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Review article

ANALYSIS OF THE EFFECTIVENESS OF XP-ENDO FINISHER R IN ORTHOGRADE ENDODONTIC RETREATMENT

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SUMMARY

Background: Removal of the root canal filling material in the course of the endodontic retreatment is achieved by the use of various instruments and techniques.

Purpose: The aim of this article is to systematically analyze published *in vitro* investigations over a five-year period of time (2018-2022), assessing the efficacy of the XP-Endo Finisher R file as a supplementary approach in orthograde endodontic retreatment.

Materials and methods: The literature data was acquired through PubMed - MEDLINE, The Cochrane Library and Science Direct database and hand web search, then the articles were assessed by three independent reviewers.

Results: An overall number of eighteen papers out of 108 titles met the eligibility criteria and were finally chosen for quantitative synthesis. Most of the studies affirmed the effectiveness of XP-Endo Finisher R by means of microcomputed tomography. Shaping with the file is not able to guarantee root canal walls free of remnants.

Conclusions: XP-Endo Finisher-R is an effective supplementary approach in endodontic retreatment procedures. Nonetheless, it is rarely reported to achieve the complete removal of the root canal filling material. Micro-CT is a reliable, non-invasive analytical tool that can accurately measure the volume and the percentage of the remaining root canal fillings.

Keywords: XP-endo finisher R, retreatment, supplementary, removal, root filling material, remnant/s,

BACKGROUND

Despite the high success rate of the initial endodontic therapy [1], residual microbiota might cause periradicular infection [2]. In such cases, the orthograde nonsurgical endodontic retreatment is regarded as the first treatment option [1, 3, 4]. Its main goal is to remove the previously contaminated root canal filling material so that the entire root canal space can be adequately shaped, disinfected and filled again [5].

Several retreatment techniques have been advocated during the past decades, including the manual root canal shaping with stainless steel files, NiTi rotary instruments, heat, ultrasonic appliances, solvents, lasers and photon-induced photoacoustic streaming, and various combinations of these methods [4]. The majority of dental clinicians opt for engine-driven endodontic systems rather than manual instrumentation due to their improved efficacy and the shortened chair time of the appointments [3, 6, 7]. Nevertheless, none of the specifically designed NiTi retreatment files renders root canals completely free of filling material [8, 9]. Thus, supplementary techniques following retreatment procedures would be beneficial to cover larger and difficult to reach root canal areas and enhance the action of the disinfecting irrigants [10].

Recently, the XP-endo Finisher-R (*FKG, La Chaux-de-Fonds, Switzerland*) was introduced to the market as an improved variant of the XP-endo Finisher. It is a non-tapered file with a larger core diameter (30/.00). The instrument is manufactured from the novel MAX-wire (MartensiteAustenite ElectropolishFleX), which allows it to expand at body temperature and upon pressure, to adopt a "spoon-like" shape of the final millimeters of its working part. Due to this, the file abrades the dentine surface with an improved distance of 6 mm in diameter and cleans areas that were previously impossible to reach by the standard instruments of the same size. Additionally, the instrument provides agitation of the irrigants due to the turbulence resulting from its action [11-16].

The aim of this article was to analyze and summarize the recently published studies investigating the efficacy of XP-endo Finisher-R (XP-FR) as a supplementary retreatment approach.

MATERIAL AND METHODS

Eligibility criteria

The review process was performed on articles assessing the *in vitro* effect of the novel file XP-Endo Finisher R on samples prepared from extracted, fully formed permanent human teeth without any root canal caries, cracks, fractures or other defects.

Exclusion criteria

Studies focusing solely on debris extrusion, microbial flora assessment, removal of root canal medications, registration of the morphological changes of the instruments after use, case reports, review articles, thesis, articles not in English or only about XP-Endo Finisher files were not included in the systematic review.

Literature search and data extraction

A thorough literature search was done on PubMed - MEDLINE, The Cochrane Library, Science Direct database and own manual search on the web. The following keywords were used*:* XP-endo finisher R, retreatment, supplementary, removal, root filling material, remnant/s.

The data search was applied for *in vitro* studies investigating the ability of XP-Endo Finisher-R to enhance the removal of root canal filling material, released in the period from 2018 to 2022. The language was restricted to English.

Screening and selection

Three independent reviewers judged the relevance of each paper to the criteria based on its title and/or abstract. Case reports, letters, reviews, and theses were not included in the search. A detàiled, full-text reading of the article was initialized when the keywords were present either in the title and/or the abstract. Those papers that fulfilled all of the selection criteria were processed for data extraction. Any conflicts between the three reviewers were resolved by a discussion.

From the collection of papers that met the eligibility criteria, data were extracted and summarized in tables.

RESULTS

In the PubMed – MEDLINE database, 20 articles were obtained with the combination of the keywords. The total number of papers found through Cochrane Library, Science Direct and manual search was: 2, 11 and 75, respectively. After removing duplicates for searches and identifying relevant studies, 108 unique papers were selected for further systematic review. A total number of 18 articles were finally chosen for quantitative synthesis (Fig.1). Table 1 shows the characteristics of the reviewed studies concerning the efficacy of the XP-FR file as a supplementary instrument.

Fig. 1. The PRISMA diagram illustrates the flow of information through the different stages of a systematic review.

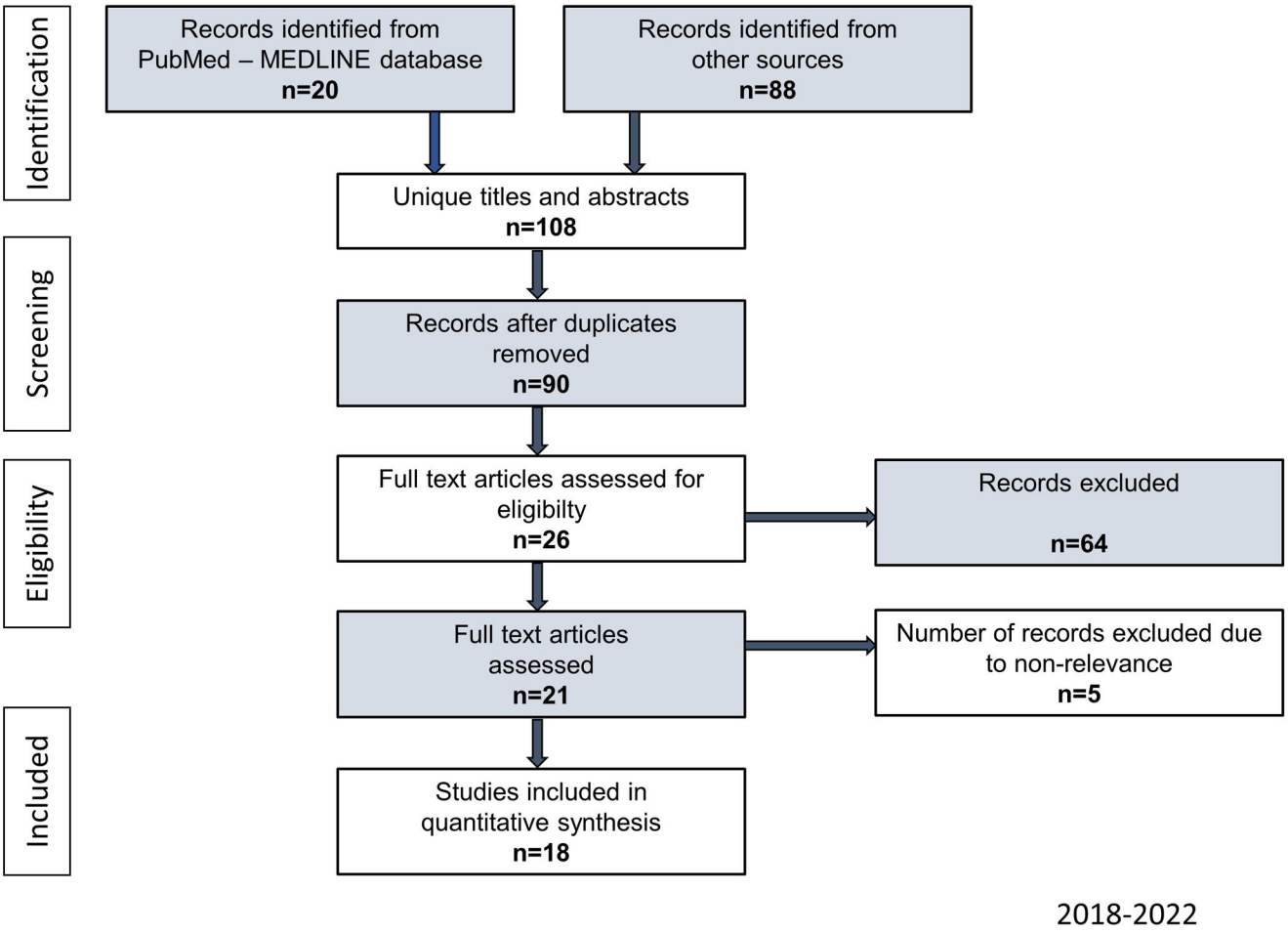

Table. 1. Summary of characteristics of the studies reviewed about the efficacy of the XP-FR file as a supplementary instrument in endodontic retreatment.

(CWC – Continuous wave of condensation; WVC – Warm vertical compaction; SC – Single cone; CLC – Cold lateral compaction; GG – Gates Glidden; PUI – Passive ultrasonic irrigation; DOM – Dental Operating microscope; OM – Operating microscope; SM – Stereomicroscope; Micro-CT – Microcomputed tomography; SEM – Scanning Electron Microscopy).

Author/year	Type and sample size	Preparation	Obturation	Retreatment	Supplementary methods	Solvents	Observation method
1. **Silva** et al., 2018 [5]	20 maxillary single-rooted	R25 (25/.08)	CWC AH Plus	R25 (25/.08) R40 (40/.06)	XP- F XP-FR	None	Micro-CT
2. **Alzuabi & Abiad**, 2018 [11]	24 mandibular single - rooted premolars	iRace (30/.04)	WVC Adseal	D-Race(DR1&DR2) + BT Race (30/.04)	XP- F XP-FR	None	DOM (x16)
3. **De-Deus** et al., 2019 [12]	20 mandibular incisors	R25 (25/.08)	SC AH Plus	R40 (40/.06)	XP-FR PUI	None	Micro-CT
4. **Machado** et al., 2019 [13]	60 mesial canals of mandibular molars	BioRaCe BR (25/.08) BR1(15/.05) BR2 (25, .04) BR3 (25/.06)		D-Race+SAF D-Race+TRUShape D-Race+XP-S	XP-FR	None	Micro-CT
5. **Campello** et al., 2019 [14]	32 mandibular molars	R25 (25/.08)	SC Sealer 26	Mtwo-R Mtwo (20/.06, 25/.06, 30/.05 and 35/.04)	XP-FR	Eucalyptol	Micro-CT
6. **Kontogiannis** et al., 2019 [17]	120 mandibular single-rooted premolars	BTRaCe (40/.04)	SC MTA Fillapex TotalFill BC AH Plus	D-Race	XP-FR	None	Split teeth OM images
7. **Iriboz** et al., 2019 [15]	120 mandibular premolars	R25 (25/.08)	CWC AH Plus	GG+H-file R25 +R40 PTU-R + F2+F3 D-Race1+XP-S D-Race1+XP-S+XP-FR	XP-FR	Resosolv (in half of the groups)	Split teeth SEM
8. Volponi et al., 2020 [18]	36 mandibular premolars	PTN X1 (17/.04) X2 (25/.06) X3 (30/.07)	SC	R40 (40/.06) Bio-C Sealer	UAI Endoactivator XP-FR	None	Micro-CT
9. Eid et al., 2021 [19]	36 mandibular incisors	PTN X1 (17/.04) X2 (25/.06) X3 (30/.07)	WVC TotalFill BC	Mani GPR (1S, 2S, 3N, 4N) + PTN (X3-30/.07; X4-40/.06)	XP-FR H-files (30/.02)	None	Micro-CT
10. Ferreira et al., 2021 [20]	24 mandibular incisors	PTN X1 (17/.04) X2 (25/.06)	SC AH Plus Jet	PTU-R PTN (X3-30/.07)	XP-FR IrriSafe	MEK/TCE	Micro-CT
11. Tavares et al., 2021 [21]	24 mandibular premolars	R40 (40/.06)	CLC Sealer 26	R50 (50/.05)	XP-FR R1-Clearsonic insert	None	Micro-CT
12. Crozeta et al., 2021 [22]	28 distal root of mandibular molars	R40 (40/.06)	SC+AH Plus SC+BC Sealer	R50 (50/.05)	XP-FR R2 Flatsonic ultrasonic instrument	None	Micro-CT
13. Liu et al., 2021 [23]	30 mandibular molars	Vortex Blue 35/.04 40/.04	SC+AH Plus SC+BC Sealer WVC+ AH Plus	D-Race (DR1-30/.10) XP-S	XP-FR	Chloroform	Split teeth OM images
14. Silva et al., 2021 [24]	20 single-rooted teeth	R25 (25/.08)	SC AH Plus	R25 (25/.08) R40 (40/.06)	XP-FR Clearsonic tip	None	Micro-CT
15. Shaheen *et al., 2021 [25]*	30 mandibular premolars	PTU F3 (30/.06)	CLC Endosequence BC Sealer	PTU-R (D1, D2, D3)	WOG (25/.07) TRN (36/.03) XP-FR	None	Micro-CT
16. Faus-Ll6cer et al., 2021 [26]	20 maxillary canines	PTG F2 (25/.08)	TF+AH Plus GC+AH Plus	DR 1 XP-S	XP-FR	None	Micro-CT

17. Matoso et al., 2022 [27]	24 mesiobuccal roots of maxillary first molars	WOG (25/.07)	CLC AH Plus	WOG Primary (25/.07) Medium (35/.06)	PUI XP-FR	None	Micro-CT
18. Hassan et al., 2022 [28]	60 mandibular premolars	BioRace BR0 (25/.08) BR1 (15/.05) BR2 (25/.04) BR3 (25/.06) BR4 (35/.04)	CLC AH Plus	GG+H files D-Race D-Race+XP-F D-Race+XP-FR	XP-F XP-FR	None	Split teeth SM x30

DISCUSSION

XP-Endo Finisher-R facilitates the removal of root canal filling materials after the initial retreatment procedures [16]. Nevertheless, almost all of the investigations noted the existence of remnants in the specimens after their upplementary use [5, 11, 12, 15, 17-28]. These findings corroborate with earlier studies where no retreatment strategy was able to clean the root canal walls completely [8, 9]. In the study of Campello et al., total removal of filling remnants was achieved only in two out of thirty-two roots after shaping with XP-FR [14]. Machado et al. reported thorough cleanliness of mesial canals of lower molars after their retreatment with D-Race, followed by XP-endo Shaper, SAF and TRUShape – 70%, 55% and 30% of the specimens, respectively. The supplementary step with the XP-endo Finisher R instrument was associated with additional filling material removal, and six more canals were rendered free of filling material after using this finishing instrument [13].

The effectiveness of XP-FR has been assessed for a variety of root canal filling materials and techniques. The majority of the experiments tested the ability of XP-FR in the removal of epoxic resin-based endodontic sealers [5, 11-14, 20, 21, 24, 27, 28]. AH Plus (*Dentsply De Trey, Konstanz, Germany*) is considered to be a 'gold standard' sealer for its excellent physiochemical properties and good biocompatibility [17]. Additional shaping with the file resulted in a significant reduction of gutta-percha and AH Plus sealer [5, 15, 17, 20, 22, 24, 27, 28]. Retreatment of bioceramic sealers is often a great challenge and might cause the blockage of the apical portion of the root canal [22]. Kontogiannis et al. compared the efficacy of XP-FR in the removal of one epoxy–AH Plus and two bioceramic sealers: MTA Fillapex (*MTA-F; Angelus, Londrina, Brazil*) and TotalFill BC (*Brasseler USA, Savannah, GA, USA*). The authors concluded that patency in the TotalFill group was regained more laboriously than in the MTA group, especially in the apical and middle third of the canal, whereas the AH Plus was the easiest of the three sealers to remove. The use of the XP-FR file significantly improved the removal only of AH Plus [17]. Crozeta et al. came to the same conclusion while retreating root canals filled with AH Plus and BC Sealer (*Brasseler USA, Savannah, GA, USA*) [22]. Contrary to them, Liu et al. found that XP-FR instruments were more efficient in removing filling material in the bioceramic group than in those filled with epoxy sealer [23].

Reports from scientific data have been inconsistent regarding the use of solvents during the retreatment procedures. Despite the manufacturer's recommendation of using solvent for the XP-endo Finisher R file, it was included in the protocol of a few of the reviewed articles [14, 15, 20, 23]. This might be explained by the possible formation of a thin layer of softened gutta percha which adheres to the root canal walls and hinders the removal of root canal filling material, resulting in a longer procedure [5, 11, 15, 29, 30]. However, Iriboz et al. outlined the effectiveness of Resosolv in combination with XP-FR [15]. A recent study by Ferreira et al. demonstrated the favourable effect of an additional solvent mixture of Methyl ethyl ketone/ Tetrachlorethylene that increased the efficiency of filling materials removal regardless of the agitating instruments employed, IrriSafe or XP endo Finisher R**.** These findings refute the results reported by Campello et al. who found that the use of eucalyptol did not improve filling material removal from Vertucci's type II molar mesial canals and isthmuses [14].

The removal of root canal filling materials has been analyzed by several methods such as tooth splitting [15, 17, 23, 28], diaphanization [11, 31], conventional and digital radiography [32], dental operating and stereomicroscope images [11, 17, 23, 28], scanning electron microscopy (SEM) analysis [15], and CBCT [7, 33]. To date, microcomputed tomography is the most preferred approach for its non-destructive nature and accuracy in qualitative and quantitative analysis of the retreatment procedures [5, 19]. This technique provides longitudinal observation of the same sample throughout the experiment at different time points [5, 12, 34]. Moreover, it reduces the risk of sample selection bias by choosing teeth with minimal anatomical differences that have almost the same volume or aspect ratio of the root canals [20].

There are no unified criteria in terms of sample selection in *in vitro* investigations on the removal of root canal filling material by supplementary approaches. Researches usually choose oval-shaped root canals due to their noncircular anatomy, representing a challenge in retreatment cases [5, 12, 25, 35-37]. The sharpened notch of the oval extensions is a site accumulated with a residue of filling material, debris and bacteria. The amount of root canal filling remnants in oval canals has been observed to be higher [38] than in round canals [39]. The expansion of the XP-FR during its action enables the instrument's tip to touch and dislodge root filling material from the canal walls even in these inaccessible areas, which may be further removed by various irrigation solutions [12].

LIMITATION

The major databases were used for the literature search. A possible limitation of this systematic analysis is that papers which are not listed in these sources might have

been omitted. The current review includes articles published in the English language, which may have neglected potentially valuable scientific data.

CONCLUSION

XP-Endo Finisher-R is an effective supplementary approach in endodontic retreatment procedures. Nonetheless, it is rarely reported to achieve the complete removal of the root canal filling material. Further efforts should be focused on the design of new instruments that can improve the cleaning and disinfection of the root canal system during retreatment.

Micro-CT is a reliable, non-invasive analytical tool that can accurately measure the volume and the percentage of the remaining root canal fillings.

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