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Endodontics

KEY WORDS: XP-Endo Shaper, Apical debris extrusion, reciprocating files

APICAL DEBRIS EXTRUSION FOLLOWING ENDODONTIC TREATMENT BY XP-ENDOSHAPER FILES: A SYSTEMATIC REVIEW AND META-ANALYSIS.

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ABSTRACT

Aim: The review aims to determine the relevant position of XPS in terms of apical debris extrusion and how it fares in comparison with the other file systems. **Methods :** A systematic search used keywords ("Debris extrusion" AND "XP Endo Shaper") across databases like MEDLINE, PubMed, PubMed Central, Web of Science, and Google Scholar. The inclusion and exclusion criteria was stringent to conduct the filtering and select the in-vitro, RCTs etc which were eligible for qualitative and subsequent quantitative analysis. **Results:** A total of n=5 studies were identified after a critical assessment of articles for the inclusion and exclusion criteria. The standard mean Difference is 1.66 (0.54 – 2.77) and the pooled estimates favour other file systems. This signifies that the debris extrusion is on average 1.66 times more by other file systems as compared to XP endo shapers file and this difference is statistically significant (p<0.05). By employing the random effect model the I^2 statistic showed 97%, the heterogeneity for Tau^2 was 1.56, x^2 being (p<0.0001) and the overall effect for Z value being 2.91 (p=0.004). **Conclusion:** XP-Endo Shaper demonstrates efficiency in challenging anatomies while minimizing debris. It shows less debris extrusion than rotational systems, though more than reciprocating ones

INTRODUCTION:

Cleaning and shaping the root canals is practically the most crucial step for a successful root canal treatment. The efficiency with which adequate mechanical shaping of the canal and chemical washing of the unwanted material is performed depends on various factors such as the type of tooth, dimensions, and curvature of the root canal, diameters at the apical foramen, and the properties of the endodontic files used for the procedure.[2]

There are multiple factors that could possibly trigger the process of endodontic flare up described in the literature. [3-5] One of the most common reasons is the extruded debris beyond the confines of root canals that include microorganisms, irrigant solutions, pulp, and dentinal fragments. Extrusion of this debris beyond the apical foramen to the periapical tissues during instrumentation disrupts the balance between host defense and microbial aggression, causes the persistence of the infection, and exacerbates inflammation.[7]

As much as eliminating apical extrusion of debris is desirable, it is virtually impossible to achieve the same with the currently existing instruments and instrumentation techniques.[9] It has been supported by many studies that the debris extrusion from the apical that can occur during endodontic treatment is closely related to the irrigation agents used, the preparation techniques applied, and the preferred root canal instruments.[10]

Recent reviews have found that the design and motion kinematics of the endodontic files influence the quantity of extruded debris significantly more than the number of files used for the biomechanical preparation of the canal.[11,12] The amount of debris extruded depends on certain properties of the endodontic files such as the blade design, cross-section, and the radial land of the instrument, or selected preparation techniques such as reciprocation, continuous rotation, or adaptive motion.

XP Endo Shaper (XPS; FKG Dentaire SA, La Chaux-de- Fonds, Switzerland) is a single-file rotary instrument system produced from a MaxWire NiTi alloy.[11,12] The instrument has a constant taper of 1% and an apical diameter of 0.30 mm.[17] Owing to the special alloy, it shows a transition to the austenitic phase at the body temperature and the taper increases to 4%.[17,18] The continuous rotary single file system combines the MaxWire and Booster Tip technologies.[18] The manufacturer has recommended the system to be used in continuous rotary motion (800 rpm and torque of 1 N/cm).[19]

The present systematic review aims to analyse findings from the studies that have compared the debris extrusion produced by XPS to other endodontic file systems. The review aims to determine the relevant position of XPS in terms of apical debris extrusion and how it fares in comparison with the other file systems.

MATERIALS AND METHOD

A systematic search used keywords ("Debris extrusion" AND "XP Endo Shaper") across databases like MEDLINE, PubMed, PubMed Central, Web of Science, and Google Scholar. Only English-language articles with full text were considered, encompassing various study types except review articles, animal studies, case reports, and case series. Additional studies were sought through cross-referencing from the included articles.

The extracted data included publication's author, year, country, study design, ethics, sample size, patient age, tooth details, inclusion/exclusion criteria, file systems used, canal preparation method, debris collection/analysis approach, and author conclusions.

Table 1: Eligibility Criteria – PICOS Criteria

Category	Inclusion Criteria	Exclusion Criteria
Population/Participants	Studies that compared extrusion of debris after endodontic treatment with XP-Endo Shaper to other file systems. Full-text available in the English language	Studies using XP-Endo Finisher Studies not comparing XP-Endo finisher with other file systems
Intervention	Extruded debris after endodontic treatment by XP-Endo shaper	Ambiguity regarding the methodology Studies not assessing extruded debris

Comparison	Debris extruded after use of other file systems other than XP-Endo shaper	Comparisons not with other file systems Comparisons between debris extruded from different types of access cavities, irrigants used, and rotation speed of XP-Endo system.
Outcome	Comparative findings of extruded debris after the use of XP-endo versus other file systems	No definite outcomes comparing XP-endo shaper with other file systems
Study design	Randomized and non-randomized clinical trials Case-control studies Cross-sectional studies In-vitro studies	Descriptive studies Systematic Reviews Case reports and Case series Animal studies.

Strategy for data synthesis -

Qualitative synthesis compared apical debris extrusion across different file systems, considering authors' conclusive findings. Due to methodological variations and file types, exact numbers and meta-analysis weren't compared.

Risk Of Bias (quality) Assessment -

Cochrane's ROB-2 tool assessed methodological quality, evaluating domains like bias in sequence generation, allocation concealment, personnel/equipment blinding, outcome assessment blinding, incomplete outcome data, selective reporting, and other biases through Review Manager software. Overall risk was categorized as low,

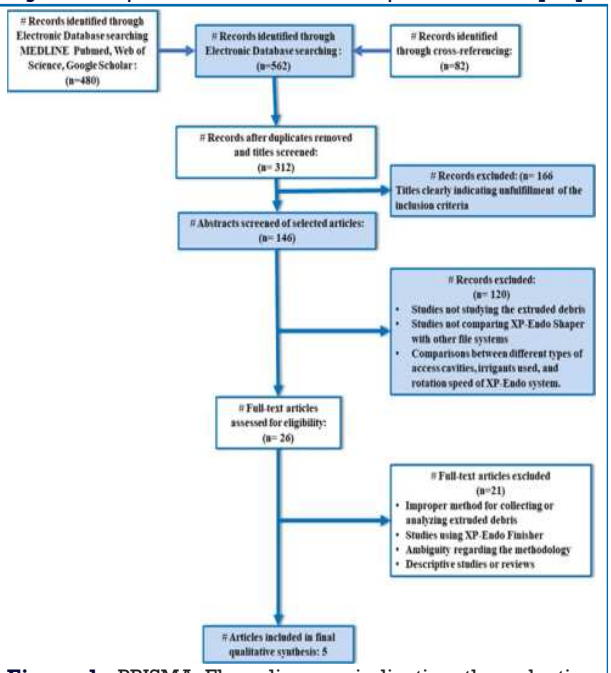

Figure 1: PRISMA Flow diagram indicating the selection process of the articles for final data analysis in the present systematic review

RESULTS:

A total of n=5 studies were identified after a critical assessment of articles for the inclusion and exclusion criteria. The data extracted from these articles in tabularized in Tables 2 and 3.

Table 2: Summarization Sample And Material Selection Made By The Authors Of Studies Included In The Present Systematic Review

Sr No.	Author	Working length	Initial prep	Irrigation	Obturation	XPS speed and torque	Motion	Analysis	Findings/Conclusion
1	Alves	1 mm short of total canal length	#15 K-file	2mL saline for 1 minute	Not provided	800 rpm speed and 1 N.cm torque	5- to 7-mm-long strokes	Micro-CT	Apical extrusion of bacteria occurred in 19 (90%) and 17 (81%) canals for the XP-endo Shaper and Reciproc groups, respectively, with no significant difference in frequency
2	Azim	0.5 mm short to the AF	30.04 (Vortex Blue, Tulsa OK)	5 mL distilled water	warm vertical compaction of gutta-percha and AH Plus sealer	3000 rpm speed and 1 N.cm torque	10 strokes	Pre- and post-operative weight, Micro-CT	No difference was found regarding the amount of extruded debris among the 3 groups. XP was the most efficient in gutta-percha removal from the canals when operated at a higher speed (3000 rpm) followed by EDM and WOG.
3	AlOmari	1mm short of the tooth length	ProTaper Next X1 (17/04) and X2 (25/06) files (Dentsply Sirona, Ballaigues, Switzerland	2 ml of tridistilled water	warm vertical compaction of gutta-percha and AH Plus sealer	3000 rpm speed and 1 N.cm torque	slow pecking motion	Pre- and post-operative weight	XPS extruded less debris than RB with a median of 1.145 mg (CI: 0.8471–1.8122) versus 1.235 mg (CI: 0.8923–1.8357), but no significant difference was detected statistically (P > 0.05) XPS was more efficient

									in the removal of gutta-percha and required less preparation time compared to RB.
4	Hazar	1mm short of the tooth length	#15 K-file	2 ml distilled water	Not provided	800 rpm speed and 1 N.cm torque	pecking movements	Pre- and post-operative weight	The XPS group showed less debris extrusion than WOG and OC groups (P < 0.05).
5	Unal	1 mm short of total canal length	#15 K-file	10 ml of distilled water	Not provided	800-1000 rpm speed and 1 N.cm torque	15 strokes	pre- and post-operative weight	When the amount of debris extrusion from the apical is ordered from high to low, it was seen that there are 2Shape, One Curve, XP-Endo Shaper, and WaveOne Gold. However, the difference between study groups was not statistically significant. When the rotational rotary instrument systems were evaluated within themselves, it was determined that the maximum extrusion was 2 Shapes, while the least extrusion was the XP-Endo Shaper

Table 3: Details Pertaining To Canal Preparation And Conclusive Findings Discerned By The Authors Of Studies Included In The Present Systematic Review

Sr No.	Author	Year	Country	Sample size (divided into)	Teeth	Root curvature/canal morphology	Inclusion criteria	Exclusion criteria	Inclusion criteria	Comparison between
1	Alves	2018	Brazil	60 (2 groups)	Maxillary molars	Distobuccal canals, moderate root curvature (mean, 12.8 16.2 ; range, 0 –70)	Not provided	Not provided	Not provided	XP-endo Shaper and Reciproc.
2	Azim	2018	New York	60 (3 groups)	mandibular incisors	single-canal with curvature less than 10°	type I Weine configuration with an oval canal	Teeth with open apices, resorptive defects, caries, root fillings, cracks, calcifications, and teeth presenting with an initial apical diameter greater than a size #25 K-file or apical curvature greater than 10o were	type I Weine configuration with an oval canal	WaveOne Gold Primary, Hyflex EDM "one file", and XP Shaper
3	AlOmari	2021	Jordan	30 (2 groups)	mandibular premolars	single-canal with curvature less than 10°	extracted for orthodontic reasons	external defects, canal curvature larger than 10°, open apices, or other	extracted for orthodontic reasons	Reciproc Blue and XP Endo Shaper

								anatomic irregularities. canal with an initial file size larger than size 25		
4	Hazar	2021	Turkey	45 (3 groups)	mandibular molar	Mesial roots with curved canals	teeth with curvature angles between 25° and 45°	extrusion of #15 K-file beyond the apical foramen	teeth with curvature angles between 25° and 45°	WaveOne Gold, One Curve, and XP-endo Shaper
5	Unal	2022	Turkey	60 (4 groups)	mandibular premolars	single-rooted, single-canal teeth without any anatomical difference, a single apical foramen with a slope less than 15°	Teeth with completed apical development extracted for orthodontic and periodontal reasons	Teeth with caries and restoration	Teeth with completed apical development extracted for orthodontic and periodontal reasons	2 Shape, One Curve, WaveOne Gold, XP-3D Endo Shaper

Assessment Of Methodological Quality And Risk Of Bias

All the included studies were largely comparable in methodological quality. All the included studies had moderate to high risk of bias with all the respective domains. The highest risk of bias was seen for allocation concealment (selection bias). Among the included studies, Azim et al 2018 and Unal et al 2022 had a high risk of bias compared to all other studies. Hazar et al 2021 reported the lowest risk of bias. Domains of incomplete outcome data (attrition bias) and other biases were given at the lowest risk of bias by included studies while respected domains. The highest risk of bias was seen for allocation followed by random sequence generation (selection bias) and blinding of personnel and equipment (performance bias) was given the highest risk of bias. The risk of bias in included studies through the Cochrane risk of bias (ROB)-2 tool is depicted in **Figures 2 and 3** as shown below.

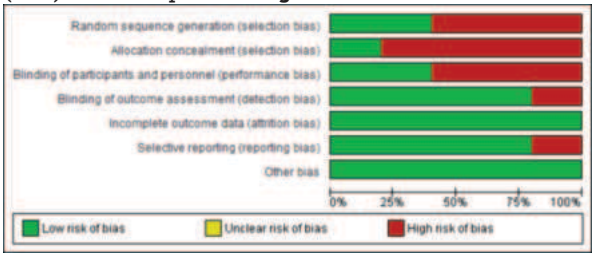

Figure 2: Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies

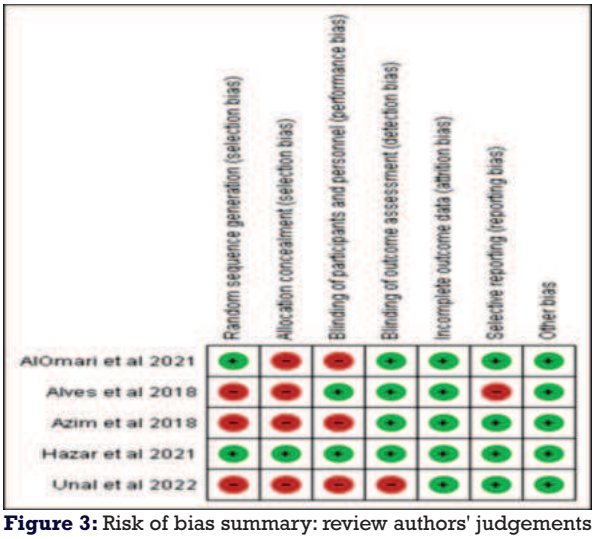

Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

SYNTHESIS OF RESULT:

As shown in **Figure 4,** five studies containing data on 510 (n=255) samples, of which (n=255) samples were evaluated by XP endo shapers file and (n=255) samples were evaluated by other file systems for the debris extrusion as an outcome. The standard mean Difference is 1.66 (0.54 – 2.77) and the pooled estimates favour other file systems. This signifies that the debris extrusion is on average 1.66 times more by other file systems as compared to XP endo shapers file and this difference is statistically significant (p<0.05). Among all the included studies, Alves et al 2018 and Unal et al. 2022 had the highest weightage at the overall pooled estimate while the lowest weightage was observed for Azim et al 2018 at the pooled estimate.

By employing the random effect model the I^2 statistic showed 97%, the heterogeneity for Tau^2 was 1.56, x^2 being (p<0.0001) and the overall effect for Z value being 2.91 (p=0.004).

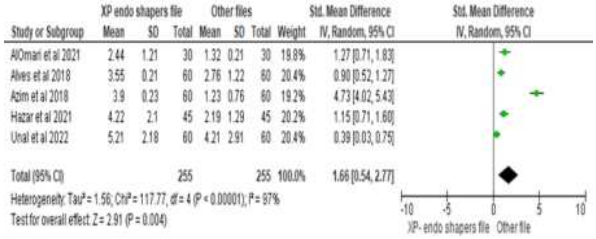

Figure 4: showing Forest plot showing XP endo shapers file versus other file system with regards to the debris extrusion

The funnel plot did not show significant asymmetry, indicating the absence of publication bias as shown in **Figure 5.** Funnel plot showing symmetric distribution with the absence of systematic heterogeneity of individual study compared to the standard error, showing an absence of publication bias in the meta-analysis.

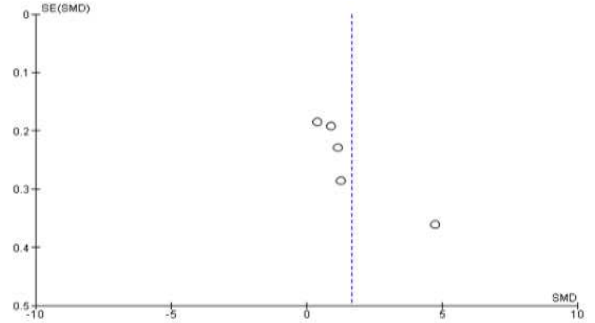

Figure 5: showing Begg's Funnel plot with 95% confidence

intervals demonstrating symmetric distribution with an absence of systematic heterogeneity of individual study compared with the standard error of each study, indicating an absence of publication bias.

DISCUSSION:

Periapical extrusion of debris, dentine mud, or microbes is linked to postoperative flare-ups and, more importantly, endodontic treatment failures. The technique for canal preparation and shaping, under the clinician's control, can influence debris extrusion and post-endodontic pain.

Owing to recent advances in production methods, metallurgy, and innovative concepts, it became possible to manufacture file systems offering easier and faster instrumentation while minimizing the amount of debris extruded.[34] XP-Endo Shaper (XPS; FKG Dentaire SA, La Chauxde-Fonds, Switzerland), is one such continuous rotary single file system combining the MaxWire and Booster Tip technologies, improving the preparation of root canals with irregular anatomy by enabling its adaptation to the canal walls, reaching areas that conventional instruments cannot access.[32] XPS files are in the martensitic phase at room temperature because of their aluminum content and get converted into the austenitic phase (memorized shape) when entering the canal at body temperature during preparation.

A number of studies have compared apical debris extrusion of continuous rotation systems with reciprocating systems. Bu rklein et al., Surakanti et al. and Toyoglu et al. reported that reciprocating files extruded more apical debris than rotary files.[41-44] In contrast, Arslan et al., Üstün et al., Dincer et al., and Silva et al. found that reciprocating instruments produced less apical debris extrusion than rotary instrumentation.[45-48] Oszu et al., Koçak et al., Vivekanandan et al., and Kirchhoff et al. found that there was no significant difference between the two systems.[49-52] The reasons for the conflicting results could be variability in file design, the number of files used and the canal anatomy differences between the studies.[53] The present systematic review inferred that the extrusion of apical debris produced by XP Endo Shaper was lower as compared to the reciprocating file systems.

It is recommended that the XPS system should be used in continuous rotary motion at 800 rpm and with a torque of 1 N/cm.[12] It could be inferred that greater rotation could generate more debris extrusion and damage to the periodontal tissues.[64,65] All the studies, therefore, invariably used the file size, taper and settings recommended by the manufacturers.

Hinrichs et al. evaluated the influence of the canal length, curvature and foramen size on the amount of debris extrusion, and they stated that these factors play no statistically significant role in the amount of extruded debris.[55] and also, Leonardi et al. confirmed this result.[56] In the study by Kartaslioglu E et al, a significant difference was found between the severe and slight curvature groups.[57] The amount of extruded debris increased along with the curvature. Thus, this study involved articles that had samples with single canals having curvature ranging from 0 to 15° (Table 3).

However, micro-CT analysis in the study by Alvez et al.[32] showed that both, rotational and reciprocating instrument systems produce a similar frequency and volume of apically extruded dentinal debris. There are some possible explanations for these findings. The irrigant is expected to diffuse or be displaced more easily through the apical foramen than solid hard tissue debris. Consequently, findings may have indicated that bacteria were mostly extruded through the foramen carried by the liquid irrigant. In addition, hard tissue debris can be packed into root canal irregularities, which may limit apical extrusion.[58] On the contrary, an in vitro study by AlOmari et al.,[59] used XPS and Reciproc blue in retreatment cases, and compared to RB, XPS displayed a trend of less debris extrusion.

Azim AA et al evaluated the amount of apical debris extrusion during retreatment using XPS, WaveOne Gold and Hyflex ED.[32] This in-vitro study showed no statistically significant difference in apical debris extrusion. The difference in the findings can be attributed to the fact that the debris extrusion apparatus used in this study was based on the previous work of Yilmaz and Ozyurek with several modifications.[60]

Hazar E et al in his study measured apical debris extrusion using single file systems in rotation (XPS and OC) and reciprocation (Wave one Gold).[61] Within the tested instruments, the XPS caused significantly less debris extrusion compared with Wave One Gold and One Curve instruments. This finding was in corroboration with results from previous studies which reported that reciprocating movement may create more debris extrusion than continuous rotation.[62,63] Both the files have more mass areas compared to the XPS file, and the design of XPS may provide a possible oscillation-like movement in the root canal, leading to a movement of debris in the coronal direction. The greater taper was associated with higher levels of extrusion.[65,66] The results of the present review supported this finding, the XPS file which has the lowest taper size, extruded less debris than both Wave One Gold and One Curve files.

On the contrary, in a study by Unal B and Zan R, rotary file systems with different kinematic features were evaluated together.[67] Although the difference between groups is statistically insignificant when the total amount of extrusion debris with the weight of the tube is examined from maximum to minimum; 2 Shape, One Curve, XP-Endo Shaper, and Wave One Gold. The reciprocal movement is due to the fact that it moves with a pressure that imitates the known balanced force technique and removes less debris from the apical.[68]

It is observed that temperature changes influence the properties of the files. The metallurgical properties of XP Endo Shaper including its adaptive core technology and superelastic features lead to generation of less pressure during the preparation of the canals, remove dentin evenly and ultimately cause lesser extrusion of debris.[21]

Establishing apical patency is the initial step in root canal treatment. The patency file ought to be used prior to irrigation to loosen compacted tissue remnants.[70] The studies included in this systematic review had standardised the initial preparation till #15 K hand file 0.5 to 1 mm short of the length at which the file is seen through the apex under magnification. A positive correlation was reported between the amount of extruded debris and the diameter of the apical foramen.[71] Distilled water was used as an irrigating solution. Sodium hypochlorite was not used to irrigate the root canals to eliminate the formation of crystals or lead to the deposition of salts after evaporation.[72]

The system that has received the most attention and has been adopted by most studies pertaining to the apical extrusion of debris is the one described by Myers & Montgomery (1991).[75] The methodology comprises weighing the collecting tubes prior to and after instrumentation using a precise microbalance and calculation of the extruded debris by subtracting the initial weight from the post-instrumentation weight.

Other shortcomings of currently used methodologies for the evaluation of debris extrusion can be summarized as follows: it is impossible to ensure that the collecting devices are not contaminated or additionally affected and loaded by sources other than the apically extruded debris during

instrumentation. Even contact of moist fingertips with the steel crown or contamination from other unpredictable sources may alter the weight by several µg.

In a study by Alves et al.[29] and Azim et al.[32], Micro CT was used to weigh apical debris extrusion. Micro-CT analysis of extruded material permits visualization of the debris outside the canal and provides information on the volume, in contrast to the other methods that weigh the extruded material. However, a possible limitation of the micro-CT method is that extruded debris may be forming a mass that reaches sufficient radiodensity to be visualized.

The majority of previous studies lacked simulation of periapical tissue resistance. Using a 1.5% agarose gel as a matrix to collect extruded material provided some resistance to extrusion. This method aimed to replicate clinical conditions more closely. It has been reported that the density of 1.5% agar gel is similar to the density of the periapical tissues (agar = 1045 kg/m3 and human tissue = 1000–1100 kg/m3).[78]

CONCLUSION:

Choosing endodontic instruments wisely and considering alternate rotary techniques could minimize debris extrusion, reducing periapical irritation. XP-Endo Shaper demonstrates efficiency in challenging anatomies while minimizing debris. It shows less debris extrusion than rotational systems, though more than reciprocating ones. Meta-analysis reveals XP-Endo Shaper's significantly lower debris extrusion (1.66 times) compared to other rotational systems. No publication bias or heterogeneity was noted. The review highlights XP-Endo Shaper's efficacy, yet gaps exist, warranting further exploratory studies to ensure its safety and efficiency. Future research is recommended to address these gaps.

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