywords: gutta-percha, nickel–titanium files, retreatment, solvents.

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Introduction

The aim of root canal retreatment is to remove the existing root canal filling material completely, thereby allowing the entire root canal system to be cleaned.

Gutta-percha is soluble in a variety of organic solvents such as chloroform, halothane and rectified turpentine. Chloroform is the most effective solvent for gutta-percha (Tamse *et al.* 1986, Wennberg & Ørstavik 1989).

Many previous studies on endodontic retreatment have used teeth obturated by lateral condensation (Wilcox *et al.* 1987, Wilcox 1989). With the growing use and development of warm vertical condensation, it would be appropriate to investigate the efficacy of retreatment of this obturation technique. These previous studies used straight-rooted teeth (Wilcox *et al.* 1987, Wilcox 1989), however, instrumentation of curved canals is more challenging, and makes effective cleaning of the root canal system more difficult. Curved root canals would therefore be a better model for assessing the efficacy of retreatment. More recently, Barrieshi *et al.* (1995) found no statistical difference in the ability of Kerr's K-Flex files with chloroform to remove gutta-percha and sealer against ProFile 0.04 Series 29 rotary files with chloroform.

Testing the efficacy of a retreatment procedure requires assessment of the root canal walls for cleanliness. Wilcox *et al.* (1987) and Wilcox (1989) used a method of splitting teeth longitudinally; samples were photographed, magnified and traced. The remaining material was quantified using a computer software package. The

Correspondence: J. S. Rhodes, Department of Conservative Dentistry, GKT Dental Institute, Guy's Hospital, London SE1 9RT, UK (e-mail: john.rhodes@kcl.ac.uk).

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problems with sectioning are that it can disturb the remaining filling and it is unpredictable. Images viewed from just one direction will not indicate the thickness of debris. Radiography is commonly used to evaluate cleanliness of root canals both clinically and in experimental work. The images produced are two-dimensional representations of three-dimensional structures and may be subject to magnification and distortion; fine layers of debris may not be sufficiently radiopaque to be picked out. The sharpness of an image has a profound effect on interpretation. Medical grade mammography film has an emulsion coating on only one side, and is used with an intensifying screen to produce images of high resolution and magnification. This film has been used in previous endodontic research (Ahmad & Pitt Ford 1989), and it therefore should be suitable for assessing the canal walls in retreatment investigations.

The purpose of this study was to compare the efficacy *in vitro* of gutta-percha removal from obturated root canals using nickel-titanium rotary files, ProFiles.

Materials and methods

Extracted human molars and premolars with curved roots were obtained and stored in 10% buffered formalin. The crowns were removed. Teeth with observable double curvatures and bifurcating canals were discarded. Each root was mounted so that the degree of greatest curvature could be viewed and radiographed in a standardized manner; canal curvatures were calculated (Schneider 1971). A proximal radiograph was then taken. Only roots with radiologically visible single canals of 9–13 mm length and curvatures ranging 25–45° were selected.

A size 10 K-Flexofile (Dentsply Maillefer, Ballaigues, Switzerland) was passed l mm beyond the apex of each canal to confirm patency; canals which were patent to greater than ISO size 20 were discarded. In this way the final size of the apical preparation could be standardized as it was intended to instrument all canals to master apical size 30.

Preparation of teeth

All canals were prepared by the same operator using a standardized technique. A size 10 K-Flexofile was placed into the canal until just visible at the apical foramen and the working length recorded as being 0.5 mm less than that length. Canals were initially flooded with 17% EDTA before preparation. A Gates Glidden bur (ISO size 90) was inserted approximately 2 mm into the canal orifice. The canals were instrumented with sizes l5 and 20 K-Flexofiles using a balanced force motion to the working length. This was followed by preparation with a series of ProFiles rotated at 300 r.p.m. Preparation was completed when a ProFile, 0.04 taper, that had a tip equivalent to ISO size 30, was at the working length. Canals were irrigated between instruments with 3 mL water using a disposable syringe.

Obturation

A fine–medium feathered cone (Kerr, Romulus, MI, USA) was trimmed to fit at the working length with 'tug back'. The equivalent sized System B condenser (Analytic Technology, Redmond, WA, USA) had a rubber stop placed 5 mm short of the working length. Canals were dried with paper points and the cone lightly coated with sealer (Pulp canal sealer EWT, Kerr) before being placed into the canal to length. The System B unit was set at 200 °C and power 10 for obturation. All points were seared off at the canal orifices. The activated condenser was then pushed apically into the gutta-percha until just short of the premeasured length. At this point the condenser was seated to length without heat and apical pressure maintained for approximately 10 s. A second burst of heat was used to remove the condenser. Canals were back filled with gutta-percha from the Obtura II and condensed with Machtou pluggers.

The standard of obturation was assessed using buccolingual and proximal radiographs. A filling was deemed adequate when it appeared to be dense and contained no voids; inadequately filled canals were recondensed. The prepared roots were randomly assigned to one of four groups.

Retreatment techniques

Initially a Gates Glidden bur (ISO size 90) was used to remove 2 mm coronal gutta-percha in a vertical manner. Hand files or engine-driven files were used to remove the remainder. Each file was used for a maximum of four canals but if unwinding or fracture occurred, the information was recorded, and instrument or tooth replaced.

The time required for each retreatment method was recorded commencing after initial gutta-percha removal with a Gates Glidden bur and ending when canals were deemed to be clean.

K-Flexofiles with chloroform. Using an endodontic syringe a few drops of chloroform were deposited into the reservoir created by the Gates Glidden bur. Using a crown-down technique and watch-winding motion,

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gutta-percha was removed to the working length, beginning with a size 30 K-Flexofile followed by sizes 25, 20 and 15. Once the working length had been reached with a size 15 file, sizes 20, 25 and 30 were instrumented to the same length. When file flutes were consistently clean on removal, the canal was flooded with maximum 0.1 mL chloroform and agitated with a size 15 file. Paper points were used to wick the dissolved gutta-percha until the canal appeared to be empty. Each root was finally flushed with 3 mL water.

Hedstrom files with chloroform. A few drops of chloroform were deposited into the reservoir created by an ISO size 90 Gates Glidden bur. The gutta-percha was removed with Hedstrom files sizes 30–15 (in descending order) to the working length using a filing action. Once the working length had been reached with a size 15 file, sizes 20, 25 and 30 were instrumented to the working length. When no further gutta-percha could be removed, the canal was wicked as described previously and irrigated with 3 mL water.

ProFiles with chloroform. A few drops of chloroform were placed in the reservoir space created by the Gates Glidden bur. A ProFile 0.04 taper ISO size 30 tip, was used in a rotary electric handpiece at 300 r.p.m. with light apical pulses of pressure to remove gutta-percha. Adherent material was removed from the file during instrumentation and chloroform replenished. This procedure was repeated until the working length had been reached and no further gutta-percha could be removed by the ProFile. Wicking was carried out as described previously and the canals flushed with 3 mL of water.

ProFiles alone. An 0.04 taper ISO 30 tip ProFile was used running at 300 r.p.m. Light apical pulses of pressure were used to work the file apically to the working length. No lubricant, irrigant or solvent was used. The procedure was considered complete when no further gutta-percha could be seen on the file. Canals were then irrigated with 3 mL water.

Radiographic technique

A macroradiographic technique was used to assess cleanliness of canals. Roots were remounted and two radiographs taken with 90° between angulation. The reproducibility was confirmed by superimposing the radiographs of the pretreated and retreated roots on an X-ray viewer. The X-ray unit was an industrial microfocal unit with focal spot size l00 µm and 25 µm aluminium exit port. The exposure time was 4 s, potential difference 50 kV and current 2.5 mA, using fine grain mammography film (Agfa, MR5, Munich, Germany). The magnification was ×5.4. Radiographs were processed automatically in a darkroom using a Gevamatic 60 medical X-ray film processor (type 9432/131, Munich, Germany) with its own developer (G153) and fixer (G354).

Evaluation

The specimens were independently evaluated by five trained dentists. Each radiograph was mounted onto black card to mask excess light and reveal only the tooth outline and canal contents. The apical, middle and coronal thirds of each root were marked beside the radiograph. Each viewing card had four radiographs of the same tooth. The two views on the left were the clinical and proximal radiographs of the instrumented but unfilled canals. The two views on the right were the clinical and proximal radiographs of the postinstrumented teeth (i.e. after the root canal filling was removed). Each card was coded so the observer did not know the method of retreatment. Radiographs were examined in a darkened room using two radiograph viewing boxes. The left hand viewer had example radiographs with scores of radiopaque debris for the three levels for comparison. The right hand box was used to examine experimental radiographs. Each observer was given written and verbal instructions before scoring the experimental radiographs.

Observers were asked to give one of the following scores for each third of the root canal: 0 = if no radiopaque debris could be observed; 1 = <25% debris; 2 = 25 – 50% debris; 3 = >50% debris.

Bucco-lingual and proximal views of each retreated root were used by the observers to gauge how much debris (gutta-percha/sealer) remained; this was compared with the example radiographs and a score given. Radiographs were rescored by the same observers 1 week later using the same method to check reproducibility (Figs 1–3).

Analysis of data

Data was analysed using a Stata Version 5.0 with significance predetermined at a level of 0.05. Intra-observer reliability over the two sessions was tested using the Spearman Brown prophecy formula. The Kruskal–Wallis test was used to estimate interobserver correlation and to compare the difference between retreatment groups at the three levels. The Bonferroni correction was used in the latter because there was no standard method for multiple comparisons in a nonparametric analysis.

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Figure 1 A mesial–distal view showing score 0 at all levels.

Figure 2 A buccal–lingual view showing score 3 apically, score 2 in the middle level and 1 in the coronal level.

Results

Each group analysed consisted of 12 roots. There was no significant difference between examiners' assessment at each recording session nor between individual examiners. Therefore the data were pooled.

Figures 4–6 are histograms of the distribution of the scores for each method of retreatment within the coronal, middle and apical parts of the roots examined.

Tables 1–3 display the probability values using Kruskal–Wallis analysis to determine differences between each method of retreatment at the three levels. No significant difference was found between Profiles with chloroform and K-Flexofiles with chloroform at all three levels. In the coronal area there was no significant difference between ProFiles with chloroform and Hedstrom files with chloroform.

The mean times required for retreatment of teeth are given in Table 4. Statistical analysis showed a significant difference between ProFiles with chloroform and K-Flexofiles with chloroform ($P < 0.01$).

Discussion

The majority of root canals have some degree of root curvature, which makes instrumentation and obturation challenging. Root canal retreatment can be assessed in simulated curved canals, but consideration must also be given to canal irregularities, such as fins, because root filling material is more difficult to remove from these areas. Complete cleaning is dependent on effective canal repreparation.

Teeth were chosen which had root curvatures between 25 and 45° as these were classed as severe by Schneider (1971) and present a challenge to clinicians. The roots were prepared, obturated and randomly assigned to one of the four groups tested.

Considerable effort has been spent by researchers and clinicians in developing instruments and techniques to

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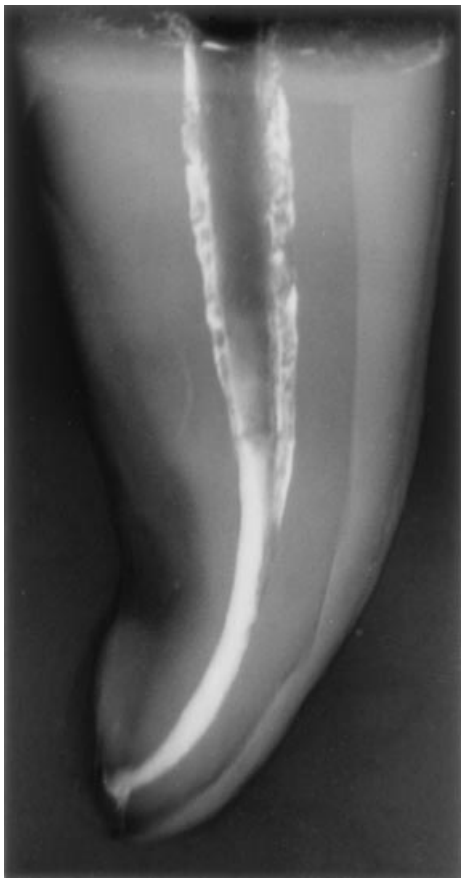

Figure 3 The mesial–distal view of Fig. 2.

cope with curved canals (Weine *et al.* 1976, Roane *et al.* 1985, Walia *et al.* 1988). Therefore, these curvatures should be considered when investigating the root canal retreatment of teeth. The macroradiographic technique has successfully been used in the past to compare canal shapes pre- and postoperatively (Ahmad & Pitt Ford 1989).

It was impossible to standardize completely the shape of each root canal. As each canal varies in its initial size and shape, a standardized method of root canal preparation was used to reduce the number of variations within each root canal system when finally prepared. Preparation was undertaken by a single operator following a predetermined protocol. By using files with an increased taper, a certain amount of dimensional uniformity was produced in the final canal shape within the confines of the natural teeth used. This meant that obturation could also be standardized. Randomly distributing teeth into separate groups further reduced the possibility of polarizing grossly variable teeth to a single group.

Most previous retreatment studies have used teeth obturated by lateral condensation, which does not create a homogeneous mass of gutta-percha but tends to entrap pools of sealer in the filling mass and concentrates the condensation more to the middle and coronal thirds rather than the apical third (Nguyen 1994). The thermoplasticized gutta-percha technique used with vertical condensation was found to give consistent homogeneous obturation with gutta-percha. By taking radiographs in the buccolingual and mesiodistal direction for each tooth, density and completeness of obturation could be checked. The aim was to fill all dimensions of the root canals densely with gutta-percha and sealer and thus provide a greater challenge for the subsequent retreatment.

It was only possible to make a semiquantitative evaluation of the amount of debris remaining. Evaluation was subjective, and observer performance is known to be variable in many cases where diagnosis is required. To standardize scoring as much as possible, evaluators were provided with written instructions beforehand. Just prior to assessment, these instructions were reiterated and examples of retreated teeth and their expected scoring provided. The purpose was to derive a common scoring pattern for each observer. Reit (1987) found that interindividual agreement can be increased by examiner calibration. The results showed no significant difference between the examiners' assessment at each recording session nor between individual examiners. This indicates the good reliability of the method used.

The macroradiographic technique gave excellent definition of the canal morphology and debris remaining after retreatment. The combination of the mammography film and an intensifying screen used in this system was sensitive enough to identify small areas of remaining gutta-percha and sealer; however, the method could not distinguish between the two materials. In this study, a very radiopaque sealer was used. Radiographs are limited to two-dimensions. Ideally, three-dimensional visualization of the root canal system would provide a better understanding of the distribution of the debris after retreatment. Micro-computed tomography may be a viable alternative for the qualitative and quantitative evaluation of retreatment procedures (Rhodes *et al.* 1999).

The radiographic technique produced magnification with good resolution that would be impossible by conventional dental radiography. By examining the teeth from two views at right angles to each other an overall impression of the amount of debris remaining could be obtained. It was noticed that much of the remaining

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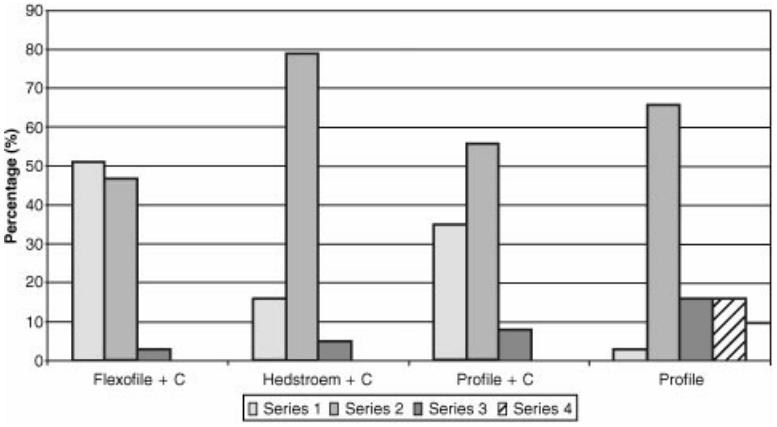

Figure 4 A histogram showing the distribution of debris scores (%) at the apical level.

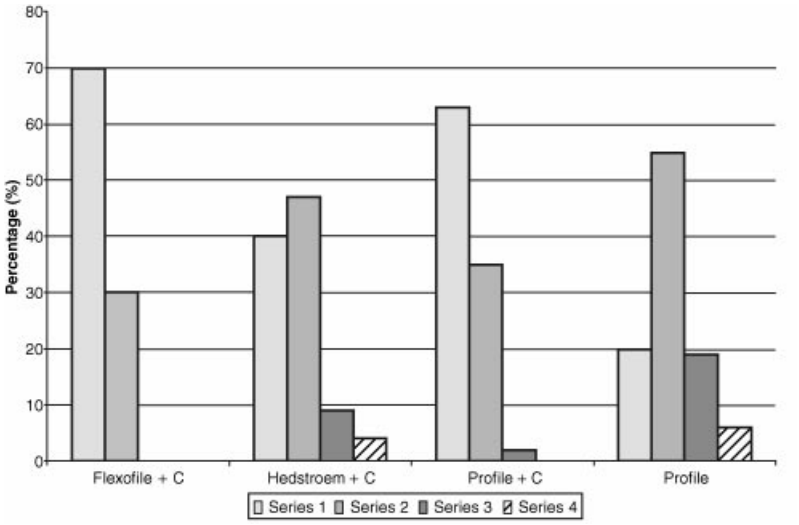

Figure 5 A histogram showing the distribution of debris scores (%) at the middle level.

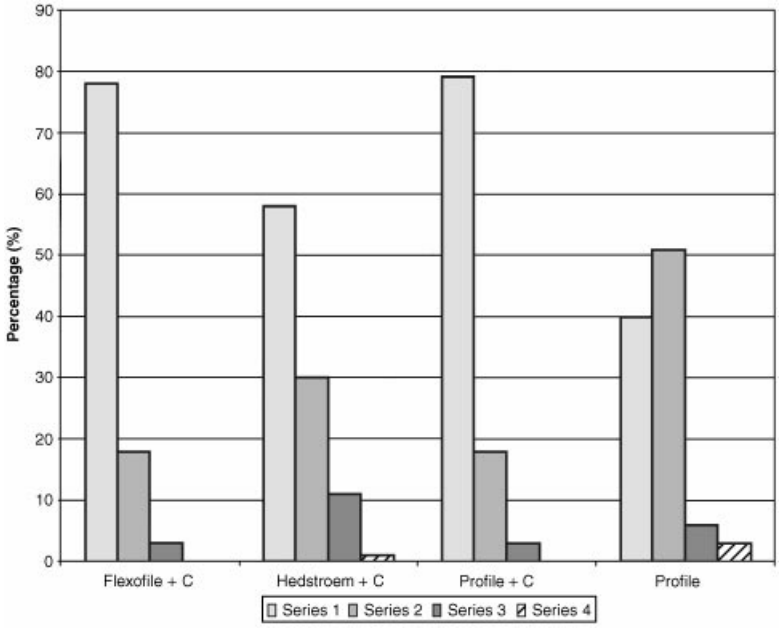

Figure 6 A histogram showing the distribution of debris scores (%) at the coronal level.

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Table 1 Probability values to determine differences between each method of retreatment at the coronal level. Kruskal–Wallis test with Bonferroni correction

	Hedstrom files + C	ProFiles + C	ProFiles
Flexofiles + C	0.01	1.00	0.01
Hedstrom files + C		0.01	0.17
ProFiles + C			0.01
ProFiles			

[a]C indicates chloroform.

Table 2 Probability values to determine differences between each method of retreatment at the middle level. Kruskal–Wallis test with Bonferroni correction

	Hedstrom files + C	ProFiles + C	ProFiles
Flexofiles + C	0.01	1.00	0.01
Hedstrom files + C		0.01	0.01
ProFiles + C			0.01
ProFiles			

[a]C indicates chloroform.

Table 3 Probability values to determine differences between each method of retreatment at the apical level. Kruskal–Wallis test with Bonferroni correction

	Hedstrom files + C	ProFiles + C	ProFiles
Flexofiles + C	0.01	0.08	0.01
Hedstrom files + C		0.10	0.01
ProFiles + C			0.01
ProFiles			

[a]C indicates chloroform.

Table 4 The mean and standard deviation (SD) of the times (min) required for gutta-percha removal in each group

	Mean	SD
K-Flexofiles + C	11.67	2.57
Hedstrom files + C	10.75	2.49
ProFiles + C	6.42	1.31
ProFiles	1.35	0.23

[a]C indicates chloroform.
[b]Number in each group was 12.

debris in the groups where chloroform had been used was located in fins and areas of canal aberration. When viewed bucco-lingually, these areas looked densely covered with remaining debris but the mesio-distal view showed a sparsely covered area which had been superimposed to give the impression of a thick mass of debris. The complex anatomy of a root canal system would make it impossible for the removal of thermoplasticized gutta-percha to be performed completely using ProFiles alone; the use of solvent was essential.

All the retreatment procedures left more debris apically than coronally. There is increased anatomical variability and difficulty of instrumentation in this region. This part would be likely to be infected by bacteria, therefore it is important in retreatment to be able to shape and clean this part, a procedure made possible only by removal of any existing root canal filling.

From the results, there was no significant difference between ProFiles with chloroform and K-Flexofiles with chloroform at all three levels of the roots. The rotary methods were considerably faster than the hand methods. The time for the ProFiles alone was less than that for Profiles with chloroform, as would be expected. Profiles with chloroform were significantly quicker ($P < 0.05$) than K-Flexofiles with chloroform.

Conclusions

The results of this study imply that the efficacy of gutta-percha removal with ProFiles is much greater when chloroform is used. There was no statistically significant difference in canal cleanliness between K-Flexofiles and ProFiles. ProFiles were significantly faster than hand files.

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