The Efficiency of Different Supplementary Irrigation Techniques After Nickel-Titanium Rotary System in Endodontic Retreatment

Running head: Supplementary irrigation techniques in retreatment

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ABSTRACT

Objective: To assess the efficiency of XP-Endo Finisher file (XPFF), EDDY, and diode laser as supplementary irrigation activation techniques following nickel-titanium rotary files in the endodontic retreatment.

Methods: 48 mandibular premolars were collected. Each root canal was shaped and filled with EndoSequence BC sealer and gutta percha. After 14 days, endodontic retreatment was performed using D-Race instruments. Then, 48 samples were assigned into 4 groups (n=12) as control, diode laser, EDDY, and XPFF according to the supplementary irrigation methods. After the irrigation procedure, all samples were visualized under a stereomicroscope. The remaining root filling material was scored and compared statistically using Kruskal-Wallis and Post-hoc pairwise comparison tests.

Results: In all thirds, there was a significant difference between the diode laser and control groups. The amount of remaining filling material in the diode laser group was significantly lower than in the control group. When the other groups were compared, a significant difference was observed only between the diode laser and XPFF groups in the coronal third.

Conclusion: No supplemental method could eliminate the root obturation material. The diode laser can be used in addition to nickel-titanium rotary retreatment systems to improve the removal of gutta percha and bioceramic sealer.

Keywords: diode laser, EDDY, endodontic retreatment, EndoSequence BC sealer, XP-Endo Finisher.

INTRODUCTION

Endodontic retreatment is the initial option for eradicating bacteria in the root canal if endodontic therapy does not succeed [1]. For optimal disinfection during endodontic retreatment, it is crucial to remove all obturation materials from the canal walls [2]. However, retreatment techniques and instruments cannot completely remove them [3]. Therefore, additional methods or devices have been suggested to improve root canal cleaning during endodontic retreatment [4, 5]. Activation of irrigation solution has been proven to aid in removing remaining root filling materials [6, 7].

Various devices have been produced for irrigation activation. The XP-Endo Finisher file (XPFF; FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) has a small core and shape memory. At body temperature, these properties enable this instrument to transform into a spoon shape. XPFF may thus induce turbulence in irrigation solutions while also touching the canal walls [8]. The tips of EDDY (VDW, Munich, Germany), a sonic activation method, are made of polyamide and operated with an air scaler. The vibration produced by the air scaler is transferred to the tips in a high-amplitude oscillating motion. According to the manufacturer, this movement generates cavitation and sonic flow, resulting in highly effective cleaning efficiency [9]. Diode laser for irrigation activation has been shown to enhance disinfection and sealing of the root canal system [10, 11]. A recent research proposed the use of diode laser as an adjunct to nickel-titanium (NiTi) retreatment rotary systems to improve the removal of bioceramic sealer [12].

The objective of the current investigation was to assess the efficiency of XPFF, EDDY, and diode laser as supplementary irrigation activation methods in the removal of root canal filling materials. The null hypothesis was that there was no significant difference between the remaining root filling materials after using XPFF, EDDY, diode laser, and conventional needle irrigation.

MATERIALS AND METHODS

G*Power program showed that the sample size should be 12 for each group (α=0.05, power=0.80). Following ethics committee permission (24.03.2022 and 2022/53), 48 straight and single-canal mandibular premolars were selected from the extracted tooth pool. During the selection process, the teeth were meticulously examined, and those with root fillings, immature apices, or root fractures were excluded. A specimen length of 16 mm was achieved by the decoronation process. All treatments were completed by a single endodontist with 10 years of experience.

Endodontic Treatment

The working length (WL) was established to be 1 mm behind the root apex. Each canal was shaped to size 35/.04 with HyFlex CM (Coltene, Altstatten, Switzerland) files using an endodontic motor (500 rpm/2.5 Ncm). After each rotary instrument, the canals were rinsed with 5.25% NaOCl (Cerkamed, Stalowa Wola, Poland) using a 30-gauge (30G) side-vented needle (Endo-Top, Cerkamed, Stalowa Wola, Poland). Final irrigation was applied with distilled water. Then, each canal was filled with EndoSequence BC sealer (Brasseler, Savannah, GA, USA) and gutta percha using the lateral condensation method. After periapical radiography was taken to validate the perfection of canal obturation, Coltosol (Coltene, Altstatten, Switzerland) was placed in the canal entrances. The roots were kept in an incubator with 37°C and 100% humidity for 14 days.

Root Canal Retreatment

D-Race rotary system (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) was used for retreatment procedures. The DR1 instruments (15mm, 30/.10; 1000 rpm/1.5 Ncm) were operated to remove the filling material in the coronal third of the root canal. DR2 files (25 mm, 25/.04; 600 rpm/1.5 Ncm) were used in the remaining part of the canal. All retreatment files were operated with brushing movements. After each rotary instrument, the canals were rinsed with 5.25% NaOCl using a 30G side-vented needle. Retreatment was deemed finished when the DR2 file surface showed no signs of gutta percha.

Then, the samples were classified according to the amount of remaining filling material by radiographic examination and were randomly assigned into 4 groups (n=12) accordingly. One of the groups was determined as the control group. In the remaining groups, XPFF, EDDY, and diode laser were used as supplementary irrigation techniques.

Control group

The canals were irrigated with 5 mL of 5.25% NaOCl for 60 s using a 30G side-vented needle. The needle was placed 1 mm shorter than WL and moved up and down.

Supplementary techniques

XP-Endo Finisher: The canals were filled with 5.25% NaOCl using a needle. The irrigant was activated by the XPFF on the endodontic motor (800 rpm/1 Ncm). The plastic rubber stop was set 2 mm behind the WL and XPFF was operated with an up-and-down motion for 20 s. In 3 cycles, each canal was rinsed with 5 mL of NaOCl in total.

EDDY: The canals were filled with 5.25% NaOCl using a needle. The irrigant was activated by the EDDY tip on the air scaler. The EDDY tip was inserted 2 mm behind the WL and operated with an up-and-down motion for 20 s. In 3 cycles, each canal was rinsed with 5 mL of NaOCl in total.

Diode Laser: The canals were filled with 5.25% NaOCl using a needle. The irrigant was activated with an 810 nm diode laser (Cheese™, Gigaa, China). The optical fiber tip (200 µm) was placed 2 mm shorter than WL and moved helically from apical to coronal (1.5 W, continuous mode). The activation was carried out 4 times, each time for 7 s, with 10 second-interval between irradiations. At these intervals, each canal was rinsed with 5 mL of NaOCl in total.

In all groups, the final flush was performed with 5 mL of 17% EDTA (Cerkamed, Stalowa Wola, Poland) followed by 5 mL of distilled water using a needle.

Analysis of Remaining Filling Material

With diamond discs (Meisinger, Neuss, Germany), grooves were created on the buccal and lingual surfaces of the samples, which were not deep enough to extend into the canal. The roots were longitudinally split by placing the chisel in the grooves.

The samples were visualized under a stereomicroscope (Leica Microsystems, Wetzlar, Germany) at 20X magnification. The grading system of Ezzie et al. [13] was used to score the remaining filling material on the canal walls (Figure 1):

1 = No to slight presence (0-25%) of filling material,

2 = Some presence (25-50%) of filling material,

3 = Moderate presence (50-75%) of filling material,

4 = Heavy presence (75%) of filling material.

The remaining obturation material in the coronal, middle, and apical third of each canal was scored by two blinded endodontists. The observers re-evaluated the images after 1 month. Observer reliability was determined using the kappa test. The intraobserver and interobserver agreement values were 0.824, 0.897, and 0.846, respectively.

Statistical Analysis

The data distribution was analyzed using the Shapiro-Wilk test. The remaining obturation material in the groups was compared using the Kruskal-Wallis and Post-hoc pairwise comparison tests. The significance level was accepted as 0.05.

RESULTS

Obturation material was detected in every root canal. The mean and standard deviation (SD) scores of the remaining root filling material for all thirds are shown in Table 1. The amount of remaining filling material in the diode laser group was significantly lower than in the control group for all thirds. When the other groups were compared, a significant difference was observed only between the diode laser and XPFF groups in the coronal third (Table 2).

DISCUSSION

During endodontic retreatment, the existing root canal filling material must be entirely removed to eliminate the microorganisms in the root canal system that cause periapical inflammation. Previous research has shown that D-

Race retreatment files cannot completely remove obturation materials from the root canal [14]. Therefore, in the current research, XPFF, EDDY, and diode laser were used following D-Race retreatment files to remove bioceramic sealer and compared with needle irrigation. According to the results, the null hypothesis was rejected since there was a significant difference between the groups. Our findings revealed that compared to needle irrigation, diode laser-activated irrigation improved bioceramic sealer removal, while the XPFF and EDDY did not exhibit any significant difference.

Various approaches, such as radiographic evaluation [15], root splitting [16-18], and micro-computed tomography (micro-CT) [4, 6, 7], have been used to determine the effect of supplementary techniques applied following NiTi retreatment files on the obturation material removal. In the current research, the samples were sectioned longitudinally and the residual obturation material was scored using stereomicroscope images. This technique is more beneficial and trustworthy than radiographic assessment, which produces only a two-dimensional image. To minimize subjectivity in the scale-based scoring method, images were evaluated by 2 blinded endodontists, and interobserver and intraobserver agreement values were calculated. Micro-CT yields more accurate results since it visualizes the root canal in three dimensions without damaging the sample. Nevertheless, access to this technology is limited due to high cost.

The findings of the present research revealed that diode laser removed more obturation material than conventional needle irrigation. This is consistent with a recent study using micro-CT analysis [12]. Furthermore, a previous study using SEM analysis reported that combining Er,Cr:YSGG with a diode laser largely eliminated resin sealer residues from the canal walls [19]. Cheng & Zhu [18] concluded that Nd:YAG laser could help to remove the resin-based sealer. Photon-initiated photoacoustic streaming (PIPS) irrigation has also been shown to improve the removal of tricalcium silicate-based sealer [20]. However, Dönmez Özkan et al. [21] observed that PIPS was not effective in removing resin-based sealer as a supplementary technique.

Earlier investigations have demonstrated that supplementary irrigation with the XPFF during endodontic retreatment improves the removal of filling material regardless of sealer type [6, 22]. Conversely, we discovered no significant difference between XPFF and needle irrigation. This disparity might be related to the use of different analysis techniques for the residual obturation material. While the root splitting and scoring method were used in this research, the residual filling material was analyzed with micro-CT in the previous studies [6, 22]. The most recently published study assessing the removal of EndoSeal MTA from artificial grooves on the canal wall found no significant difference between XPFF and needle, similar to our findings. However, they discovered a significant difference between the EDDY and needle, which contradicts our results [23]. The reason for this contradiction may be that they used only root canal sealer as obturation material. In the present study, EDDY may not have effectively eliminated gutta percha.

Bioceramic materials have become increasingly preferred as root canal sealers because of their biocompatibility and antibacterial effects [24]. Bioceramic sealers chemically bond to dental structures [25, 26], which can make them difficult to retreat. The absence of difference between the EDDY, XPFF, and diode laser groups in this research might be attributed to the difficulty of removing EndoSequence BC sealer. However, only Oltra et al. [27] stated that AH Plus sealer can be removed more effectively than EndoSequence BC sealer. While some research revealed similar retreatability [6, 28, 29], another study demonstrated less sealer residue with EndoSequence BC sealer compared to AH Plus [30].

On the other hand, no previous investigation has compared the effectiveness of EDDY and XPFF with diode lasers in the removal of root obturation material. The possibility of damage to the dentin and obturation material during root splitting process was a limitation of the current study. To obtain more precise results, future studies should compare the efficacy of diode lasers with EDDY and XPFF using micro-CT. Another limitation of the research was the removal of tooth crowns to ensure an equal WL. Although decoronation is not reflective of clinical practice, it does minimize factors such as crown anatomy and access cavity. As a result, more reliable data on the instruments' effectiveness is collected.

CONCLUSIONS

Under the experimental conditions of this investigation, no supplemental irrigation method might completely remove the obturation materials. The diode laser can be used in addition to NiTi rotary retreatment systems to improve the removal of gutta percha and bioceramic sealer.

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Table 1 Mean and standard deviation (SD) scores of the remaining root filling material for all thirds

	Groups	n	Mean	Median	SD	Minimum	Maximum	p
Coronal	Control	12	2.17	2.00	1.115	1	4	**0.005**
	EDDY	12	1.17	1.00	0.577	1	3	
	XPFF	12	1.58	1.00	0.996	1	4	
	Diode laser	12	1.08	1.00	0.289	1	2	
Middle	Control	12	2.50	2.50	1.314	1	4	**0.049**
	EDDY	12	1.58	1.00	0.996	1	4	
	XPFF	12	1.75	1.00	1.055	1	4	
	Diode laser	12	1.25	1.00	0.622	1	3	
Apical	Control	12	3.50	3.50	0.522	3	4	**0.013**
	EDDY	12	2.92	3.00	1.165	1	4	
	XPFF	12	3.17	3.50	1.115	1	4	
	Diode laser	12	1.83	1.00	1.193	1	4	

Kruskal-Wallis test, Bold letters indicate significant difference ($p<0.05$).

Table 2 Pairwise Comparison

	Coronal	Middle	Apical
Groups	**p**	**p**	**p**
Control-EDDY	**0.032**	0.271	0.673
Control-XPFF	0.440	0.455	0.980
Control-Diode laser	**0.017**	**0.047**	**0.011**
EDDY-XPFF	0.484	0.973	0.945
EDDY-Diode laser	1.000	0.778	0.159
XPFF-Diode laser	0.409	0.519	0.083

Bold letters indicate significant difference (p<0.05).

FIGURE LEGEND

Figure 1 Stereomicroscope images of representative samples. a) The apical third of the root canal was graded as score 4, and the coronal and middle thirds as score 1. b) The coronal third of the root canal was graded as score 2, and the middle and apical thirds as score 3.