

Influence of Final Apical Width on Smear Layer Removal Efficacy of Xp Endo Finisher and Endodontic Needle: An *Ex Vivo* Study

 Divya NANGIA,  Ruchika ROONGTA NAWAL,  Seema YADAV,  Sangeeta TALWAR

ABSTRACT

Objective: Chemical disinfection along with mechanical instrumentation, is required to achieve debridement, especially in apical third of root canal. Thus, this study aimed to compare the influence of final apical width on the smear layer removal efficacy of XP Endo Finisher and Endodontic Needle, in mandibular premolars.

Methods: 40 single-rooted mandibular premolars were included in the study, prepared using K3 XF rotary files (SybronEndo, Orange, CA). The samples were equally divided into 4 groups: Group 1: Master apical file 30/0.06 taper, final irrigation with endodontic needle (30G Max I probe, Dentsply International, York PA); Group 2: Master apical file 40/0.06 taper, final irrigation with endodontic needle; Group 3: Master apical file 30/0.06 taper, final irrigation with XP-Endo Finisher (FKG Dentaire, La Chaux-de-Fonds, Switzerland); Group 4: Master apical file 40/0.06 taper, final irrigation with XP-Endo Finisher. Smear layer and debris scores were given using SEM.

Results: Group 3 and 4 performed significantly better than group 1 & 2 ($P < 0.05$). No significant difference was observed in Group 1&2 ($P > 0.05$); and Group 3&4 ($P > 0.05$). Significantly higher scores were observed in the apical third, as compared to other sections of the root canal, in all the 4 groups.

Conclusion: Increase in the final apical width did not significantly improve root canal cleanliness for both XP Endo Finisher and endodontic needle. However, XP endo finisher proved to be significantly better than the endodontic needle.

Keywords: Apical width, SEM, XP-Endo finisher

HIGHLIGHTS

- The present study evaluates debris and smear layer removal efficacy of XP Endo Finisher versus Endodontic Needle, and highlights the influence of increased apical preparation size on root canal cleanliness.
- It outlines the various recommendations suggested by different authors in relation to final apical width.
- This study postulates that the final apical preparation should be till 3 sizes greater than the initial binding file, as there is no significant improvement in canal cleanliness beyond that.

INTRODUCTION

The success of endodontic treatment lies in intensive debridement of the root canal space. For accomplishing this objective, extensive cleaning and shaping of the canal ought to be done, so as to evacuate any organic or inorganic debris. Past research has proposed that even after the thorough mechanical debridement, microbe-free canal can't be obtained (1). It becomes even more difficult to instrument complex anatomical spaces isthmus, lateral canals, recesses, oval-shaped canals. There-

fore, it is necessary to chemically debride these areas with the help of suitable irrigants and irrigation systems (2).

In spite of the fact that there is no consistent understanding about the impact of enlarging apical third on adequacy of mechanical debridement; a few researchers (3) propose to prepare the apical area to a smaller size with a tapered shape, in order to increase the flushing effect and antibacterial efficacy of irrigants in the apical third. In 2012, Saini et al. (4) contemplated the impact of different final apical width on the outcome of pulp canal therapy. The authors suggested that the canal ought to be enlarged to three sizes larger than the initial binding file. It was likewise proposed

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From the Department of Conservative Dentistry and Endodontics (D.N., R.R.N. ✉ r_roongta@yahoo.com, S.Y., S.T.) Maulana Azad Institute of Dental sciences, Delhi 110002, India

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that any further increment of apical width did not result in increased debridement of the apical third.

In endodontic treatment, irrigation is typically done using a syringe and endodontic needle (EN). This technique is easy to manipulate and does not require any special equipment. Although the literature has suggested certain shortcomings of this technique like passive irrigation and limited agitation, still it remains the most widely used in clinics (5). New irrigation techniques have thus been developed which agitate irrigants in the root canal by mechanical means such as sonic devices, ultrasonics, lasers. One recently introduced instrument for irrigant activation is XP Endo Finisher (XP). XP Endo finisher (FKG Dentaire, La Chaux-de-Fonds, Switzerland) is a new NiTi finishing instrument of size 25 and 0% taper. The special alloy of this instrument makes it change shape at body temperature, which makes the instrument to scrape the canal walls and cause turbulence of the irrigant (6).

Bevertheless, there is a scarcity of studies determining the effect of final apical preparation size on cleaning efficacy of XP, as compared to EN. Thus, the present study was undertaken to compare the influence of final apical width on the smear layer removal efficacy of XP and EN, by means of a scanning electron microscope. The null hypothesis tested was that no difference exists in canal wall cleanliness for different irrigation techniques at different final apical width.

MATERIALS AND METHODS

The ethical clearance for this study was taken from the Institutional Ethical Review Board. Forty human single rooted mandibular premolars extracted for periodontal/prosthetic/orthodontic reasons, with no previous endodontic treatment, caries, coronal restorations, signs of resorption, or cracks, were selected from a pool of extracted teeth, from the Department of Oral Surgery of the same institution. Teeth with fully developed, straight roots with a single straight canal were included in the study. All the samples were radiographically examined in buccolingual and mesiodistal directions to confirm the presence of a single canal, and absence of any internal root resorption. The samples were then inspected under a stereomicroscope for the absence of cracks, fractures, or any other structural or resorptive defects.

The cusps were flattened and access to the pulp chamber was established using a high-speed handpiece under copious water-cooling. The crowns were not removed at the level of the cemento-enamel junction in order to preserve the normal trajectory of NiTi rotary instruments. After the root canal orifice was identified, patency of the canal was determined by using a size 10 K file (M-Access, Dentsply-Maillefer, Baillagues, Switzerland), until it was visible at the apical foramen. The working length (WL) was established 1 mm short of this length. The working length of all the samples ranged between 20-22mm. For all the selected samples, the initial binding file was #15 K. If the initial binding was not achieved at #15K file, the sample was replaced.

Root canal preparation

A single experienced operator prepared all root canals. A total of 40 root canals were instrumented with K3 XF rotary instru-

ments (SybronEndo, Orange, CA) in a simultaneous technique to a size 25/0.06 taper till WL.

The teeth were equally and randomly divided into four different experimental groups depending on the subsequent apical root canal preparation and final irrigation technique:

Group 1: Final apical width 30/0.06 taper, final irrigation with EN;

Group 2: Final apical width 40/0.06 taper, final irrigation with EN;

Group 3: Final apical width 30/0.06 taper, final irrigation with XP;

Group 4: Final apical width 40/0.06 taper, final irrigation with XP.

Instruments were taken to working length with light apical pressure. The patency of the apical foramen was checked by passing the tip of a size 10 K file through the foramen after each instrument.

All root canals were irrigated with 4ml of 2.5% sodium hypochlorite after each instrument using EN.

Final irrigation protocol

The final irrigation was done with 5 ml of 17% EDTA for 2 minutes at the end of the preparation. The final irrigant was delivered using EN in Group 1 and 2; while it was agitated using XP in Group 3 and 4. A final flush with 4 ml of sterile saline solution was used for 1 minute to wash out all the irrigant remnants (6, 7).

Following irrigation protocol was used in the study groups

Group 1 & 2 (EN): A 30-gauge side-vented needle (Max I probe, Dentsply International, York PA) was placed within 2 mm from the WL and moved in a vertical motion to avoid the needle being locked in the canal. To ensure length control, a stopper was placed on the needle at the desired length.

Group 3 & 4 (XP): The working length was set by positioning the rubber stop using the plastic tube. The XP endo finisher was then inserted to WL, the canal access cavity was filled with the irrigant and the instrument was operated in the canal for 60 s using mild 7-8-mm lengthwise vertical strokes, making sure that the file was always within WL. The file was used at a speed of 800 rpm and torque 1 Ncm, in an Endodontic motor (Endomate DT, NSK UK Ltd), to achieve final canal cleaning.

Scanning electron microscopy (SEM) preparation and analysis

All root canals were observed through SEM to evaluate canal wall cleanliness in the coronal, middle and apical third, by measuring them after splitting. The roots were split longitudinally as reported by Wu and Wesselink (8). Two shallow longitudinal grooves were cut on each root in a buccolingual direction. The roots were then split with a mallet and chisel, resulting in a mesial and distal half of the root canal.

The photomicrographs from the apical to coronal thirds of the root of each specimen were taken at 2000X for smear layer

and debris evaluation. The scores were evaluated by an experienced endodontist, who was blinded to the study groups.

The presence of debris was evaluated by using the following scores: score 1; clean root canal wall and only a few small debris particles, score 2; few small agglomerations of debris, score 3; many agglomerations of debris covering less than 50 % of the root canal wall, score 4; more than 50 % of the root canal wall covered by debris, and score 5; complete or nearly complete root canal wall covered by debris (9).

The presence or absence of a smear layer was evaluated using the following scores: score 1; no smear layer and dentinal tubules open, score 2; small amounts of scattered smear layers and dentinal tubules open, score 3; thin smear layer and dentinal tubules partially open (characteristic image of crescent), score 4; partial covering with a thick smear layer, and score 5; total covering with a thick smear layer. This scoring system was applied to the coronal, middle, and apical thirds of the canal (9).

Statistical analysis

Comparisons between groups were analyzed statistically using the Kruskal–Wallis nonparametric analysis of variance and Mann–Whitney U tests. The statistical significance level was set at $P < 0.05$. All statistical analyses were performed using IBM SPSS 20 software (IBM SPSS Inc, Chicago, IL).

RESULTS

Table 1 shows the median scores of debris and smear layer for all the tested groups. XP (group 3 and 4) revealed significantly lower debris and smear layer scores than EN (group 1 and 2) at the coronal, middle, and apical regions ($P < 0.05$).

There was no significant difference between group 3 (final apical width–30/.06) and group 4 (final apical width–40/.06) ($P > 0.05$). Similarly, there was no significant difference between group 1 (final apical width–30/.06) and group 2 (final apical width–40/.06) ($P > 0.05$). Smear layer and debris scores were reported to be significantly higher in the apical third as compared to middle and coronal thirds, in all the 4 groups ($P > 0.05$) (Fig. 1)

DISCUSSION

A smear layer is formed on the dentinal walls during mechanical instrumentation of canal walls. Literature suggests that the

TABLE 1. Debris and smear layer median scores for the tested groups

Parameter	Groups			
	Group 1 30/.06, EN	Group 2 40/.06, EN	Group 3 30/.06, XP	Group 4 40/.06, XP
Debris scores				
Coronal third	3	3	1	1
Middle third	4	4	2	2
Apical third	4	4	3	3
Smear layer scores				
Coronal third	3	3	2	2
Middle third	4	4	2	2
Apical third	4	4	3	3

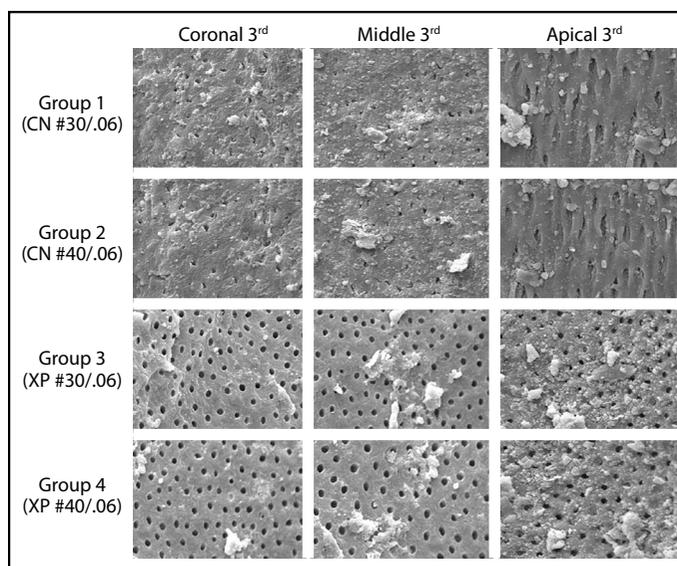


Figure 1. Scanning Electron Micrographs (at 2000X) showing the presence of debris and smear layer in all the four groups. XP Endo Finisher (Group 3 & 4) has shown significantly cleaner root canal surface as compared to Endodontic needle irrigation (Group 1 & 2)

smear layer should be removed for better penetration of irrigants into dentinal tubules, thus enhancing disinfection of the canal. It has also been shown to improve sealer penetration into dentinal tubules, resulting in a complete three-dimensional seal of the root canal (10). It was therefore proposed that irrigants should be used in combination with mechanical instrumentation to denude the organic and inorganic smear layer contents. In addition, irrigants should be agitated effectively with irrigant activation devices to maximize their effect (11). The aim of this study was to assess the impact of increasing the final apical width on smear layer removal efficacy of XP in comparison to the EN, using SEM. SEM is a useful tool to determine the removal of debris and smear layer as it allows evaluation of the entire canal segment based on objective scoring (12). For the present study, it was therefore chosen as the diagnostic tool.

Results of this study showed that in both final apical sizes (# 30/.06 and #40/.06) XP was significantly better than EN in terms of debris and smear layer removal. These findings are in accordance with earlier studies, which also showed failure of EN as a technique of irrigation to thoroughly debride the canal, particularly in apical third (13). Nevertheless, the Max wire NiTi alloy metallurgy of XP can be credited for its improved performance. XP's shape memory theory allows it to presume in the channel at body temperature a rounded or spoon-shaped form. The shape memory principle of XP allows it to assume a curved or spoon-shaped configuration in the canal at body temperature. This spoon-shaped configuration is responsible for causing enhanced turbulence in irrigants and effective scraping of canal walls. These results are in line with the study carried out by Elnaghy et al (2016) which has shown lesser SEM scores for XP as compared to EN, when the canals were prepared till a final size of #35 (14). Similar results were shown by Bao et al, at an apical preparation size of #40 (15).

This study showed that in apical third, there was a greater amount of debris and smear layer compared to other canal

regions. The apical portion of the root canal is smaller in size and thus interferes with the irrigants' passage and operation. Consequently, the remaining debris and smear layer in this region are difficult to eliminate effectively (16). Another important factor may be the presence of more sclerotic areas in the root canal apical part, as sclerotic dentine may minimize the removal of the smear layer (17).

It was also found that the increase in apical width did not result in a significant change in the cleaning effectiveness of any of the techniques, but improved cleanliness was seen in a few samples of group 2 and 4. This is in line with an *in-vitro* study conducted by Akhlaghi et al. (18) that showed that final apical preparations of different sizes (# 25, #30 and #35) and tapers (0.04, 0.06) did not lead to a significant reduction in canal bacteria when tested in mandibular molar mesiobuccal canals. These results can also be correlated with a Computational Fluid Dynamic study done by Boutsoukis et al. (19) which showed that different final apical preparation sizes (# 35, #45 and #55) resulted in only minor differences in the flow pattern in the apical root canal. Butcher et al. (20) performed a similar experiment using EN, achieving optimum cleanliness at an apical width of 35/04, 3 sizes larger than the initial file (i.e. #20). Similar findings were also confirmed by Khademi et al. (21) and Rollison et al. (22), showing no significant improvement in smear layer removal beyond the final apical scale of #30.

However, these findings are contradictory to a microbiologic study done by Paranjpe et al. (23), which showed a significant improvement in the root canal disinfection on increasing apical width from #20 to #30 in maxillary premolars with single canals. These results might be attributed to the fact that an apical preparation of #20 is quite less in premolars with single canals and it has been suggested to prepare the canal upto three file sizes greater than the first binding file, for utmost disinfection. The final apical width in the present study was kept to be three sizes (#30) and five sizes (#40) larger than the initial binding file (#15). This explains the contradictory results.

Nevertheless, it is very important on the part of the clinician to weigh the benefits of increasing apical width against the risk of weakening root dentin. Hoskinson et al suggested that with an increased apical width, there is a greater risk of causing iatrogenic accidents like perforations, canal transportations, zipping, etc (24). Mitchell et al. demonstrated increased frequency of apical extrusion of sodium hypochlorite at increased apical width, which may further lead to increased incidence of intra- or post-operative pain in patients (25).

The available literature has been debatable regarding the final apical preparation size. Buchanan recommended apical preparation till the size of #20 or #25 (26). Salzgeber and Brilliant suggested that the final apical width should not exceed #35 as it resulted in greater apical extrusion of irrigant (27). However, the most accepted protocol till date is to prepare the canal up to three sizes greater than the first binding file, and not beyond that (4). The results of the present study are also supportive of this fact since an apical size of #40 (five sizes larger) did not result in significant improvement of root canal

cleanliness as compared to the apical size of #30 (three sizes larger).

CONCLUSION

Within the limitations of the present study, XP seems to be more effective in the removal of debris and smear layer as compared to EN. Also, it is suggested not to increase the final apical preparation beyond three sizes larger than the initial binding file, since it did not lead to an increased root canal cleanliness.

Disclosures

Conflict of interest: The authors declare that they have no conflicts of interest.

Ethics Committee Approval: The ethical clearance for this study was taken from the Institutional Ethical Review Board.

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REFERENCES

1. Siqueira JF Jr, Lima KC, Magalhães FA, Lopes HP, de Uzeda M. Mechanical reduction of the bacterial population in the root canal by three instrumentation techniques. *J Endod* 1999; 25(5):332–5. [\[CrossRef\]](#)
2. Wu MK, Wesselink PR. A primary observation on the preparation and obturation of oval canals. *Int Endod J* 2001; 34(2):137–41. [\[CrossRef\]](#)
3. Bartha T, Kalwitzki M, Löst C, Weiger R. Extended apical enlargement with hand files versus rotary NiTi files. Part II. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006; 102(5):692–7. [\[CrossRef\]](#)
4. Saini HR, Tewari S, Sangwan P, Duhan J, Gupta A. Effect of different apical preparation sizes on outcome of primary endodontic treatment: a randomized controlled trial. *J Endod* 2012; 38(10):1309–15. [\[CrossRef\]](#)
5. Nielsen BA, Craig Baumgartner J. Comparison of the EndoVac system to needle irrigation of root canals. *J Endod* 2007; 33(5):611–5. [\[CrossRef\]](#)
6. Alves FR, Marceliano-Alves MF, Sousa JC, Silveira SB, Provenzano JC, Siqueira JF Jr. Removal of Root Canal Fillings in Curved Canals Using Either Reciprocating Single- or Rotary Multi-instrument Systems and a Supplementary Step with the XP-Endo Finisher. *J Endod* 2016; 42(7):1114–9.
7. Tabrizzadeh M, Shareghi A. The Effect of Preparation Size on Efficacy of Smear Layer Removal; A Scanning Electron Microscopic Study. *Iran Endod J* 2015; 10(3):169–73.
8. Wu MK, Wesselink PR. Efficacy of three techniques in cleaning the apical portion of curved root canals. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1995; 79(4):492–6. [\[CrossRef\]](#)
9. Caron G, Nham K, Bronnec F, Machtou P. Effectiveness of different final irrigant activation protocols on smear layer removal in curved canals. *J Endod* 2010; 36(8):1361–6. [\[CrossRef\]](#)
10. Violich DR, Chandler NP. The smear layer in endodontics - a review. *Int Endod J* 2010; 43(1):2–15. [\[CrossRef\]](#)
11. Uroz-Torres D, González-Rodríguez MP, Ferrer-Luque CM. Effectiveness of the EndoActivator System in removing the smear layer after root canal instrumentation. *J Endod* 2010; 36(2):308–11. [\[CrossRef\]](#)
12. Kamel WH, Kataia EM. Comparison of the efficacy of Smear Clear with and without a canal brush in smear layer and debris removal from instrumented root canal using WaveOne versus ProTaper: a scanning electron microscopic study. *J Endod* 2014; 40(3):446–50. [\[CrossRef\]](#)
13. Peeters HH, Suardita K. Efficacy of smear layer removal at the root tip by using ethylenediaminetetraacetic acid and erbium, chromium: yttrium, scandium, gallium garnet laser. *J Endod* 2011; 37(11):1585–9. [\[CrossRef\]](#)
14. Elnaghy AM, Mandorah A, Elsaka SE. Effectiveness of XP-endo Finisher, EndoActivator, and File agitation on debris and smear layer removal in curved root canals: a comparative study. *Odontology* 2017; 105(2):178–83.

15. Bao P, Shen Y, Lin J, Haapasalo M. In Vitro Efficacy of XP-endo Finisher with 2 Different Protocols on Biofilm Removal from Apical Root Canals. *J Endod* 2017; 43(2):321–5. [\[CrossRef\]](#)
16. Blank-Gonçalves LM, Nabeshima CK, Martins GH, Machado ME. Qualitative analysis of the removal of the smear layer in the apical third of curved roots: conventional irrigation versus activation systems. *J Endod* 2011; 37(9):1268–71. [\[CrossRef\]](#)
17. Mohammadzadeh Akhlaghi N, Rahimifard N, Moshari A, Vatanpour M, Darmiani S. The Effect of Size and Taper of Apical Preparation in Reducing Intra-Canal Bacteria: A Quantitative SEM Study. *Iran Endod J* 2014; 9(1):61–5.
18. Paqué F, Luder HU, Sener B, Zehnder M. Tubular sclerosis rather than the smear layer impedes dye penetration into the dentine of endodontically instrumented root canals. *Int Endod J* 2006; 39(1):18–25. [\[CrossRef\]](#)
19. Boutsioukis C, Gogos C, Verhaagen B, Versluis M, Kastrinakis E, Van der Sluis LW. The effect of apical preparation size on irrigant flow in root canals evaluated using an unsteady Computational Fluid Dynamics model. *Int Endod J* 2010; 43(10):874–81. [\[CrossRef\]](#)
20. Butcher S, Mansour A, Ibrahim M. Influence of Apical Preparation Size on Effective Conventional Irrigation in the Apical Third: A Scanning Electron Microscopic Study. *Eur Endod J* 2019; 4(1):9–14. [\[CrossRef\]](#)
21. Khademi A, Yazdizadeh M, Feizianfard M. Determination of the minimum instrumentation size for penetration of irrigants to the apical third of root canal systems. *J Endod* 2006; 32(5):417–20. [\[CrossRef\]](#)
22. Rollison S, Barnett F, Stevens RH. Efficacy of bacterial removal from instrumented root canals in vitro related to instrumentation technique and size. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2002; 94(3):366–71.
23. Paranjpe A, de Gregorio C, Gonzalez AM, Gomez A, Silva Herzog D, Piña AA, et al. Efficacy of the self-adjusting file system on cleaning and shaping oval canals: a microbiological and microscopic evaluation. *Endod* 2012; 38(2):226–31. [\[CrossRef\]](#)
24. Hoskinson SE, Ng YL, Hoskinson AE, Moles DR, Gulabivala K. A retrospective comparison of outcome of root canal treatment using two different protocols. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2002; 93(6):705–15.
25. Mitchell RP, Baumgartner JC, Sedgley CM. Apical extrusion of sodium hypochlorite using different root canal irrigation systems. *J Endod* 2011; 37(12):1677–81. [\[CrossRef\]](#)
26. Buchanan LS. The standardized-taper root canal preparation--Part 1. Concepts for variably tapered shaping instruments. *Int Endod J* 2000; 33(6):516–29. [\[CrossRef\]](#)
27. Salzgeber RM, Brilliant JD. An in vivo evaluation of the penetration of an irrigating solution in root canals. *J Endod* 1977; 3(10):394–8. [\[CrossRef\]](#)