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Efficacy of two Ni-Ti systems and hand files for removing gutta-percha from root canals

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Abstract

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Aim To compare the effectiveness of two Ni-Ti systems and hand files for removing gutta-percha and sealer from root canals.

Methodology The root canals of 60 single-rooted human teeth were prepared, filled with gutta-percha and sealer (Pulp Canal Sealer; SybronEndo, Orange, CA, USA). Specimens were then divided into three groups (n = 20), and root filling material was removed using MTwo Retreatment Files (group 1); R-Endo (group 2); K-files and Gates-Glidden drills (group 3). After retreatment, the efficacy of each technique was assessed using radiographs that were later digitized and the images analysed using AutoCAD 2004. The percentage of residual gutta-percha was calculated for the whole canal as well as for the coronal, middle and apical thirds. Time required, apically extruded debris and the number of fractured instruments were also recorded. Data were statistically analysed using Kruskal–Wallis and Mann–Whitney *U*-tests.

Results All instrumentation techniques left gutta-percha and sealer remnants inside the root canals. Ni-Ti systems were significantly faster ($P < 0.05$) than the manual technique and significantly more effective ($P < 0.05$) in removing gutta-percha particularly from the middle and apical thirds of the root canal. R-Endo instrumentation was significantly more effective ($P < 0.05$) than MTwo retreatment files in removing gutta-percha from the middle and apical thirds. R-Endo instruments were associated with the least number of cases of apical extrusion. One MTwo instrument fractured.

Conclusions The Ni-Ti systems were more effective and faster than hand files, although all techniques left gutta-percha and sealer remnants on the root canals.

Keywords: endodontic retreatment, gutta-percha, nickel-titanium.

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Introduction

Post-treatment disease is associated with the persistence of microorganisms in the root canal system after cleaning and shaping or the recolonization of the root canal space by bacteria following coronal or apical microleakage (Nair *et al.* 1990). As for previous treatment, root canal retreatment aims to eliminate or to substantially reduce the microbial load from the root canal (Kvist & Reit 1999). Removing all root filling materials is a prerequisite of non-surgical retreatment, as it allows subsequent cleaning, shaping and filling of the root canal system.

Gutta-percha is the most commonly used material for filling root canals, and it should be removed when retreatment is indicated (Friedman *et al.* 1989). Many procedures have been advocated for gutta-percha removal (whether manual, mechanical or ultrasonic), with or without the use of solvents. Studies have shown that none of the retreatment procedures are able to completely clean the root canal walls (Wilcox *et al.* 1987, Imura *et al.* 2000, Ferreira *et al.* 2001, Gu *et al.*

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2008, Taşdemir *et al.* 2008), particularly in the apical third, where microorganisms generally persist. In many cases, the combined use of different techniques seemed to be the most effective solution, even if it was time-consuming and implied a loss of the standardization (Lambrianidis 2001).

Ni-Ti systems have been suggested for removing gutta-percha from the root canal, and studies have shown that they could be both effective and safe (Bramante & Betti 2000, Imura *et al.* 2000, Betti & Bramante 2001, Ferreira *et al.* 2001, Hülsmann & Bluhm 2004, Masiero & Barletta 2005, Zmener *et al.* 2005, de Carvalho Maciel & Zaccaro Scelza 2006, Kosti *et al.* 2006). The aim of the present laboratory study is to compare the efficacy of two Ni-Ti systems especially designed for endodontic retreatment with that of traditional hand files in removing gutta-percha and sealer from the root canal.

Materials and methods

Sample preparation

Sixty-five extracted human maxillary anterior teeth of similar length were selected. Inclusion criteria were absence of a root filing presence of a single root canal, complete formation of the apex and no caries nor fracture. Soft tissues and calculus were mechanically removed from the root surfaces immediately after extraction. Teeth were then immersed for 24 h in a bath containing 3% sodium hypochlorite to eliminate residual soft tissues. After access cavity preparation, working length was set 1 mm short of the length established visually using size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) inserted into the root canal until its tip was visible at the apical foramen.

Shaping and filling of the root canals

Initial root canal preparation was performed using the Protaper system (Dentsply Maillefer) according to manufacturer's instructions to size F3. The shaping sequence was completed using size 35 K-files at the working length. Canals were irrigated between instruments with 5.25% NaOCl and 17% EDTA alternatively. Instruments were cleaned after each use, each sequence being used for five canals before being discarded. Canals were dried after instrumentation with paper points and filled using the continuous wave of condensation technique (System B; Analytic Technology, Redmond, WA, USA). Pulp Canal Sealer (SybronEndo, Orange, CA, USA) was used as the sealer. The coronal section of the canal was filled in increments using Obtura III and manual pluggers. Initial shaping, cleaning and filling were performed by the same operator to avoid interoperator variability. The quality of the root fillings was confirmed using postoperative radiographs in mesio-distal (MD) and buccolingual (BL) views (Ultraspeed; Kodak, Rochester, NY, USA). A radiographic platform similar to that described by Veltri *et al.* (2005) was used to standardize and allow for reproducible tooth/film/X-ray beam alignment. The platform consisted of two interlocking plexiglass slabs connected to a Rinn film holder supporting the radiographic cone (EvolutionX 3000, 70 kV; New Life Radiology, Turin, Italy). Five samples displaying radiographic voids inside the gutta-percha were discarded. Access cavities were sealed with Cavit (3M-ESPE, Seefeld, Germany), and teeth were stored at 37 °C for 30 days to allow for setting of the cement. The samples were later divided into three groups of 20 samples each. Each group was then treated with a different technique.

The canal filling in group 1 was removed using MTwo Retreatment Files (Sweden & Martina, Padova, Italy). An MTwo R file size 15, 0.05 taper was first used to working length followed by MTwo R size 25, taper 0.05 also to working length. The normal shaping sequence was then used (e.g. MTwo size 30, taper 0.05; size 35, taper 0.04 and size 40, taper 0.04). All instruments were used with a Tecnica micromotor (Dentsply Maillefer) at 300 rpm and 80 N cm^2 torque setting.

Canal filling material in group 2 was removed using the R-Endo system (Micro-Mega, Besançon, France). The Rm stainless steel manual file (17 mm, 4% taper) was used first to its full length. It was followed by nickel-titanium rotary instruments Re (12% taper), R1(8% taper), R2(6% taper), R3(4% taper) to working length. The Rs (optional finishing file) was used next followed by Hero Shapers size 35, 0.04 taper and size 40, 0.04 taper to the working length. R-Endo instruments were used using the special InGet microhead mounted on a Tecnika micromotor (300 rpm, 80 N cm^2 torque setting).

In group 3 (control group), retreatment was initiated using size 3-, 0.9-mm and then size 2-, 0.7-mm Gates-Glidden drills (Dentsply Maillefer) to remove gutta-percha from the coronal and middle thirds. Chloroform (Laboratori Farmaceutici Ogna, Milano, Italy) was placed into the root canal to facilitate penetration of

hand files. A crown-down approach was used to bring a size 10, 0.02 taper file to the working length. After a step-back sequence, a size 40, 0.02 taper stainless steel K-file was placed at working length. Gates-Glidden drills size 3, 0.9 mm and size 2, 0.7 mm were finally used to finish the preparation. To eliminate interoperator variability, the same operator carried out all retreatment procedures.

In all groups, each set of instruments was used for five canals and then discarded. Saline was used to irrigate root canals between instruments.

Gutta-percha removal

Radiographs performed in BL and MD directions for each specimen were digitized using a scanner (Epson Perfection 3490 Photo, 600 dpi, Epson America, Inc, Long Beach, CA, USA; Fig. 1). Images were later analysed using AutoCAD 2004 (Mechanical Desktop Power Pack; Microsoft, Redmond, WA, USA). One observer was used to assess remnants of filling materials, and he was blinded to the technique. Root canals were divided into thirds, and the area of the whole root canal and of each third was calculated and expressed in mm^2; then the ratio between root canal area covered by the remnants of gutta-percha and sealer and the total root canal area was calculated and expressed as a percentage. The mean distribution of gutta-percha within the three groups was also calculated.

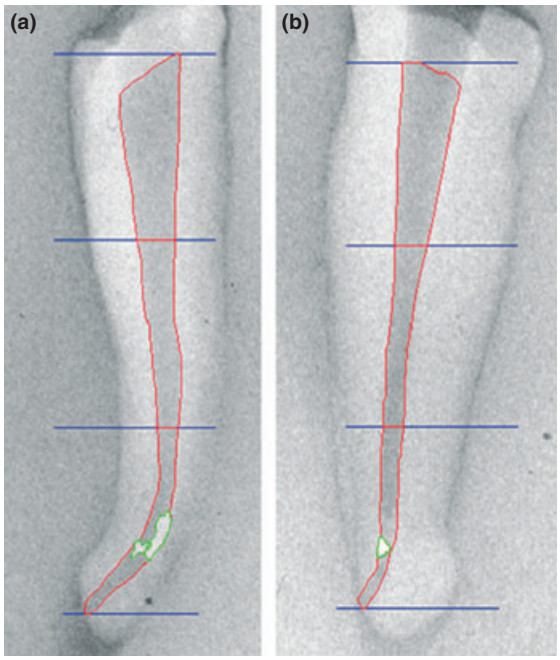

Figure 1 Radiographs in mesio-distal (a) and bucco-lingual (b) directions showing the AutoCAD tracing of the outline of the canal in red and of the filling remnants in green. Blue lines represent separation between the coronal, middle and apical area of the root canal.

Time required for gutta-percha removal

The total time needed to complete the procedure was recorded for each sample. Time measurements were performed by the same operator. Time included placement of two drops of solvent in the coronal/middle region and then at the middle/apical junction levels until WL (working length) was reached and 4 mL of NaOCL as final flush.

Apical extrusion

Material extruded through the apical foramen was assessed visually during the procedure. Those samples where gutta-percha remnants beyond the apex could be observed were recorded.

Instrument fracture

The number of fractured instruments was recorded. Statistical analyses were carried out using the Kruskal–Wallis and Mann–Whitney U test (SPSS statistical package, Version1.1, IBM Corporation 1, Armonk, NY, USA). Significance level was set at $\alpha = 0.05$.

Results

Gutta-percha removal

When considering the root canal in its entirety (Table 1), no significant differences between the material removal ability of the M-Two and R-Endo systems were observed. When compared with the manual technique, however, both systems were more effective in removing filling material from the root canal walls ($P < 0.05$).

There was no significant difference between systems regarding the coronal third. However, differences were significant in the middle and apical third ($P < 0.05$) with the R-Endo leaving less debris on root canal walls than the other two systems and the M-Two being significantly more effective ($P < 0.05$) than manual techniques for removing filling material (Table 1).

Table 1 Gutta-percha and sealer removal by instrument and canal region

	MTwo RF		R-Endo		K-Files + GG		Manual versus MTwo RF	Manual versus R-Endo	MTwo RF versus R-Endo
	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD			
Root Canal	10	0.180	6	0.085	21	0.183	<0.05	<0.05	>0.05
Coronal	7	0.183	7	0.130	9	0.152	>0.05	>0.05	>0.05
Middle	13	0.276	4	0.088	28	0.294	<0.05	<0.05	<0.05
Apical	10	0.125	4	0.106	35	0.367	<0.05	<0.05	<0.05

Time required for gutta-percha removal

The nickel-titanium rotary systems were significantly faster than the control group (4.60 ± 1.83; $P < 0.05$). There was no significant difference between M2 instruments (2.77 ± 1.11) and R-Endo instruments (3.77 ± 1.80) in removing gutta-percha from root canals.

Apical extrusion of debris

MTwo and the control group had apical extrusion of gutta-percha in eight (40%) and nine (45%) cases, respectively ($P < 0.05$); R-Endo had extrusion in three (15%) cases ($P < 0.05$).

Fractured instruments

Only one instrument fractured (MTwoRF2 size 25, 0.05 taper). This occurred when treating the last sample for that set of instruments. The fractured instrument was removed successfully, and the time needed for removal was not recorded.

Discussion

Several reports have proposed techniques for removing gutta-percha and sealer from root canals (Hülsmann & Stotz 1997, Bramante & Betti 2000, Imura *et al.* 2000, Betti & Bramante 2001, Ferreira *et al.* 2001, Hülsmann & Bluhm 2004, Masiero & Barletta 2005, Zmener *et al.* 2005, de Carvalho Maciel & Zaccaro Scelza 2006, Kosti *et al.* 2006). These reports generally compare the safety and efficiency of shaping rotary Ni-Ti instruments to that of stainless steel hand files.

Recently, Ni-Ti instruments specially designed for removal of filling materials have been marketed, including MTwo Retreatment Files (Sweden & Martina, Padova, Italia) and R-Endo (Micro-Mega). This study set out to evaluate radiographically the effectiveness of these instruments in removing gutta-percha and sealer from the root canal and to compare them with hand files and GG (Gates Glidden) burs. To standardize procedures, a single operator carried out the initial treatment, another one the retreatment procedures and a third one the evaluations.

Most previous studies on removal of root fillings have used lateral compaction to fill the canal, which frequently influences the accumulation of cement within the gutta-percha, particularly in the middle and coronal levels rather than apically. However, the present study, as in the study by Ferreira *et al.* (2001) and Gergi & Sabbagh (2007), used the System B system in an attempt to enhance the volume of gutta-percha compared with the sealer.

Bramante & Betti (2000) reported that, in terms of material removal, there are no significant differences when using Ni-Ti instruments at speeds of 350, 700 or 1500 rpm. In this study, the rotational speed was kept intentionally low (300 rpm) to remain close to clinical conditions. If it is true that theoretically higher speed allows for faster retreatment procedures, this is likely to be true in straight canals only. In curved canals, higher speeds may lead to problems such us ledges, zips, perforations and even instrument fracture owing to cyclic fatigue (Ounsi *et al.* 2007).

In the control group, gutta-percha and sealer were removed in the coronal entrance and middle third using GG drills. A solvent was used in this group to speed up the removal process with hand files (Bramante & Betti 2000). Chloroform was selected, as it is often used clinically and has limited toxicity at the dosage used in endodontics. Conversely, no solvent was used with Ni-Ti instruments as they generally plasticize gutta-percha through the heat generated by friction, thus easily and quickly allowing them to reach the working length. In this scenario, using a solvent would generate a thin film of gutta-percha on the root canal walls that would be difficult to identify and remove. This could compromise the antimicrobial action of the irrigants and increase the operating time (Wilcox & Juhlin 1994). However, using a solvent with hand

instrumentation is recommended as manual retreatment is significantly more difficult without its use (Ferrari 2008).

Different methodologies have been used to evaluate the effectiveness of instruments in removing material from the root canal (Bramante & Betti 2000, Imura *et al.* 2000, Betti & Bramante 2001, Ferreira *et al.* 2001, Hülsmann & Bluhm 2004, Masiero & Barletta 2005, Zmener *et al.* 2005, de Carvalho Maciel & Zaccaro Scelza 2006, Kosti *et al.* 2006). In this study, a quantitative radiographic method was carried out using two radiographs, one BL and one MD. This was thought to be more reliable and provided more information. The AutoCAD software is a Computer Aided Design/Drafting (CAD) program developed by Autodesk and is used by architects and designers to produce floor plans and calculate material requirements. It allowed vectorial enlargements giving precise images and thus minimizing operator bias. The results obtained are quantitative (expressed in percentages and mm^2) and not scores (as in qualitative evaluations); data are available for the whole root canal and/or specific areas. As reported by several authors (Bramante & Betti 2000, Imura *et al.* 2000, Betti & Bramante 2001, Ferreira *et al.* 2001, Hülsmann & Bluhm 2004, Masiero & Barletta 2005, Zmener *et al.* 2005, de Carvalho Maciel & Zaccaro Scelza 2006, Kosti *et al.* 2006), none of the three techniques evaluated was able to completely remove the filling material from the root canals. This is not surprising, as it is well known that it is difficult to completely remove all traces of gutta-percha and sealer regardless of the technique (Wilcox *et al.* 1987).

Statistical tests revealed that, with the exception of the coronal third, nickel-titanium instruments were more effective at removing gutta-percha from the root canal when compared with the hand instruments. Many reports have concluded that Ni-Ti instruments are no better than hand files (Bramante & Betti 2000, Imura *et al.* 2000, Ferreira *et al.* 2001, Hülsmann & Bluhm 2004, Zmener *et al.* 2005, de Carvalho Maciel & Zaccaro Scelza 2006, Kosti *et al.* 2006). Indeed, Betti & Bramante (2001) claimed that hand files were more efficient in the coronal third. However, Masiero & Barletta (2005) reported that K3 Endo System (SybronEndo) was more efficient than hand files in the apical third. In this study, a greater effectiveness of Ni-Ti instruments was found: this may be due to the fact that these instruments were designed specifically for removing material. The fact that no statistically significant differences were found in the coronal third may be due to the use of GG burs that are known to be effective in this area.

When comparing the two Ni-Ti techniques (group 1 and 2), no statistically significant differences were found in the whole root canal and in the coronal third, while in the middle and apical third, the R-Endo (group 2) gave better results. This can be explained by the fact that the system uses a crown-down approach, while M-Two retreatment files (group 1) tend to immediately reach the working length. The crown-down approach eliminates the filling material from the coronal third, and this may be why instrumentation was more effective in the apical and middle thirds and why R-Endo instruments produced fewer cases of apical extrusion.

Out of the 84 instruments used, only one fractured. This may be due to the fact that instruments were discarded after five uses, to the strict observance of manufacturers' instructions and to the expertise of the operator. The fractured instrument was an MTwoRF2 (size 25, 0.05 taper), and it occurred when treating the last root canal for that set of instrument, so cyclic fatigue is likely to be the cause. Hülsmann & Bluhm (2004) and Zmener *et al.* (2005) did not report any fracture, whereas other authors such as Bramante & Betti (2000) and Imura *et al.* (2000) reported fractures, probably due to cyclic fatigue.

Apical extrusion is generally recorded by visual evaluation (Bramante & Betti 2000, Betti & Bramante 2001, Hülsmann & Bluhm 2004, de Carvalho Maciel & Zaccaro Scelza 2006), directly or on radiographs. Some authors have given a score to the amount of material outside the apex (Bramante & Betti 2000, Betti & Bramante 2001). These studies confirm that no statistically significant differences exist between Ni-Ti and hand files (Bramante & Betti 2000, Imura *et al.* 2000, Betti & Bramante 2001). Moreover, Hülsmann & Bluhm (2004) reported no extrusion during retreatments.

In this study, the extrusion during retreatment was recorded visually. It is a qualitative method that does not take into account the amount of material found. Manual instrumentation gave the greatest number of extrusions (nine of 20), followed by MTwo (eight out of 20) and R-Endo (three out of 20). It can be postulated that the crown-down approach, which immediately eliminates gutta-percha from the coronal third, reduces the likelihood of extrusion while removing the remaining filling material from the apical third, possibly by allowing evacuation of the debris in a coronal direction. All MTwo retreatment files are immediately taken to

the WL, increasing the risk of extruding material through the apex. For the manually retreated group, the use of a solvent could account for more extrusion as it renders the filling material softer and thus more prone to extrusion.

Ni-Ti instruments were more rapid than hand files (Betti & Bramante 2001, Ferreira *et al.* 2001, Zmener *et al.* 2005, Kosti *et al.* 2006). The gutta-percha plasticized by mechanical instrumentation offers a lower resistance to the action of the subsequent instrumentation (Zmener *et al.* 2005). For this reason, it was probably easier to reach the working length with Ni-Ti instruments rather than hand files.

Conclusions

None of the techniques was able to remove gutta-percha and sealer completely from the root canal. Ni-Ti engine-driven rotary instruments were significantly faster and more effective in removing gutta-percha than hand files. When compared with manual instrumentation, engine-driven systems were significantly more effective than the M-Two and manual instrumentation in removing gutta-percha and sealer from the apical and middle third and led to less apical extrusion.

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