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Original Research Article

Endodontic Retreatment with D-Race NiTi Instruments Supplemented with XP-Endo Finisher R

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Abstract: The main goal of orthograde root canal retreatment is to completely remove the root canal content and chemically treat the residual infection. ***Purpose*:** The aim of this study was to evaluate the effectiveness of D-Race retreatment files supplemented with XP-Endo Finisher R in the removal of root canal filling material from oval-shaped canals. ***Methodology*:** Twelve mandibular incisors initially shaped with XP-Endo Shaper and filled by warm vertical compaction were consistently retreated with D-Race files and XP-Endo Finisher R. Micro-CT images were used to evaluate the quality of the root canal filling and the amount of remaining filling material after the two retreatment procedures. ***Results*:** The largest amount of root canal filling was removed at full canal length after using each of the retreatment systems. Significant difference was registered between the accumulated effect of the retreatment with D-Race and XP-Endo Finisher R and the volume of the initial filling material at full canal length ($p<0.001$). Insignificant difference in the amount of remaining filling material was found after using the supplementary retreatment system ($p>0.05$). The XP-Endo Finisher R file was almost equally efficient in the different portions of the canals but was still most productive apically. ***Conclusions:*** The additional application of XP-Endo Finisher R after the D-race retreatment files removed a significant amount of root canal filling. The combined use of the two retreatment systems did not result in completely clean root dentin walls.

Keywords: D-Race, micro-CT, orthograde retreatment, XP-Endo Finisher R, XP-Endo Shaper.

INTRODUCTION

The success and long-term prognosis of the endodontic treatment are highly dependent on the quality of shaping and hermetic sealing of the root canal space (Ng YL *et al.*, 2010; Ng YL *et al.*, 2011), which sometimes represents a real challenge with its complex anatomy. The inability to thoroughly eradicate the primary or secondary bacterial infection is the main cause of persistent apical periodontitis (Nair PN *et al.*, 1990; Rocas IN *et al.*, 2004; Siqueira JF Jr *et al.*, 2014). The majority of such cases can be resolved by orthograde root canal retreatment only if all root canals are discovered, cleaned and properly shaped after the complete removal of the previous root canal filling (Friedman S & Stabholz A, 1986; Hülsmann M *et al.*, 2011; Virdee SS & Thomas MB, 2017).

Orthograde retreatment is highly successful when performed under strictly defined indications (Ng YL *et al.*, 2010; Glickman GN & Vogt MV, 2011). Regardless of the technique used, the main goal is to completely remove the root canal content and chemically treat the residual infection (Bergenholtz G *et al.*, 1979). For this purpose, various combinations of solvents, solutions and tools are used alone or as part of multicomponent systems - manual or machine-driven, made of stainless-steel or nickel-titanium alloy (Gavini

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G *et al.*, 2018; Betti LV & Bramante CM, 2001; Barrieshi-Nusair KM, 2002). The comparison between hand and machine instruments is in favor of the machine ones, as they clean the walls of the root canals more efficiently in a shorter time (Rossi-Fedele G & Ahmed HM, 2017).

Retreatment procedures require development of specific rotary NiTi systems. The two retreatment files of D-Race system (*FKG Dentaire, La Chaux-de-Fonds, Switzerland*) have a triangular cross-section and alternating cutting edges, the first of which has an active tip enabling the initial penetration into the filling. Limited data considering the effectiveness of this system exist at present (Rödig T *et al.*, 2012; 45:580-589; Akhavan H *et al.*, 2012; Delai D et al., 2018).

Despite the effectiveness of the contemporary endodontic instruments, complete removal of the root canal filling is registered only in some of the samples of single experiments (Bernardes RA *et al.*, 2016; Silva E *et al.*, 2018;51: 86–91; Pedulla E *et al.*, 2019; Machado AG *et al.*, 2019; Crozeta BM *et al.*, 2020). The anatomical substrate significantly affects the efficiency of the instruments, especially when oval-shaped canals are considered. Removing canal content from such teeth is a challenge for standard endodontic files, as they rotate in the center of the canal space and cannot affect its remote buccolingual areas (Versiani MA *et al*, 2013). This determines the need for additional mechanical and/or chemical treatment of the canal (Rechenberg DK & Paqué F, 2013; Alves FR *et al.*, 2016; Bernardes RA *et al.*, 2016; De-Deus G *et al.*, 2019; Pawar AM *et al.*, 2016).

XP-endo Finisher R (*FKG Dentaire, La Chaux-de-Fonds, Switzerland*) is an innovative instrument made of superflexible MaxWire alloy, changing its shape with the change of temperature. When exposed to body temperature, the file acquires a "sickle-shape" in the 10 mm segment from its tip.

(Zupanc J *et al.*, 2018) The radius of the hemispherical part of the file is 1.5 mm but during rotation affects a surface of 3 mm. It has zero apical taper and a slightly more aggressive tip designed for retreatment (Crozeta BM *et al.*, 2020; De-Deus G *et al.*, 2019; Silva E *et al.*, 2018).

The aim of this study was to evaluate the effectiveness of D-Race retreatment files supplemented with XP-Endo Finisher R in the removal of root canal filling material from oval-shaped canals.

MATERIAL AND METHODS

Sample selection

The research protocol was approved by the University Ethics Committee (№ 907/22.03.22). The specimens were selected from a collection of 41 lower incisors, recently extracted for periodontal reasons. Immediately after the extraction, the teeth were stored in a 0.1% thymol solution for one hour.

The presence of an oval-shaped canal was proved by digital radiography of teeth in buccolingual and mesiodistal projections. Twelve mandibular incisors with a >2:1 ratio between the buccolingual and mesiodistal dimensions in the coronal two-thirds of the canal, a single straight oval canal (<5°), complete root development and intact anatomical apexes were included in the study. Teeth with denticles, calcified root canals, hypercementosis, previous endodontic treatment, root caries or two root canals were discarded and replaced with new ones. Throughout the study, all samples were stored in saline (0.9% NaCl).

Sample preparation

The root surfaces were cleaned with ultrasound and polished with paper discs, polishing brush and polishing paste. The teeth were decoronated at the level of the cemento-enamel junction with a fine, diamond file with good water cooling. A standardized root length of 16 mm was obtained. A hand stainless-steel K-file ISO 10 (*Dentsply Sirona, Ballaigues, Switzerland*) was used for the working length measurement. It was introduced into the root canal until its tip was visible from the apical foramen and then the length was reduced by 1 mm.

A glide path was initially created with hand K-files ISO 10 and 15. The canals were shaped with the single-file rotary NiTi system XP-Endo Shaper 30/.04 (*FKG Dentaire SA, La Chaux-de-Fonds, Switzerland*). Driven by the X-Smart Plus (*Dentsply Sirona Endodontics, Ballaigues, Switzerland*) endodontic motor at a speed of 800 rpm and a torque of 1 Ncm, the files reached the working length after 5 long gentle strokes. With 15 additional long gentle strokes to working length, the shaping of the canal finished. Each instrument was used for the instrumentation of 3 root canals, according to the recommendations of the manufacturer.

The shaping of all canals was performed in the presence of the chelating agent Glyde *(Dentsply Sirona Endodontics, Ballaigues, Switzerland*) and under copious irrigation with 2% sodium hypochlorite solution. At the end of the preparation, the root canal space was additionally rinsed with 17% EDTA for 1 minute, followed by saline in a syringe with a 30-G NaviTip needle (*Ultradent, Salt Lake City, UT*).

The canals were dried with paper points and filled by warm vertical compaction technique, using gutta-percha cones, AH-Plus sealer (*Dentsply Sirona Endodontics, Ballaigues, Switzerland*) and ElemetsTM Free Cordless Obturation System (*SybronEndo/Kerr Endodontics, Orange, CA*). The roo ts were temporarily sealed with Citodur Hard (*DoriDent,Wien, Austria*) and stored for 14 days at 37ºC and 100% humidity to allow

full setting of the sealer. The quality of the root canal filling (volume, homogeneity) was verified by micro-CT analysis. The scanning was conducted by a high-resolution industrial micro-CT device Nikon XT H 225 (Nikon Metrology, Tring, UK) at a voltage of 87 kV, a current of 90 µA, and a 0.5-mm-thick aluminum filter. Volumetric analysis of the residual filling (mm^3) in the whole root canal space and at 5 and 10 mm transverse cross sections from the root apex was made by VG Studio MAX version 2.2 (Volume Graphics, Heidelberg, Germany) software, individually for each root canal.

The samples with inadequate filling were filled again.

Retreatment procedures

The root canal filling was removed with the files from the D-Race system (*FKG Dentaire, La Chaux-de-Fonds, Switzerland*) in the following sequence: DR1 (30/.10) in the coronal and middle root canal third at a speed of 1000 rpm and a torque of 1.5 Ncm and DR2 (25/.04) until full working length was reached (rotation speed 600 rpm and torque 1 Ncm). Irrigation was performed with 2% NaOCl solution in the course and after the gutta-percha removal. The effectiveness of the tested instruments and the volume of the remaining filling were verified by a second micro-CT analysis.

All specimens were additionally shaped with XP-endo Finisher R (*FKG Dentaire, La Chaux-de-Fonds, Switzerland*) for at least 1 minute (800-1000 rpm, 1 Ncm), using slow and gentle longitudinal and small multidirectional movements to contact the full length of the canal. The treatment was completed by copious irrigation with 2% NaOCl. A new micro-CT was performed.

All procedures were performed by one and the same operator.

Statistical analysis

Results were analysed with the IBM SPSS Statistics 23.0 software (International Business Machines Corporation, New York, NY, USA). Mean and standard deviations (SD) were calculated for all the variables. Nonparametric statistical methods were used: Mann-Whitney U Test for comparison of two independent samples and Kruskal-Wallis Test for comparison of several independent samples.

RESULTS

The amount of root canal filling was calculated at full canal length and at 10 mm and 5 mm segments measured from the root apex.

The largest amount of root canal filling was removed at full canal length after using each of the retreatment systems, but the difference with the other two root portions remained insignificant (Table 1). Significant difference was registered between the accumulated effect of the retreatment with D-Race and XP-Endo Finisher R and the volume of the initial filling material at full canal length ($p<0.001$).

Table 1: Amount of removed root canal filling (%) at different canal levels using D-Race and XP-Endo Finisher R

Retreatment technique	Root level	Mean±Std.Dev (%)	Median (%)	Min (%)	Max(%)	p-value
D-Race*	Full length	50,89±28,11	56,05	3,42	83,65	
	10 mm	34,07±21,57	27,87	6,37	70,15	0,243
	5mm	34,54±29,75	29,29	3,74	89,11	
XP-Endo Finisher R *	Full length	65,50±24,44	69,09	16,01	91,31	
	10 mm	52,86±26,11	57,31	18,66	86,43	0,537
	5 mm	52,77±37,83	56,90	6,18	100	

** The amount of filling removed after using both retreatment techniques is compared with the initial values after filling the root canal*

The mean volume of filling remnants (mm^3) after using D-Race was 4.96±3.4, 2.95±1.5 and 0.85±0.52 at full length, 10 mm and 5 mm, respectively. The amount of residual filling was additionally reduced after using XP-Endo Finisher R, leaving 3.56±3.03, 2.21±1.61, 0.65±0.57 mm^3 of it at the same root levels. Insignificant difference in the amount of remaining filling material was found after using the supplementary retreatment system ($p>0.05$).

The XP-Endo Finisher R file was almost equally efficient in the different portions of the canals but was still most productive apically (Table 2).

Table 2 Amount of removed root canal filling (%) at different canal levels using XP-Endo Finisher R after the initial retreatment with D-Race

XP-Endo Finisher R	Mean±Std.Dev (%)	Median (%)	Min (%)	Max (%)	p-value
Full length	32,33±20,65	36,42	5,06	68,49	
10 mm	31,87±24,35	30,15	0,15	68,52	0,986
5 mm	38,57±39,20	20,43	1,34	100	

DISCUSSION

The study design aimed to compare the effect of the D-Race retreatment system, followed by the XP-Endo Finisher R in removing root filling of oval canals. These canals need special attention during the retreatment process as rotary instruments are not able to properly shape the entire canal wall and in most cases leave untouched recesses filled with bacteria, debris and filling material (Masiero AV & Barletta FB, 2005; Roggendorf MJ *et al.*, 2010).

Standardization of samples is a prerequisite for obtaining reliable results (Barletta FB *et al.*, 2007). For all teeth included in the experiment, the presence of an oval-shaped canal was proved by digital radiography of teeth in buccolingual and mesiodistal projections. All mandibular incisors were decoronated to obtain equal working length of 16 mm. One and the same preparation protocol with XP-Endo Shaper files and filling with warm vertical compaction technique were applied to all specimens. The shaping system and the filling technique were chosen as they were expected to preserve and fill as much as possible the original anatomy of the canals.

The efficiency of the studied retreatment systems was assessed by micro-CT imaging which is known to be a reliable, precise and nondestructive method for three-dimensional quantitative measurement of existing filling material (Barletta FB *et al.*, 2008; Roggendorf MJ *et al.*, 2010). Similar to previous studies (Barletta FB *et al.*, 2008; Dall'Agnol C *et al.*, 2008), the removed gutta-percha and sealer were expressed as a percentage of the preoperative volume of root canal filling.

The results of our experiment revealed that the combined use of D-Race and XP-Endo Finisher did not achieve complete removal of the root canal filling material, although the difference with the initial filling volume was significant. Our findings coincide with other results reported in the literature (Wilcox LR *et al.*, 1987; Mollo A *et al.*, 2012; Celik Ünal G *et al.*, 2009; Rödig T *et al.*, 2012; Tavares SJO *et al.*, 2020) and can be explained by the anatomical features of the specimens. D-Race files demonstrated efficiency in removing gutta-percha and sealers similar to the findings in other studies (Rödig T *et al.*, 2012; Akhavan H *et al.*, 2012; Delai D *et al.*, 2018). Their effectiveness is attributed to some of their design features – superior sharpness of the cutting blades, smooth surface, alternating cutting edges, enabling the removal of filling material.

XP-Endo Finisher R was designed as a supplementing tool in the root canal filling removal and proved its efficacy in all parts of the canal. The larger semiactive tip distinguishes XP-endo Finisher R from XP-Endo Finisher. Although unable to completely clean the root dentin walls, the file revealed a potential for displacement of root filling residues after conventional retreatment techniques. The combination of the superelastic Max-Wire alloy and ability of its tip to expand under compression during rotation, made it very effective in detaching the remaining filling from the canal space. Our results are consistent with other studies, proving the ability of XP-Endo Finisher R to improve the degree of cleaning of the canal walls during retreatment (Silva EJNL *et al.*, 2018; De-Deus G *et al.*, 2019; Tavares SJO *et al.*, 2020).

XP-Endo Finisher R was more efficient in the apical region, which can be explained by the tendency for more circular shape of the canal approaching the apex (Wu MK *et al*, 2000) and the same size of the tip as that of the shaping file (size 30). Although supplementary retreatment enhanced the removal of root canal filling, it is still not sufficient to completely clean the apical segment of oval-shaped root canals.

Under the conditions of the present study, it can be concluded that the additional application of XP-Endo Finisher R after the D-race retreatment files removed a significant amount of root canal filling. The combined use of the two retreatment systems did not result in completely clean root dentin walls.

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