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Efficacy of automated versus hand instrumentation during root canal retreatment: an *ex vivo* study

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Abstract

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Aim To compare automated and manual instrumentation techniques for removing filling material from root canal walls during root canal retreatment.

Methodology One hundred extracted human single-rooted teeth were root filled and stored. Specimens were divided into two groups: group A, Endofill plus gutta-percha; group B, Sealer 26 plus gutta-percha. The filling material was removed using the following techniques: group I – Gates–Glidden and K-type files; group II – ProFile; group III – ProTaper; group IV – K3; group V– Micro Mega Hero 642. The remaining filling debris on the root canal walls were assessed radiographically, images were digitized and analysed using Image ProPlus software. The roots were split for evaluation in a stereomicroscope by epiluminescence and photomicrographs were taken for further analysis. The area covered with filling debris was analysed by means of Student's *t*-test to compare the evaluation methods. The student's *t*-test was also used to compare the removal of filling materials. An ANOVA test was applied to compare the different techniques ($P < 0.05$).

Results A significant difference occurred between radiographic and photomicrographic evaluation methods ($P < 0.05$). No significant difference was observed between the filling materials on terms of their removal ($P > 0.05$). Manual instrumentation left more filling debris on the root canal walls when compared to K3 ($P < 0.05$) and ProTaper ($P < 0.01$).

Conclusions A photomicrographic method by epiluminescence was more effective than the radiographic method to evaluate filling debris. There was no significant difference between the filling materials in terms of their removal. K3 and ProTaper were more efficient than manual instrumentation.

Keywords: automated instrumentation, gutta-percha, root canal retreatment.

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Introduction

During retreatment, it is essential to remove all the filling material so that the residual microbial population can be eliminated (Stabholz & Friedman 1988, Friedman *et al.* 1989, Chohayeb 1992).

A variety of different techniques have been used for removing filling materials. These include stainless steel hand files, heat, ultrasonics, laser and rotary instruments with or without the aid of solvents (Taintor *et al.* 1983, Friedman *et al.* 1989, Hülsmann & Stotz 1997, Farge *et al.* 1998, Barletta & Lagranha 2002, Hülsmann & Bluhm 2004).

To facilitate the removal of filling material without damage to the tooth, chemical solvents have been used for solubilization of gutta-percha (Barbosa *et al.* 1994, Chutich *et al.* 1995). In the studies of Hansen (1998) and Oyama (2003), orange oil was shown to be an effective solvent, less cytotoxic than eucalyptol, xylol, chloroform and halothane.

Several automated instrumentation techniques have been proposed as alternatives to manual instrumentation for the removal of filling materials from root canal walls (Barrieshi *et al.* 1995, Zuolo *et al.* 1996, Barletta & Lagranha 2002, Barrieshi-Nusair 2002, Hülsmann &

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Bluhm 2004, Masiero & Barletta 2005). Studies have reported that NiTi instruments were safe, fast and efficient. The maintenance of the root canal shape with the use of an automated device was more rapid and avoided apical extrusion of debris (Barrieshi *et al.* 1995, Zuolo *et al.* 1996, Barletta & Lagranha 2002, Barrieshi-Nusair 2002, Hülsmann & Bluhm 2004, Masiero & Barletta 2005).

The purpose of the present study was to compare manual and automated instrumentation techniques for removing filling materials (gutta-percha and two kinds of sealers: Sealer 26 and Endofill) from root canal walls in root canal retreatment.

Materials and methods

One hundred extracted human single-rooted teeth obtained from the Tooth Bank of the Universidade Federal Fluminense were radiographed to select those with single straight canals, fully formed apices and no calcifications or internal resorptions.

The crowns were removed to provide roots measuring 21 mm in length. Working length was determined at 20 mm and the root canals were prepared in a crown-down technique to a size 30 K-type file apically and flared cervically to a size 80 K-type file.

Canals were irrigated copiously with 2 mL of 5.25% NaOCl (Formula & Ação Farmácia, São Paulo, SP, Brazil) at each change of instrument. When instrumentation was completed, canals were irrigated with 20 mL of 10% citric acid for smear layer removal and then 20 mL of distilled water (Formula & Ação Farmácia).

The roots were dried with paper points and randomly divided into two groups of 50 roots each. One group was filled with gutta-percha and Sealer 26, a resin-based sealer with calcium hydroxide (Dentsply, Petrópolis, RJ, Brazil) and the other with gutta-percha and a zinc-oxide–eugenol-based sealer, Endofill (Dentsply). Lateral condensation was used in both groups. The coronal access cavities of the specimens were sealed with a temporary filling material (Coltosol; Coltene-Whaledent, Cuyahoga Falls, OH, USA).

The roots were radiographed and stored at 37 °C in 100% humidity (artificial saliva) for 3 months. The two groups were further divided into five subgroups of 10 teeth each according to the instrumentation technique employed to remove the filling material.

The temporary filling material was removed and to facilitate instrument penetration into the root canal, two drops of orange oil solvent (Formula & Ação Farmácia) were applied to the gutta-percha for 10 min. All the roots were first negotiated with size 20 K-type file to achieve working length.

Thereafter, removal of the filling materials continued with one of the following techniques.

Group I – manual (control)

Gates–Glidden drills sizes 3 and 4 (Dentsply Maillefer, Ballaigues, Switzerland) were used to remove filling material from the cervical and middle thirds of the root canals. A size 60 K-type file (Dentsply Maillefer) was introduced in the canal and then used sequentially with smaller diameter sizes 55, 50 and 45 to the end-point until working length was achieved with sizes 40 or 35 K-type files. Apical diameter was enlarged to size 45 at working length and a cervical flare to size 80 was achieved.

Group II – ProFile

ProFile 0.04 taper instruments (Dentsply Maillefer) sizes 90, 60 and 45 were used sequentially until working length was reached. Apical diameter was enlarged to size 45 using a K-type file at working length.

Group III – ProTaper

A ProTaper Starter Kit (Dentsply Maillefer) consisting of 'Shaping Files' S1, S2, S1, was used in decreasing instrument sizes until working length was accomplished. Apical instrumentation at working length was completed with 'Finishing Files' F1, F2 and F3, the F3 instrument corresponding to a size 30.

Group IV – K3

K3 0.04 taper instruments (Sybron-Endo, Orange, CA, USA) of sizes 60, 50 and 45 were used sequentially to reach working length. The apical diameter was enlarged to a size 45 at working length.

Group V – Micro Mega Hero 642

A 0.06 taper size 30 Micro Mega Hero instrument (MicroMega, Besançon, France) was introduced two-thirds into the root canal. Then, a 0.04 taper size 30 was used 2 mm from working length, and a 0.02 taper size 30 used at working length. Apical instrumentation was completed with 0.02 taper instrument of sizes 35, 40 and 45 at working length.

In summary, reinstrumentation followed a crown-down sequence for all the techniques employed with a final apical diameter corresponding to size 45 instrument, except for the ProTaper group, where the apical diameter corresponded to size 30.

When difficulties during material removal occurred, instrumentation with a size 20 K-type file and ensuring apical patency with a size15 K-type file were undertaken.

Copious irrigation with 2 mL of 5.25% NaOCl was performed throughout the procedures at each change of instrument.

Working time for automated instruments inside the root canals was standardized as 10 s, at 300 rpm and 2 N cm torque. An Endo plus P65 (VK-Driller Equipamentos Elétricos Ltda, São Paulo, Brazil) system and a 1 : 1 handpiece (Kavo do Brasil S.A.-Ind. Brasileira, Santa Catarina, Brazil) were used with an amplitude of 3 mm.

All instruments were used in three root canals and were then discarded. Reinstrumentation was considered complete when no more filling materials were observed in the irrigating solution.

The roots were radiographed in a buccolingual direction, the images digitized with Genius ColorPage Vivid Pro scanner (Genius Inc., Dongguan City, Guangdong Provience, China) at 600 pixels inch^{-1} and analysed with Image ProPlus 4.5.2.9 software (Media Cybernetics, Los Angeles, CA, USA) for evaluation of the amount of filling debris remaining on root canal walls. The ratios between these areas were calculated as percentages of remaining filling debris (Fig. 1).

The roots were then cut longitudinally and photographed with a SONY DXC-151A (Sony Corporation, Tokyo, Japan) camera adapted to a trinocular stereomicroscope (Olympus SZX; Olympus, Tokyo, Japan) and a Pentium III computer (New Orchard Road Armonk, New York, NY, USA).

The portion of the roots that had the largest area of the root canals and the largest quantity of filling debris were selected for analysis using a stereomicroscope, illuminated with a Nikon 100 W optical fibre (Nikon Corporation, Tokyo, Japan). This type of illumination is known as epiluminescence. The images were captured at ×6 original magnification (Fig. 2).

Filling debris observed in the digitized images were segmented by tones of greyish colour, numerically

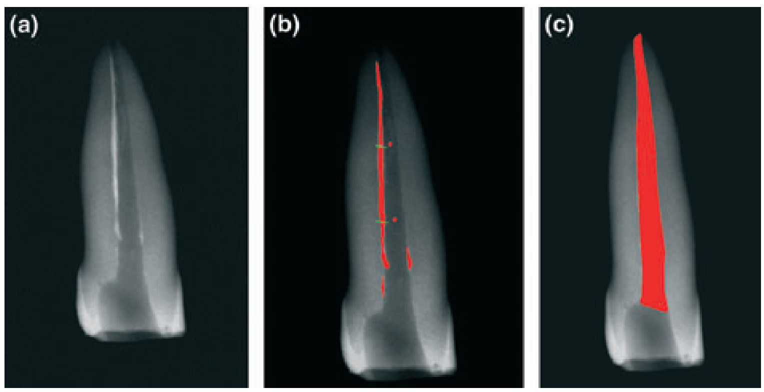

Figure 1 Radiographic analysis (a). Filling debris (b). Total area of the root canal (c).

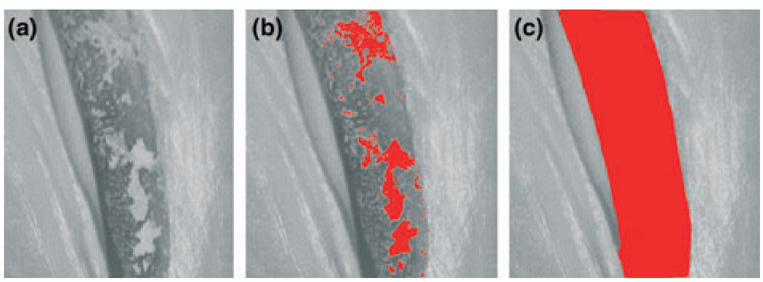

Figure 2 Photomicrographic analysis ×6 magnification (a). Filling debris (b). Total area of the root canal (c).

Table 1 Comparative analysis of the methods of evaluation – epiluminescence with optical fibre (Epi) or digitized radiographs (Rad) expressed as percentages of remaining filling debris

	HE Epi	HE Rad	K^3 Epi	K^3 Rad	MN Epi	MN Rad	PF Epi	PF Rad	PT Epi	PT Rad
Mean	53.28	8.98	34.70	6.57	71.95	9.02	52.46	7.59	23.74	2.98
Standard error	8.945	2.428	9.633	3.253	4.765	3.887	12.000	1.918	7.432	0.950
P (*t*-test)	0.0001		0.0127		<0.0001		0.0017		0.0126	

K^3, K3; MN, manual; PF, ProFile; PT, ProTaper; HE, Micro Mega Hero instruments.

Table 2 Comparative analysis of material removal – Sealer 26 (Sea) and Endofill (End), by epiluminescence expressed as percentages of remaining filling debris

	HE Sea	HE End	K^3 Sea	K^3 End	MN Sea	MN End	PF Sea	PF End	PT Sea	PT End
Mean	36.76	53.28	31.64	34.70	45.46	71.95	43.49	52.46	27.51	23.74
Standard error	7.707	8.945	8.910	9.633	13.52	4.765	6.998	12.00	5.848	7.432
P (*t*-test)	0.1787		0.8184		0.0812		0.5268		0.6949	

K^3, K3; MN, manual; PF, ProFile; PT, ProTaper; HE, Micro Mega Hero instruments.

represented by the relative area occupied on the root canal walls. Differences in the amount of filling debris detected by each evaluation method (radiographic and photomicrographic) were compared by Student's *t*-test that was also used to make a comparison between the two sealers (Sealer 26 and Endofill). ANOVA was applied to compare the different techniques for removing the material (manual and automated instrumentation techniques) with a level of significance of 5% ($P < 0.05$).

Results

A significant statistical difference was found between the radiographic (Rad) and photomicrographic by epiluminescence methods (Epi) ($P < 0.05$) (Table 1).

No significant differences were found in the amount of debris removed when comparing the sealers ($P > 0.05$) (Table 2).

Significant differences were found between the amount of filling debris remaining on canal walls by manual (MN), K^3 (K3) ($P < 0.05$) and ProTaper (PT) ($P < 0.01$) instruments (Table 3).

Table 3 Numerical values derived from the ANOVA test, applied to the data obtained from epiluminescence images

Comparisons	*P*-value	95% interval
HE versus K3	>0.05	−15.02 to 53.08
HE versus MN	>0.05	−51.08 to 14.92
HE versus PF	>0.05	−31.59 to 34.40
HE versus PT	>0.05	−2.873 to 63.13
K3 versus MN	<0.05	−73.73 to −0.4863
K3 versus PF	>0.05	−54.24 to 19.00
K3 versus PT	>0.05	−25.52 to 47.72
MN versus PF	>0.05	−16.16 to 55.13
MN versus PT	<0.01	12.56 to 83.85
PF versus PT	>0.05	−6.921 to 64.36

K^3, K3; MN, manual; PF, ProFile; PT, ProTaper; HE, Micro Mega Hero instruments.

Discussion

To achieve standardized procedures throughout the study, only one operator conducted the experiments to avoid variables during the preparation of samples.

The speed of the automated instruments was adjusted according to the information indicated by the manufacturers. The low-torque motor increased tactile sensitivity, gave better control of rotary instrumentation and reduced the risk of instrument separation (Gambarini 2000, Yared *et al.* 2001). This might be the reason for the lack of instrument fracture in the present study (Hülsmann & Bluhm 2004).

The option of using a radiographic method for evaluation of the cleanliness of root canal walls was to simulate clinical procedures, as radiographs are used to verify the presence of filling debris on the root canal space (Barrieshi *et al.* 1995, Bramante & Betti 2000, Barletta & Lagranha 2002, Barrieshi-Nusair 2002).

Stereomicroscope and digitized photographs were used to confirm the efficacy of the radiographic method; samples were magnified up to six times to detect filling debris. The presence of artefacts following the splitting of teeth was overcome by cleaning all samples with air (Friedman *et al.* 1993).

One of the variables related to filling material removal from root canal walls was the type of sealer used in association with gutta-percha. No statistical differences ($P > 0.05$) were observed between the group filled with zinc-oxide–eugenol-based sealer (Endofill) and the group filled with a resin-based sealer (Sealer 26). On the contrary, Pécora *et al.* (1992) and Lopes & Gahyva (1995) observed that a zinc-oxide–eugenol-based sealer had less adhesion to the root canal wall than a resin-based sealer.

Significant differences ($P < 0.05$) were observed between the evaluation methods. This supports the work of Wilcox (1989), who regarded that photomicrographic methods led to a more accurate diagnosis than radiographic methods for the detection of filling debris.

In relation to the instrumentation techniques applied, K3 ($P < 0.05$) and ProTaper ($P < 0.01$) provided cleaner root canal walls than the manual technique. The reason for this finding may be associated with the design of the so-automated instruments.

Masiero & Barletta (2005) demonstrated that K3 instruments removed more filling materials from the apical third of root canals compared to manual technique M4 (SybronEndo, Orange, CA, USA) and Endo-gripper (Moyco Union Broach, York, PA, USA) instrumentation techniques. Hülsmann & Bluhm (2004) have reported that as ProTaper instruments present a negative cutting angle, they might yield better results in terms of working time and root canal cleanliness than manual instruments.

Conclusions

Among the methods used for evaluation of filling debris on the root canal walls, the photomicrographic method with epiluminescence was more effective than the radiographic method ($P < 0.05$).

No significant differences were observed in the amount of filling materials removed regardless of the sealer used ($P > 0.05$).

K3 ($P < 0.05$) and ProTaper ($P < 0.01$) instrumentation techniques were more effective in the removal of filling material from root canal walls than the manual technique.

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