Original Article

Comparative Evaluation of Smear Layer on the Canal Walls Prepared with Different Rotary Endodontic Files Under Scanning Electron Microscope: An *Ex Vivo* Study

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Abstract

It has been known that the endodontic smear layer affects the penetration of irrigants and sealers into the dentinal tubules, which in turn leads to the compromised seal of root canal filling. Therefore, this study was designed to compare the clinical efficacy of Edge Taper Encore File (EdgeEndo, Albuquerque, New Mexico), E3 Azure File (Endostar, Warsaw, Poland), Silk File (Mani, Tochigi, Japan), and HyFlex CM File (Coltene Whaledent) on the removal of the smear layer, under a scanning electron microscope (SEM). Eighty freshly extracted human permanent mandibular premolars were collected and randomly divided into 4 groups. The teeth were decoronated, and the working length was determined. For each group, a different rotary file system was used. Specimens were longitudinally sectioned and sent for SEM examination. The smear layer on the prepared canal walls was subjected to statistical analysis. Within the limitations of this study, E3 Azure produced the least smear layer, and HyFlex CM produced the most amount of smear layer in the coronal and middle thirds. In the apical third, a significant difference was only noted in Edge Taper Encore versus Silk, wherein Silk produced the most smear layer, and Edge Taper Encore produced the least.

Keywords: Smear Layer, Dentinal Tubules, Scanning Electron Microscope, Irrigants

Introduction

Thorough cleaning and shaping of the root canal system are considered key requirements for success in root canal treatment. Numerous investigations have demonstrated the limitation of manual and automated root canal instrumentation regarding the overall quality of preparation. Most hand preparation techniques are time-consuming, technically demanding, and may lead to iatrogenic errors. Therefore, attention has been directed toward nickel-titanium (NiTi) rotary instruments. Numerous studies have reported that they could efficiently create a smooth, predetermined funnel-form shape, with minimal risk of ledging and transporting the canals.[1]

It has been known that root canal instrumentation produces a smear layer. This smear layer covers the surface of the root canal walls containing both inorganic and organic materials. Penetration of irrigants and sealers into the dentinal tubules is affected by the presence of a smear layer and debris, which in turn leads to the compromised seal of root canal filling.[2]

The scanning electron microscope (SEM) has proved to be a valuable method in the comparison of the remaining debris and smear layer on the root canal wall after preparation with different instruments.[3] Variations in the designs of rotary NiTi instruments result in variation in their debris removal and smear layer production.[4]

Therefore, this study was designed to compare the clinical efficacy of Edge Taper Encore File (EdgeEndo, Albuquerque, New Mexico), E3 Azure File (Endo Star, Warsaw, Poland), Silk File (Mani, Tochigi, Japan), and HyFlex CM File (Coltene Whaledent) on the removal of smear layer, under an SEM.

Materials and Methods

A total of 80 recently extracted intact caries-free human permanent mandibular first premolars with single straight root canals and mature apices were selected. Extraneous soft tissue, superficial debris, and calculus were removed from

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the roots with an ultrasonic scaler, and teeth were disinfected with a 5.25% of sodium hypochlorite solution. The teeth were then examined under an operating microscope to evaluate for the microcracks and stored in normal saline under 4°C until use. RVG radiographs were recorded in the buccolingual and mesiodistal dimensions before the instrumentation to assess the internal anatomy of the tooth. All 80 specimens were then autoclaved at 240°F, 20 psi pressure for 40 min, and were then stored in an incubator for 7 days at 37°C with 100% relative humidity, immersed in normal saline in a glass beaker. Coronal access was achieved by using Endo Access Bur to obtain straight-line access. Canal patency was established using a #10 K-file. Working lengths were determined by subtracting 1 mm from the length at which the tip of the file is just visible to the naked eye at the apical foramen. Specimens were randomly divided into four groups (n = 20), and each group was prepared with a different rotary file chosen for the study. The canals were constantly irrigated with 5 ml of 5.25% sodium hypochlorite solution and EDTA. All specimens were sent for a scanning electron microscopic study. Figures 1-4 are the photomicrographs obtained from scanning electron microscope for different groups at different levels.

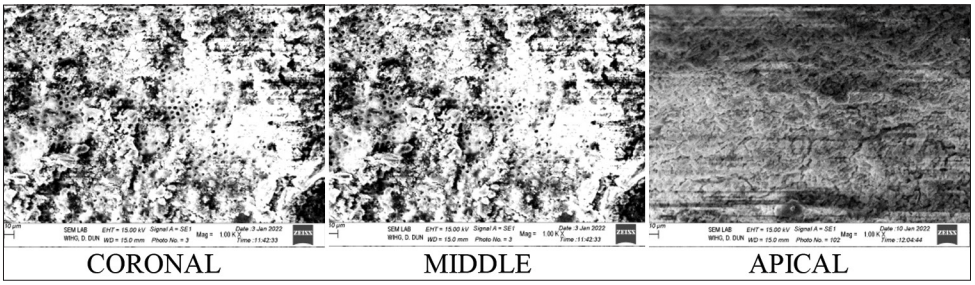


Figure 1: Scanning electron microscopic image for group I: Edge Taper Encore (coronal, middle, and apical third)

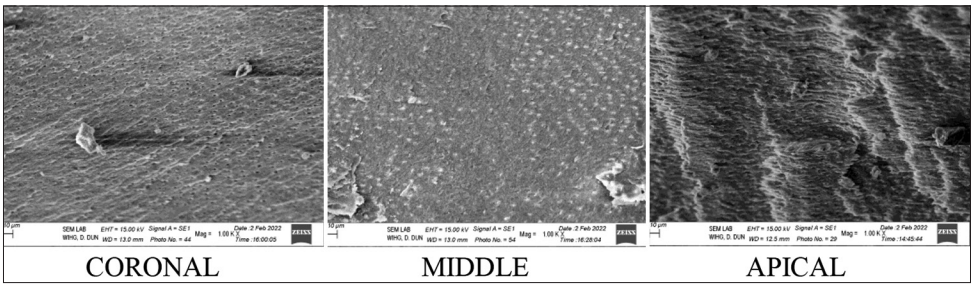


Figure 2: Scanning electron microscopic image for group II: E3 Azure (coronal, middle, and apical third)

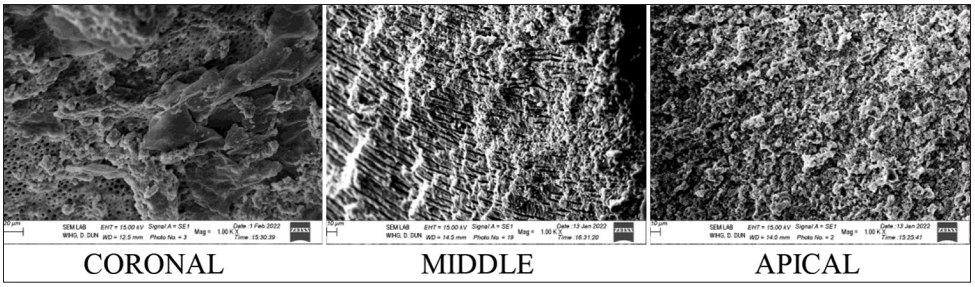


Figure 3: Scanning electron microscopic image for group III: Silk (coronal, middle, and apical third)

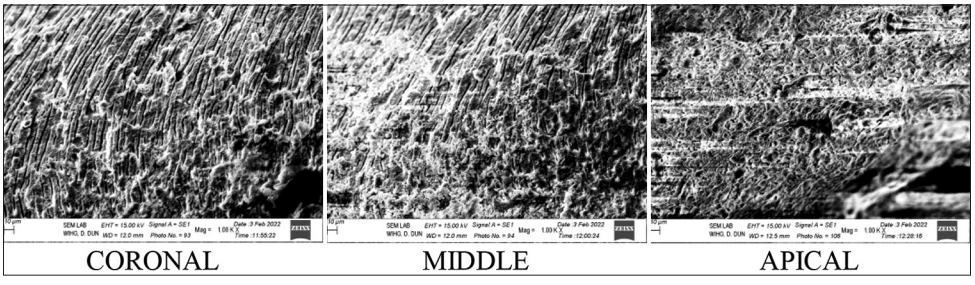
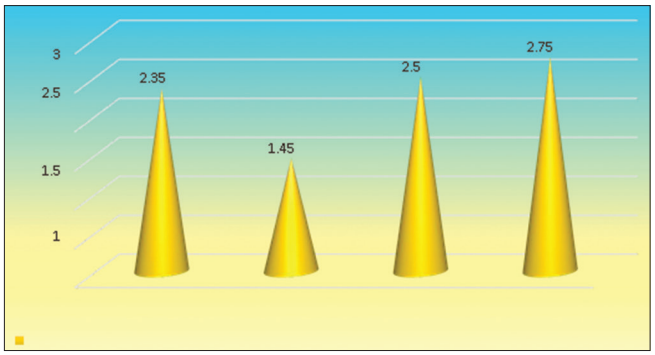
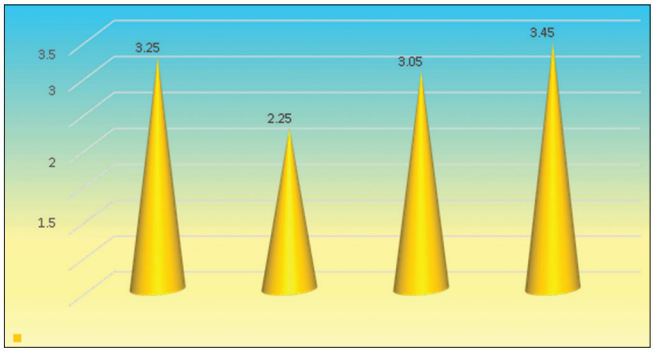


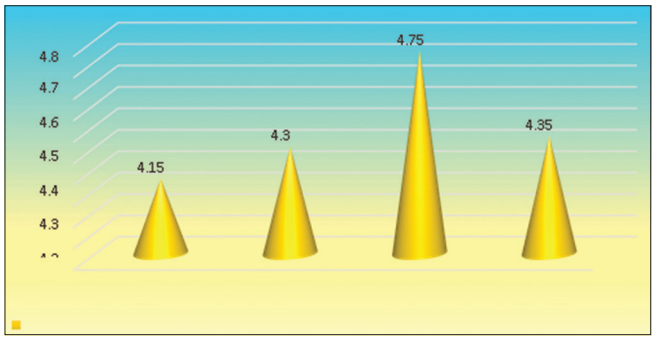
Figure 4: Scanning electron microscopic image for group IV: HyFlex CM (coronal, middle, and apical third)



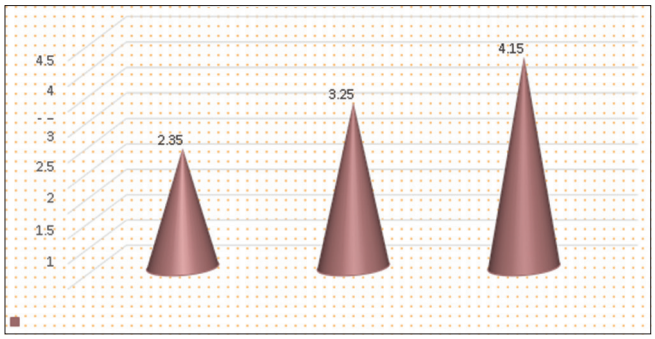
Graph 1: Comparative evaluation of smear layer produced among different file systems in the coronal third



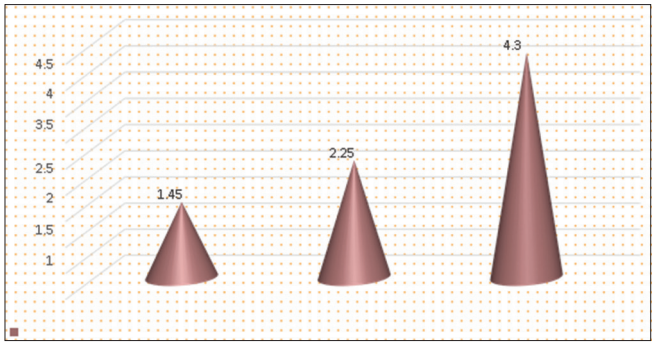
Graph 2: Comparative evaluation of smear layer produced among different file systems in the middle third



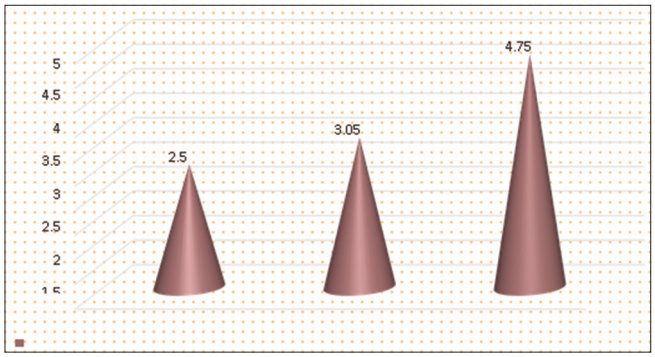
Graph 3: Comparative evaluation of smear layer production among different file systems in the apical third



Graph 4: Comparative evaluation of smear layer produced in Edge Taper Encore (coronal, middle, and apical)



Graph 5: Comparative evaluation of smear layer produced in E3 Azure (coronal, middle, and apical)



Graph 6: Comparative evaluation of smear layer produced in silk (coronal, middle, and apical)

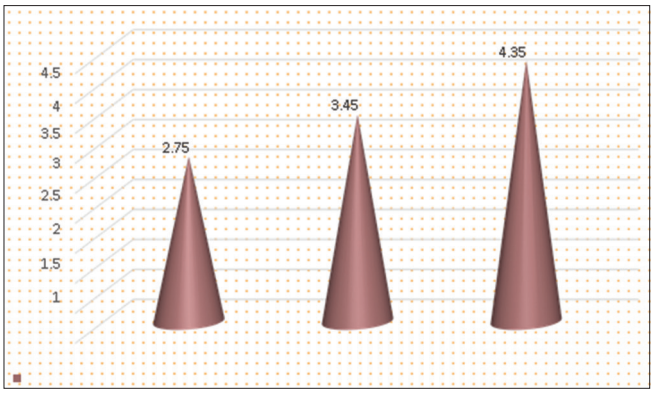
Scoring of the smear layer was done by 5-score criteria:

- Score 1: No smear layer, dentinal tubules open.
- Score 2: Small amount of smear layer, some dentinal tubules open.
- Score 3: Homogenous smear layer covering the root canal wall, only a few dentinal tubules open.
- Score 4: Complete root canal wall covered by a homogenous smear layer, no open dentinal tubules.
- Score 5: Heavy, non-homogenous smear layer covering the complete root canal wall.

The data obtained were subjected to statistical analysis. The mean for different readings between the groups was compared using a one-way analysis of variance, and the intercomparison between each group was done using Tukey's *post hoc* analysis. $P < 0.05$ was considered statistically significant.

Results

In the coronal third of the root canal, HyFlex CM produced the most smear layer with a mean of 2.7500 ± 0.44426, followed by Silk with a mean of 2.500 ± 0.51299. The file which produced the least smear layer was that of E3 Azure, which was statistically significant at $P = 0.000$. The greatest ability to produce a smear layer in the middle third was demonstrated by HyFlex CM with a mean of 3.4500 ± 0.60481, while the least produced was by E3 Azure with a mean of 2.2500 ± 0.44426, which was significant. Graphs 1-3 shows Comparative



Graph 7: Comparative evaluation of smear layer produced in HyFlex CM (coronal, middle, and apical)

evaluation of smear layer production among different file systems in the coronal, middle and apical third. Graphs 4-7 shows Comparative evaluation of smear layer produced in Edge Taper Encore, E3 Azure, silk and HyFlex CM (coronal, middle, and apical)

Discussion

The ability to clean effectively the endodontic space is dependent on both instrumentation and irrigation. On mechanical root canal preparation, organic and inorganic debris are formed, named smear layer.[5] Sodium hypochlorite is an irrigant solution widely used in root canal treatment due to its bactericidal properties and ability to dissolve organic tissue; however, it is not effective in removing the inorganic smear layer. Therefore, combined use of NaOCl and EDTA has been reported to be suitable for removing both the organic tissues and the inorganic smear layer.[6]

Bertrand *et al*., in 1999, stated that endodontic instruments may, in themselves, vary in their debris removal efficacy and their smear layer production, due to their specific flute design. Different endodontic instruments have variable cutting efficiency. This depends on the cross section, flute design, tip design, pitch, rake angle, and radial land of an instrument. Hence, the amount of dentinal debris and smear layer is variable with different instrumentation systems.[7] SEM magnification used in such studies ranged from ×15 to ×2500. High amounts of smear can be observed at low magnifications, but details as waste remnants or the entire dentinal tubules must be seen at a higher magnification. However, the disadvantage of using large magnifications is the decrease of the assessment area, and therefore, the performance of very limited observations; hence, the decision was taken to use ×1000 for this study.[8]

This study was designed to compare the clinical efficacy of Edge Taper Encore File (EdgeEndo, Albuquerque, New Mexico), E3 Azure File (Endo Star, Warsaw, Poland), Silk File (Mani, Tochigi, Japan), and HyFlex CM File (Coltene Whaledent) on the removal of the smear layer, under an SEM. In the present study, in each group, the average remaining debris and smear layer was greater in the apical region than in the coronal and middle third of the root canal. Normal root canal anatomy suggests that the apical region of the canal system is the narrowest portion. Hence, in the apical region, more contact with instruments produces more debris, and also irrigation procedure cannot be successfully performed in this narrowest part. The present study confirms previous observations by that cleanliness decreased from the coronal to the apical part of the root canal for all files.[7]

In this study, when compared between the file systems, the highest significant mean difference was noted for E3 Azure versus HyFlex CM, where the file which produced the least smear layer was that of E3 Azure, and the file which produced the most smear layer was HyFlex CM. The sequence of the smear layer in the coronal third was Group4 > Group1> Group3> Group2. The sequence in the middle third was Group4 > Group1> Group3> Group2. The sequence in the apical third was Group3 > Group4> Group2> Group1.

No studies have been done yet on the smear layer removal efficacy of E3 Azure; however, its geometry is similar to that of Mtwo. Two symmetrical blades characterize Mtwo cross section. The Endostar E3 Azure system possesses a modified S-shaped cross section, similar to the Mtwo instrument.[1] This geometry reduces the contact lengths of the blades on the dentinal walls, thus reducing the production of debris and smear layer, and increases the available volume for irrigating solutions and upward debris elimination.[7] E3 Azure files are characterized by a positive rake angle with two sharp cutting edges. The smaller cross-sectional area increases its flexibility, and greater chip space allows increased debris clearance. Furthermore, an increasing helical pitch from tip to shaft reduces the transportation and accumulation of debris toward the apex.

The cross section of Edge Taper Encore is asymmetric, and the cross section of Silk is tear drop shape. HyFlex CM's result is probably related to their cross section and flutes: some instruments (0.02/20, 0.06/20, 0.04/30, and 0.04/40) have triangular cross section with three blades and three flutes, and others (0.04/20 and 0.04/25) have quadrangular cross section with four blades and four flutes. The geometry of flutes could be related to the low capacity of debris removal and a higher amount of smear layer found along the dentinal walls.[9] A positive rake angle (obtuse angle) is more effective in cutting dentin, while a negative rake angle (acute angle) tends to grind dentin.[10] HyFlex CM has a positive rake angle. HyFlex CM has a positive rake angle, Double-fluted hedstroem design, cutting blades, wider flutes, and absence of radial land.

Conclusion

Within the limitations of this study, E3 Azure produced the least smear layer, and HyFlex CM produced the most amount of smear layer in the coronal and middle thirds. In the apical third, a significant difference was only noted in Edge Taper Encore versus Silk, wherein Silk produced the most smear layer, and Edge Taper Encore produced the least. However,

more *ex vivo* studies need to be conducted to correlate the result of this study.

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