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The Efficiency of Hand-files, ProTaper R, Reciproc, XP-Endo Shaper and XP-Endo Finisher R in the Removal of Root Filling Material from Oval Root Canals

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Abstract: *To evaluate the effectiveness of hand files, ProTaper R, Reciproc, XP-Endo Shaper in combination with XP-Endo Finisher R in the removal of obturation material with and without the aid of solvent. 120 extracted human mandibular premolars with single straight oval root canal were selected and prepared with a Reciproc #25.08 to the working length. The teeth were obturated with Elements Free Obturation Unit with AH Plus Sealer and then divided randomly into ten groups (n=10) according to the retreatment techniques. Group 1; hand files, Group 2; Reciproc, Group 3; ProTaper R, Group 4; XP-Endo Shaper, Group 5; XP-Endo Shaper in combination with XP-Endo Finisher R. In Groups 6, 7, 8, 9 and 10 the mechanical retreatment procedures were the same as Groups 1, 2, 3, 4 and 5 respectively. In these groups Resosolv was added to the procedure. The teeth were then split vertically into halves, and the cleanliness of the canal walls was determined by scanning electron microscopy. Statistical analysis were performed using one-way ANOVA, Kruskal–Wallis and Tukey's honestly significant difference tests (P < 0.05).Reciproc was significantly faster than all the other techniques at removing the filling material from the root canals (p<0.01). XP-Endo Shaper and XP-Endo Finisher R groups were statistically more effective than the other techniques at removing the filling material (p<0.01). All the solvent aided groups were slower than the other groups at root filling removal (p<0.01). Neither retreatment protocols completely removed the filling material from the root canals.*
Keywords*: Protaper R, Reciproc, Retreatment, SEM, XP-Endo Shaper, XP-Endo Finisher R.*

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I. Introductıon

The main goal of non-surgical root canal retreatment is to re-establish healthy periapical tissues following ineffective root canal treatment or reinfection. The procedure requires removal of the original root canal obturation material, reinstrumentation and disinfection of the root canal system, and refilling [1]. Non-surgical retreatment requires to treat the infectious process by removing the filling material and eliminating debris and microorganisms associated with apical periodontitis [2].

With the advent of mechanized instrumentation, different techniques have beenproposed for endodontic retreatment by using nickel-titanium rotary systems [3-6] and reciprocating systems [7-11]. The rotary nickel titanium ProTaper Universal Retreatment (Dentsply Maillefer, Ballaigues, Switzerland) system is being used for retreatment. The PTUR system consists of D1, D2, and D3 files. D1 files have an active working tip to promote initial entry into the obturating material, and the rest of the files have a nonactive tip to reduce procedural errors during obturation removal [12, 13]. The reciprocating motion system, Reciproc (VDW, Munich, Germany) consists of 3 single-use files: R25 (25/.08 in the first millimeters), R40 (40/.06 in the first millimeters), and R50 (50/.05 in the first millimeters) [14].

Irrespective of the retreatment technique, numerous studies have shown that complete removal of root canals fillings is not commonly attained [14, 15], particularly in the apical portion of the root canal [16, 17]. Therefore, additional approaches have been suggested to enhance the removal of filling material [18, 19]. Recently, new NiTi shaping and finishing instruments were developed with the purpose of improving root canal shaping and cleaning—the XP-Endo Shaper and the XP-Endo Finisher R (FKG Dentaire, La Chaux-de-Fonds, Switzerland). The XP-Endo Shaper is the latest instrument of the FKG's range of 3D instruments. It is a truly innovative broad spectrum shaping instrument which can be used to radically simplify endodontic sequences. It is a "One File Shaper" (Fig. 1). It has the ability to start shaping at ISO diameter 15 and to achieve ISO diameter 30, but also to increase the taper from .01 to at least .04. It allows to reach a final canal preparation of minimum 30/.04 and this with only one instrument. The XP-Endo Shaper is the instrument of choice for the treatment of

the vast majority of canals.

Figure 1. XP Endo Shaper

The XP-Endo Finisher R, which is a size 30 nontapered instrument made with the NiTi MaxWire alloy (Martensite-Austenite ElectropolishFleX, FKG Dentaire). Because of this special alloy, this instrument is straight in its martensitic phase, which is achieved below 30°C; however, when placed in the canal at the body temperature, it changes to the austenitic phase in which the instrument assumes a spoon shape in the last 10 mm with a depth of approximately 1.5 mm. When rotating, this instrument achieves a natural diameter of 3 mm in the last 10 mm (Fig. 2). According to the manufacturer, when the instrument tip is squeezed, the bulb can be expanded to 6 mm; when the bulb is compressed, the tip will expand to 6 mm. Thus, when the XP-Endo instrument is moved up and down for 7 to 8 mm inside the canal, the natural constrictions and expansions in the canal will alternately cause the bulb and tip to expand and contract. This makes the instrument scrape the canal walls and cause turbulence of the irrigant solution. It seems that the XP-Endo Finisher R instrument has the potential to be applied as an additional procedure in retreatment cases to maximize filling removal [19].

Figure 2. XP Endo Finisher R

Solvents are often used during endodontic retreatments to facilitate removal of gutta-percha and sealers from the root canal system [20]. Resosolv (Pierre Rolland, Merignac, France) is a solvent specifically produced for solving resin-based sealers, such as AH Plus (Dentsply DeTrey, Konstanz, Germany). Resosolv contains 95% dimethylformamide and 1%–2% Cinnamomum cassia . Endosolv E (Septodont, Paris, France) is a solvent specifically for eugenol-based sealers, such as Tubli-Seal (Kerr Italia SPA, Scafati, Italy). Endosolv E contains 50%–90% tetrachloroethylene, 2.5%–10% isopentyl acetate, and 1% thymol. Guttasolv (Septodont) is an eucalyptol-based solvent for softening gutta-percha [21]. We used Resosolv in our study as we used AH Plus as a sealer during the obturation of the root canals.

The aim of this study was to evaluate the effectiveness of hand files, ProTaper R, Reciproc, XP-Endo Shaper and XP-Endo Shaper in combination with XP-Endo Finisher R in the removal of resin-based obturation technique during retreatment. The time required for gutta-percha removal was also recorded and evaluated.

II. Materıals And Methods

Specimen Selection and Initial Preparation

A total of 120 freshly extracted human mandibular premolars with similar lengths and diameters and with one single straight root canal, completely formed apices and no root fillings were selected for this study. The teeth were radiographed in both directions to ensure that there were no calcifications or obstruction and that a single canal could be observed. To be considered oval, the buccolingual diameter had to be twice as long or longer than the mesiodistal diameter throughout the first two thirds of the canal. The teeth were decoronated to

obtain a standardized root length of 16 mm.A size 15 K-file (MANI˙, Inc., Tochigi, Japan) was placed into the canal until visible at the apical foramen. The working length was established 1 mm short of this length. The teeth were then divided randomly into ten groups of 10 teeth each (n=10).Twenty teeth served as negative and positive control groups of 10 teeth each. The teeth were disinfected in 0.5% chloramine T, embedded in acrylic blocks and stored in distilled water.

Root Canal Preparation

All teeth were prepared with aReciproc #25 .08 NiTi system (VDW GmbH, Munich, Germany) to the working length, with a reciprocatingslow in-and-out pecking motion according to the manufacturer's recommendation.The apical canal patency was controlled with a size 15-K file. The instrument was coated with a lubricant containing ethylenediamine tetraacetic acid (EDTA) before placement. Root canals were irrigated using 5 mL of 5.25% NaOCl between all instrument changes. The smear layer was removed by irrigation with 10 mL of 5.25% NaOCl, then with 10 mL of 17% EDTA, then with 10 mL of 5.25% NaOCl. This was followed in all canals by a final rinse with 10 mL of distilled water. Then, the root canals were dried with sterile paper points.

Root Canal Obturation

The teeth were obturated with Elements Free Obturation Unit (Kerrdental, Bioggio, Switzerland) by using thecontinuous wave of condensation technique. AReciproc R25 gutta-percha (VDW GmbH, Munich, Germany) was cut0.5 to 1 mm short of working length to accomodate vertical movement from compaction and placed into the root canal with AH Plus Sealer (Dentsply De Trey, Konstanz, Germany) on apical one third. The Buchanan heat plugger set at 200°C was introduced into the canal, and the conewas seared off at the canal orifice. The gutta-percha cone was seated with a stainless steel hand plugger. The tip of the plugger was reactivated,and condensation was terminated within 3 mm of the working length.The plugger was held in position for 10 seconds before the Buchanan heat plugger was activated for 1 second and withdrawn from the tooth. As the Buchanan heat plugger is removed from the root canal, it carriesthe coronal mass of gutta-percha, leaves the apical plug and seals lateral and accessory canals. A thin layer of sealer was applied to the canal walls with a size 25 paper point (taper .02; Dentsply/Maillefer) before filling the coronal portion of the canal with Backfill unit of the Elements Free. Then, the warm gutta-percha was condensed with the appropriate hand plugger. Access cavities were sealed with Cavit (ESPE, Seefeld, Germany) temporary filling material. All the teeth were stored in a humidor at 37°C and 100% humidityfor 30 days.

Root Canal Retreatment

In Group 1,size 2 and 3 Gates-Glidden drills were used to remove the coronal 3 mm of the root canal fillings. Then a size 40 K-type file was introduced into the root canal by using a crown-down technique until the working length was reached with a size 25 K-type file.Afterwards, circumferential filing was applied with a size 30 H-type file.

In Group 2,an R25 file was moved in the apical direction in a reciprocating motion using in-and-out pecking motions of 3 mm in amplitude. The progression was performed with light apical pressure until the instrument reached two thirds of the canal length. After 3 pecking motions, the instrument was removed and cleaned, and the canal was irrigated with 5 mL of 5.25% NaOCl for 60 seconds. Another cycle of 3 pecking motions was performed until the R25 instrument reached the working length. The instrument was then used in a brushing motion, and the canal was irrigated with 5 mL of 5.25% NaOCl for 60 seconds. Patency of the apical foramen was checked with a size 15 K-type file. The retreatment procedure is finalized by apical enlargement with an R40 file.

In Group 3, the obturation material was removed using ProTaper R instruments with a constant speed of 500 rpm, as suggested by the manufacturer. D1 was used to remove the filling from the coronal third of the root. D2 was used to remove the filling from the middle third of the root. D3 was used to remove the filling from the apical third of the root. After reaching the working length, root canals were reshaped using F2 and F3 respectively.

In Group 4, D-Race 1 was used to remove the coronal 3 mm of the root canal fillings. Then XP-Endo Shaper was operated in the canal for 30 seconds at 800 rpm and 1 Ncm to remove the filling from the middle and the apical third of the root. It has the ability to start shaping at ISO diameter 15 and to achieve ISO diameter 30, but also to increase the taper from .01 to at least .04. It allows to reach a final canal preparation of minimum 30/.04.

In Group 5, the retreatment procedure was the same as Group 4. In this group XP-Endo Finisher R was used following the appliance of XP-Endo Shaper. The XP-Endo Finisher R was operated in the canal for 1 minute at 800 rpm and 1 Ncm up to the working length and in slow up and down 7- to 8- mm long movements. Parietal movements were applied during the procedure. The XP-Endo Finisher R has a core diameter larger (ISO

30) than the XP-Endo Finisher (ISO 25), making it slightly stiffer and also more efficient in removing root fillings materials adhering to the canal walls, especially in the curvature or oval areas.

In Groups 6, 7, 8, 9 and 10 the mechanical retreatment procedures were the same as Groups 1, 2, 3, 4 and 5 respectively. In these groups Resosolv solvent was added to the procedure. After removal of the coronal 3 mm of the root canal fillings, 0.01 mL Resosolv was placed for 2 minutes. After removal of every 4 mm of root canal filling, 0.01 mL solvent was placed into the root canal for another 2 minutes. A total volume of 0.03 mL solvent was used for each specimen.

Root canals were irrigated using 2 mL of 5.25% NaOCl between all instrument changes. Preparation was deemed complete when there was no obturation material covering the instruments. The time required for retreatment was recorded. Sample preparation, canal preparation, canal filling, retreatment and evaluation were performed by a single operator under an operating microscope to maintain standardization since results of mechanical processes, such as root canal preparation or root canal filling, can differ from person to person.

Evaluation

Canal wall cleanliness

After removal of the obturation materials, the roots were split vertically into halves and the cleanliness of canal walls was examined by scanning electron microscopy.

Time to reach the working length (T1)

The time elapsed from entering the canal with the first instrument until reaching the working length was measured.

Time for reshaping (T2)

The time elapsed after reaching the working length until no obturation material was seen covering the instruments was measured, including the time required for instrument changes and irrigation protocols.

Total time for retreatment (Tt)

The time elapsed from entering the canal with the first instrument until no obturation material was seen covering the instruments was measured (T1 + T2).

Sample Analysis

The roots were vertically split into halves using diamond burs and a spatula. After vacuum-drying, the specimens were sputter-coated with gold-palladium under a 10-mA current.

Micrographs at magnifications of 500× were then taken under a scanning electron microscope at 25 kV. The residual obturation material and debris at the coronal, middle, and apical thirds of each canal were evaluated using the Hülsmann [22] grading system.

The Hülsmann system comprises the following grades (Fig. 3):

1. Canal walls are clean with a slight presence of debris
2. Some presence of debris
3. Presence of debris in <50% of the canal walls
4. Presence of debris in >50% of the canal walls
5. Nearly all of the canal walls (90–100%) are covered with debris

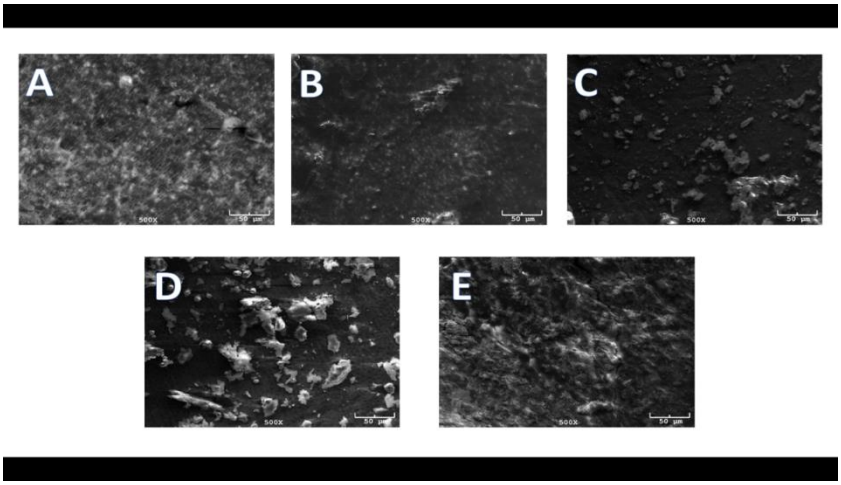

Figure 3.SEM images of the coronal, middle, and apical areas of the samples. (A) XP Endo Shaper + XP Endo Finisher R. Canal walls are clean, slight presence of debris (1). (B) XP Endo Shaper. Some presence of debris (2). (C) Reciproc. Presence of debris at less than 50% of the canal walls. (3). (D) Protaper R. Presence of debris at more than 50% of the canal walls. (E) Hand files. Nearly all of the canal walls are covered with debris (5).

Statistical analysis

Statistical analysis was performed using the Number Cruncher Statistical System 2007 and PASS 2008 Statistical Software programme. Intergroup comparison was performed using one-way analysis of variance and Kruskal–Wallis tests. Tukey's honestly significant difference test was performed to identify significant differences among groups. The level of significance was set at $P < 0.05$.

III. Results

Reciproc instruments were significantly faster than all the other techniques at removing the filling material from the root canals ($p<0.01$) (Table 1). XP-Endo Shaper and XP-Endo Finisher R groups with or without solvent were statistically more effective than the other techniques at removing the filling material ($p<0.01$) (Table 2). All the solvent aided groups were slower than the other groups at root filling removal ($p<0.01$) (Table 3). However the filling material were removed more effectively in those groups.No statistically significant difference was found between the techniques in terms of remaining obturation material at the coronal, middle and apical thirds of the roots ($p> 0.05$). Neither systems completely removed the filling material from the root canals.

Table 1. Time required for material removal according to retreatment technique (min).

	Without Solvent	With Solvent
	Mean ± SD	**Mean ± SD**
Hand Files	7.38 ± 1.25	13.50 ± 0.76
Reciproc	3.28 ± 1.12	7.58 ± 0.91
ProTaper R	6.56 ± 1.36	12.46 ± 0.88
XP Endo Shaper	5.07 ± 1.19	11.43 ± 0.86
XP Endo Shaper + XP Endo Finisher R	6.41 ± 1.41	12.38 ± 0.81

one-way ANOVA $p< 0.01$

Table 2. Evaluation of remaining obturation material. Samples were scored using the Hülsmann grading system.

	Without Solvent	With Solvent
	Mean ± SD	**Mean ± SD**
Hand Files	4.22 ± 0.66	4.03 ± 0.72
Reciproc	2.35 ± 0.55	2.26 ± 0.61
ProTaper R	3.86 ± 0.58	3.71 ± 0.59
XP Endo Shaper	1.88 ± 0.49	1.66 ± 0.56
XP Endo Shaper + XP Endo Finisher R	1.61 ± 0.52	1.46 ± 0.39

Kruskal–Wallis $p< 0.01$

Table 3. Time required for material removal according to solvent usage (min).

	Without Solvent	With Solvent
	Mean ± SD	**Mean ± SD**
Time to reach the WL(T1)	3.17 ± 1.38	3.60 ± 0.86
Time for re-shaping(T2)	2.38 ± 1.06	2.78 ± 0.81
Total retreatment time (Tt)	5.74 ± 2.05	6.47 ± 1.26

Tukey's honestly significant difference test $p< 0.01$

IV. Dıscussıon

Removing root filling material, shaping and cleaning, and then refilling the root canal are the main goals of a successful retreatment [23, 24]. However, several studies have shown that regardless of the retreatment technique used, filling material remains in the root canal system [7, 11, 25]. Therefore, a new supplementary strategy using a finishing instrument was evaluated for its ability to improve filling material removal. The results using the XP-Endo Finisher instrument were encouraging because the remaining filling volume was significantly reduced after its use. The instrument expansion at the body temperature added to its helical movement inside the canal may have allowed it to touch and displace the residual filling material [19]. The XP-Endo Finisher R instrument differs in its core diameter and in the angulation of its tip compared to the XP-Endo Finisher file, which makes it potentially more aggressive for removing filling material.

To date, few studies have evaluated the performance of the XP-Endo Finisher instruments. Their ability to remove hard-tissue debris [26, 27], bacteria [28, 29] and calcium hydroxide paste [30] has been demonstrated. The ability of this instrument to remove filling material during root canal retreatment was reported to be 69% mean reduction in volume [19], which was similar to the results observed in the present study.

Although the Reciproc systems was not originally designed for retreatment, the hypothesis that the special design of their instruments as well as the reciprocating motion can be potentially beneficial for the effective removal of filling material [14] was confirmed in the present study given that there was no statistical difference between the ProTaper Retreatment system, which was devised specifically for retreatment, and the Reciproc systems. In addition, Reciproc instruments were significantly faster than all the other techniques at removing the filling material from the root canals.

Solvents can be used to soften and dissolve gutta-percha in the root canal to facilitate its penetration and removal. Several studies have suggested that using a solvent did not reduce the duration of retreatment procedures [31-34]. In our study they did not reduce the time of retreatment either. However in solvent aided groups the filling material were removed more effectively. This may be because in some studies solvent was used only once in the coronal portion of the root canal [31-33]. Thus, the softening and solving effect of the solvent may have been limited. However, in our study, solvent was used after removing every 4 mm of gutta-percha for a total volume of 0.03 mL for each specimen.

Oval-shaped canals represent a challenge to any mechanized system for both preparation of canals and removal of filling material [2, 34-36]because the flattened areas of the canal are not touched by the instruments [35]. The reason for using oval-shaped canals in the our study was to test the different types of motion both rotary and reciprocating for filling material removal.

Future studies should evaluate the performance of XP-Endo instruments associated with a solvent or not. It might be speculated that the larger diameter of the XP-Endo Finisher R instrument cleans better in the apical region. This may be the reason of the more effective removal of the filling material from the root canals using XP-Endo Shaper and XP-Endo Finisher R instruments despite the fact that, in the present study, the apex was enlarged to a size 25. It is important to emphasize that, according to the manufacturer's instructions, XP-Endo Finisher R instruments should be used following any retreatment case involving a diameter of 30 or more.

V. Conclusıons

It can be concluded that the different retreatment protocols tested in the current study did not remove the entire root canal obturation and failed to present an entirely clean root canal. All the samples showed the presence of some obturation material. However, under the limitations of this study Reciproc instruments were found to be faster in removing guttapercha from the canal walls. Furthermore, use of XP-Endo Shaper and XP-Endo finisher R files resulted in cleaner canal walls.

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