Original Article

Cone-Beam Computed Tomography Evaluation of the Shaping Characteristics of Four Different File Systems in Mesial Canals of Mandibular First Molars an – *Ex Vivo* Study

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Abstract

Aim: This *ex vivo* study compared the shaping characteristics of Edge Endo, Mani Silk, Hyflex EDM, and FKG 3D Shaper file systems using cone-beam computed tomography (CBCT). **Methodology:** Eighty extracted human permanent mandibular first molars with mesial roots curvature angles ranging within 20–30° were assigned into four groups (n = 20 each). Teeth were imaged (90 micron resolution) with CBCT imaging software CS9300 equipment set at 84Kv, 5mA, 10.8 s exposure, and a slice thickness of 76 um to obtain a pretreatment outline of the root canals. All the scans were reoriented with respect to x, y, and z axis. The canal transportation and volume of root canals were evaluated at 1.0, 2.0, 3.0, 4.0, and 5.0 mm intervals. **Results:** Hyflex EDM Files did the least modifications in canal anatomy as compared to other groups ($P < 0.05$). **Conclusion:** Hyflex EDM maintained the original canal anatomy.

Keywords: Biomechanical preparation, Cone-beam computed tomography, Radiovisiography, Root canal, Transportation.

Introduction

The main aim of root canal treatment is proper cleaning and shaping of the root canal system. The root canal instrumentation needs to preserve the existing root anatomy, the position of the apical foramen and the original curvature. This is possible only when there is continuous tapering of the root canal which helps the irrigating solution to flow easily within canal to remove debris and for the proper placement of the obturating material. Considerable importance should be given not to cut excessive dentin to get adequate taper of the canal. Hence, the challenge for every file system is to clean and shape the root canal without cutting the excessive dentin. Preparation of root canal system includes both enlargement and shaping of the complex endodontic space together with its disinfection.

Cleaning and shaping of the root canal system should eliminate or at least reduce the intra-canal microorganisms and also maintain the original shape of the root canal. Transportation is one of the mishaps that deviate canal terminus to a new location which can jeopardize the treatment outcome.[1] Eventually, apical transportation may lead to zipping or perforation of the canal.

Edge Endo the instrument is made of an Annealed Heat Treated nickel-titanium alloy brand named Fire-Wire™. All files are constant tapered. These files are used in endodontics for the removal of dentin and root canal shaping. They are compatible with the ProTaper® and ProTaper Next® rotary file system and can be used in the same hand piece at the same speed and torque settings[1]. Edge Endo produces three different file systems (X3, X5, and X7) which, according to the manufacturer, can be used with the same hand piece, speed, and torque as their specified competitor's recommended settings. X3 files can be used with the same settings as ProTaper and ProTaper Next (Dentsply Tulsa Specialties, Tulsa, OK, USA) rotary file systems.[9] X5 files are compatible with GT and GT Series X (Dentsply) rotary file systems.[2] X7 files are compatible with Vortex, ProFile (Dentsply), K3 (SybronEndo, Orange CA), EndoSequence (Brasseler USA, Savannah GA), TF (SybronEndo), and other similar 04/06 taper rotary file systems.[3] If the competitor's settings are unavailable, then the settings should be 300–

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500 rpm and 300 g/cm for all three file systems MANI FILE SYSTEM Mani Silk simple, standard, and complex packs each contain three instruments. All sizes, including additional sizes, are available in 21 mm and 25 mm lengths.

Mani Silk Files are anatomy-based, have a smooth tactile feel (do not "screw in" the canal), and yet provide efficient and safe canal shaping with a minimum number of instruments. Using the standard pack as an example, after making straight line access, removing the cervical dentinal triangle (using the 0.08/25 orifice opener—the file on the left side of the pack), and preparing a glide path, Mani Silk Files are used from the left to right in the pack (from 0.06/20 to 0.06/25) until the 0.06/25 reaches the true working length any motor that provides 500 rpm with an auto reverse torque setting of 300 gf cm (3.0 Ncm) can power Mani Silk Files[2].

Hyflex EDM Success in endodontic therapy relies on thorough cleaning and shaping of the root canal system followed by its complete obturation. With increase in number of cases reporting for endodontic therapy, dental professionals have to deal with more complicated cases such as those with very fine and curved canals. Standard Nickel Titanium rotary endodontic files, due to their shape memory property and larger tapers, can often not serve well for such difficult cases. The introduction of controlled memory files (Hyflex and Coltene) and the new generation electrical discharge machine files (EDM and Coltene) has revolutionized endodontics by their extraordinary properties which have begun a new era in dentistry[3].

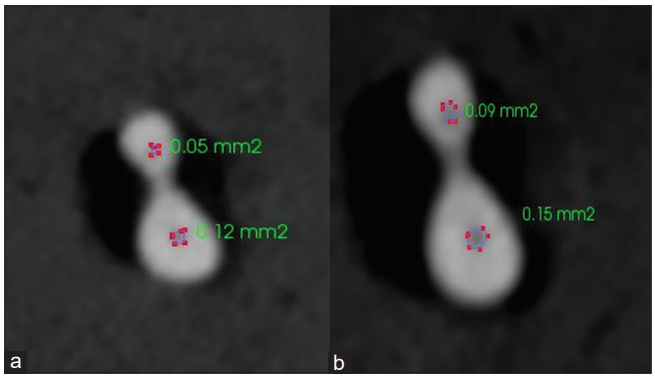


Figure 1: (a and b) Pre- and Post-operative scan calculating area of the canal using cone-beam computed tomography

FKG 3D ENDO SHAPING FILES The XP-endo Shaper is the latest addition to the XP-endo® range. It is a truly innovative broad-spectrum shaping instrument which can be used to radically simplify endodontic sequences. It results from the combination of two cutting-edge technologies: Made with MaxWire® alloy, like the XP-endo Finisher, it offers remarkable flexibility and fatigue resistance, and the ability to progress within the canals with ease and agility, expanding or contracting according to the canal morphology. With an initial taper of 0.01, the XP-endo Shaper expands once inside the canal, achieving a taper of at least 0.04. Thanks to the Booster Tip (BT), the XP-endo Shaper benefits from a unique geometry, having six cutting edges at the tip. The BT tip respects the trajectory of the canal whilst removing more material with each pass. It enables the instrument to start shaping an ISO diameter smaller than the one of the instrument. In the case of the XP-endo Shaper, the BT enables it to start shaping after a glide path of at least ISO 15 and, to gradually, increases its working field to achieve an ISO 30.

Cone-beam technology has existed since the 1980s. However, the convergence of technology and its applications has only recently made cone-beam volumetric tomography (CBCT) or cone-beam computed tomography (CBCT) a viable option for the dental office[4].

Methodology

Eighty extracted human permanent mandibular first molars with mesial roots curvature angles ranging within 20–30° were assigned into four groups (n = 20 each). Teeth were imaged (90 micron resolution) with CBCT imaging software CS9300 equipment set at 84Kv, 5mA, 10.8 s exposure, and a slice thickness of 76 um to obtain a pretreatment outline of the root canals. All the scans were reoriented with respect to x, y, and z axis.

Radiovisiography radiographs were recorded in buccolingual and mesiodistal dimension before the instrumentation. In an attempt to standardize the length of root canal, teeth were decoronated at Cemento Enamel Junction using High-Speed Alloy Grinder to get approximately 14 mm length of samples to confirm the presence of two distinct and separate root canals. In the mesiodistal dimension, K-File number of 10 were inserted

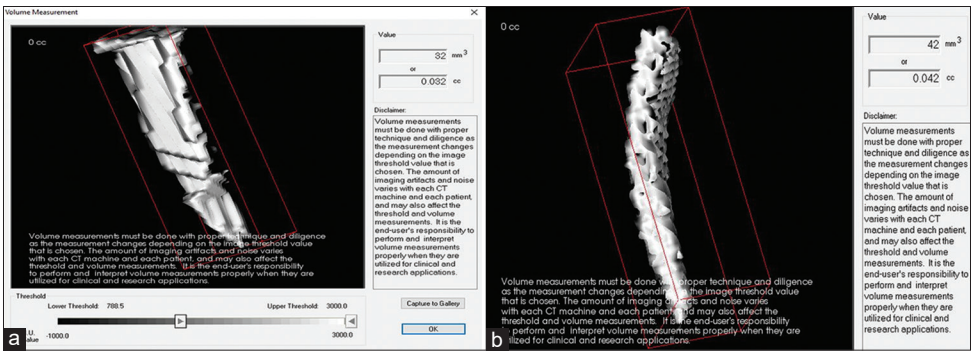


Figure 2: (a and b) Pre- and post-operative scan calculating volume of the canal using cone-beam computed tomography

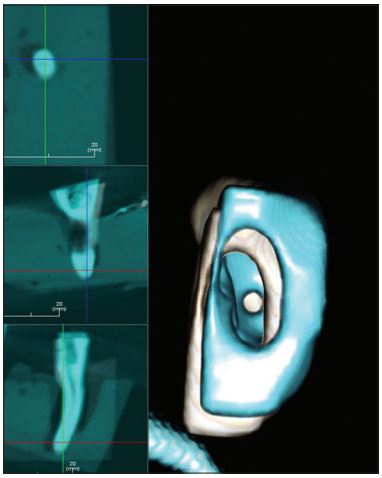


Figure 3: Superimposition images of sample at 1, 2, 3, 4, and 5 mm using cone-beam computed tomography

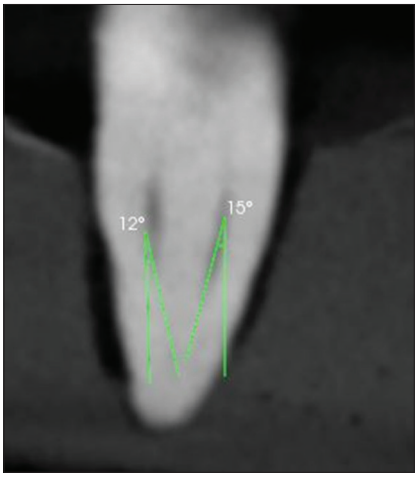
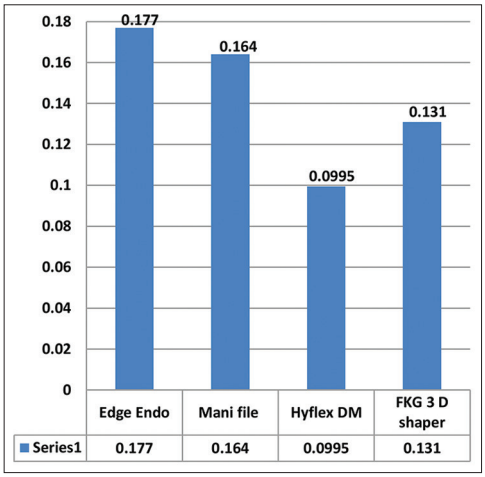
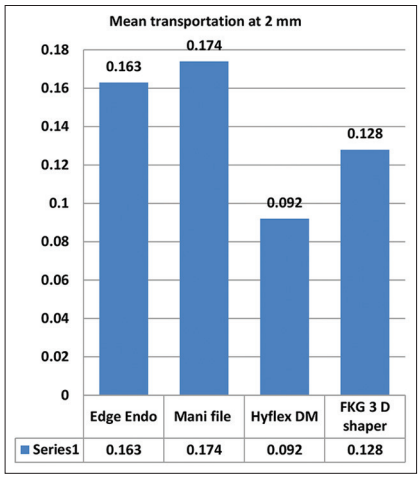


Figure 4: Calculating canal angulation of mesiobuccal and mesiolingual canal using cone-beam computed tomography



Graph 1: Comparison of mean transportation between groups at 1 mm



Graph 2: Comparision of mean transportation btw groups at 2mm

into the buccal and lingual canals to assess the degree of root canal curvature according to Schneider's technique. Coronal access was achieved using high-speed water cooling Airotor along with Endo-Access Bur to obtain a straight line access. Each tooth was sectioned through the furcation and mesial portion of the root and crown was used. Distal roots with the respective part of crown were sectioned at the furcation level and discarded.

The canal transportation and volume of root canals were evaluated at 1.0, 2.0, 3.0, 4.0, and 5.0 mm intervals.

- Group A: Edge Endo
- Group B: Mani File system
- Group C: Hyflex EDM
- Group D: FKG 3D shaper.

Comparison parameters were:

a. The mean difference of superimposition at 1, 2, 3, 4, and 5 mm in root canal area from pre- to post-treatment (Figure 1)
b. The mean difference of superimposition in mesiobuccal and mesiolingual canal volume from pre- to post-treatment (Figure 2)
c. The mean difference of superimposition in mesial and distal root angulation from pre- to post-treatment (Figure 3).

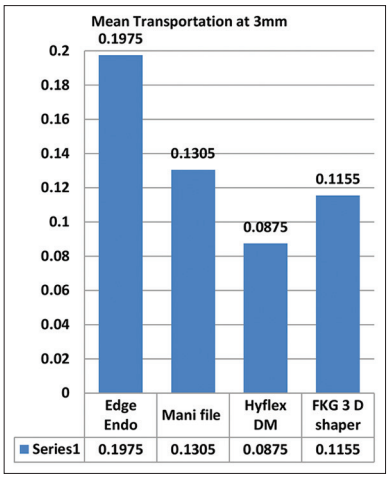
Comparisons parameters were calculated by subtracting values obtain for treated canals with those from untreated canals through CBCT.

Statistical analysis

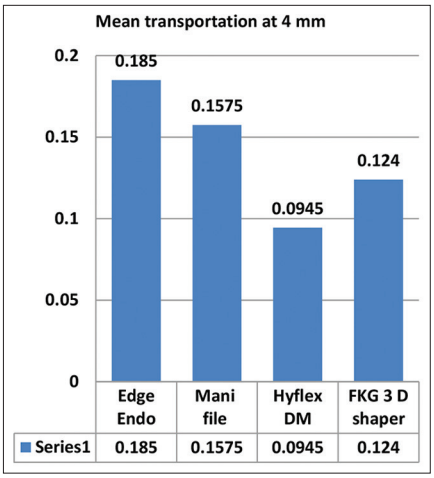
The data were entered into spread sheets and analyzed using Social Package for the Statistical System – 23.0 version (IBM; Chicago). One-way analysis of variance was used to determine the variance between the four different file groups $P < 0.05$.

Results

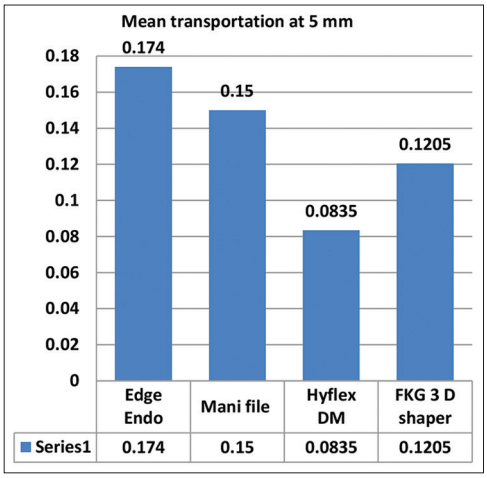
Overall, on considering the mean transportation at all levels, that is., 1 mm, 2 mm, 3 mm, 4 mm, and 5 mm. At all levels, maximal mean value was achieved for Edge Endo while minimal value was attained for Hyflex EDM. Transportation was significantly less with Hyflex EDM (Graph 1-5).



Graph 3: Comparison of mean transportation btw groups at 3mm

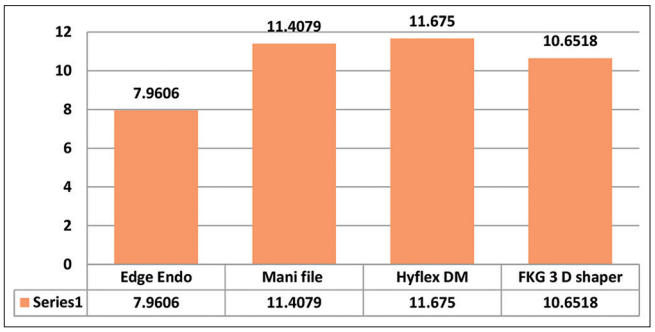


Graph 4: Comparison of mean transportation at 4 mm

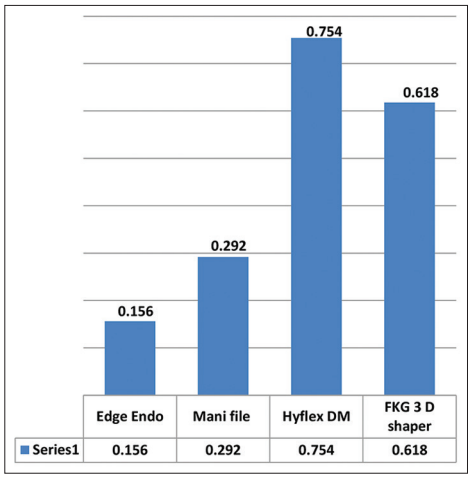


Graph 5: Comparison of mean transportation at 5 mm

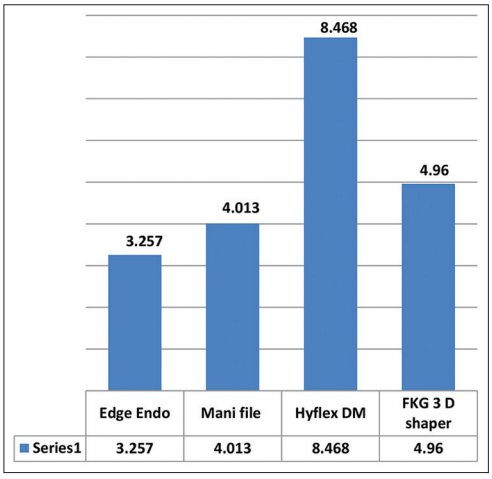
Hyflex EDM had the highest area of 0.754, while Edge Endo had the lowest with a mean of 0.156. Hyflex EDM had the highest area of 8.468, while Edge Endo had the lowest with a mean of 3.257.



Graph 6: Comparison of canal angulation in superimpostition pre-treatment and post-treatment periods



Graph 7: Area parameters of files



Graph 8: Volume parameters of all files

Discussion

To investigate the efficacy of instruments and techniques developed for root canal preparation, numerous methods have been used to evaluate the canal shape before and after instrumentation[5]. CBCT imaging is a non-invasive technique for analysis of canal geometry and efficiency of shaping techniques. Using CBCT, it becomes possible to compare

the anatomic structure of root canal before and after root canal preparation.[6] With no need to cut into the tooth, before the process begins. Furthermore, the quality of the three-dimensional images acquired by this method is superior to other techniques, which improves its use for geometric analysis of root canal area.[7]

Transportation is defined within the glossary of endodontic terms as removal of the root canal dentin on the outer wall of the curve within the apical half of the canal as a result of the tendency of instruments to regain their original straight shape during canal preparation[8]. Maintaining original canal shape during instrumentation is one of the most important principles during treatment. Evaluation of shaping ability of various endodontic instruments by computed tomography is advantageous due to its noninvasive nature, in *ex vivo* and *in vitro* models and, therefore, has been used extensively in the literature.[9] A major advantage of CBCT is the three-dimensional geometric accuracy compared with conventional radiographs, as well as elimination of structural superimpositions. On the other hand, the main disadvantages of the technique are the high cost of the equipment and the time-consuming scanning and reconstruction[10]

The Hyflex EDM (Group 3) and FKG3D SHAPER (Group 4) systems resulted in significantly less untouched canal walls and a higher increase in the surface area, perimeter, and minor diameter of the canals than the Edge Endo and Mani file system. These results might be explained by differences in the design of the instruments.[13] The mean curvature angle, area, and volume recorded for Group 1 (Edge Endo Files),Group 2 (Mani Silk), Group 3 (Hyflex EDM), and Group 4 (FKG 3D Shaper Files), showed that Group 1 (Edge Endo) and Group 2 (Mani Silk Files) were not sufficient to properly clean and shape the root canal system (Figure 4). The mean curvature angle recorded pre and post for mesiobuccal and mesiolingual canals for Group 1 (Edge Endo), Group 2 (Mani Silk), Group 3 (Graph 6) (Hyflex EDM Files), and Group 4 (FKG 3D Shaper) were MB (13.75 ± 6.40) and ML (10.75 ± 5.01), MB (10.25 ± 6.70) and ML (14 ± 3.91), MB (11.25 ± 2.50) and ML (12 ± 5.71), MB (16 ± 6.05) and ML (15.75 ± 2.25), respectively, showed that Edge Endo Files (Group 1) and Mani Silk Files (Group 2) were not sufficient to maintain a specific canal shape during cleaning and shaping better results in Group 3 (Hyflex Edm) and Group 4 (FKG 3D Shaper). The mean area recorded pre and post for Group 1 (Edge Endo), Group 2 (Mani Silk), Group 3 (Hyflex EDM), Group 4 (FKG 3D Shaper) 0.156, 0.292, 0.754, and 0.618, respectively, showed that Group 1 (Edge Endo) and Group 2 (Mani Silk) were not able to touch the walls of the canal while shaping. Better results were observed in Group 3 (Hyflex EDM) and Group 4 (FKG 3D Shaper) as the files touched the walls of the canals leading to proper (Graph 7) cleaning and shaping of the canal. Better results were observed in Group 3 as the files touched the walls of the canals, leading to proper cleaning and shaping of the canal. Overall, Group 1 and Group 2 systems resulted in significantly less unprepared root dentin canal walls and a higher increase in the surface area, perimeter, and minor diameter of the canals. These results might be explained by differences in the design and geometry of the instruments[11]. The mean volume recorded pre and post for 1 (Graph 8) (Edge Endo File), Group 2 (Mani Silk File), Group 3 (Hyflex EDM), and Group 4 (FKG 3D Shaper) were 3.257, 4.013, 8.468, and 4.960, respectively, showed that Edge Endo and Mani Silk were not able to touch the walls of the canal while shaping[12]. Better results were observed for Hyflex EDM and FKG 3D Shaper as the files cleaned and shaped the root canal approaching the maximum walls of the canal. The mean difference in distal aspect from pre- to post-treatment was significantly more among Hyflex EDM Files and FKG 3D Shaper Files in comparison to Edge Endo Files and Mani Silk Files. The mean difference in mesial from pre- to post-treatment was significantly more among Hyflex EDM Files and FKG 3D Shaper Files in comparison to Edge Endo Files and Mani Silk Files. Within the limitations of this study, long-term use of this method should be followed up in clinical studies. However, more *ex vivo* studies need to be conducted to correlate the result of this study.

Conclusion

Hyflex EDM maintained the original canal anatomy. Hyflex EDM files showed significant increase in canal curvature significantly as compared to the FKG 3D Shaper, Edge Endo, and Mani Silk Files. Hyflex EDM showed the significant increase in canal area and volume but showed less canal transportation as compared to other groups (FKG 3D Shaper, Edge Endo, and Mani Silk Files). Within the limitations of this study, Hyflex EDM Files resulted in less transportation and greater ability to maintain dentin thickness than the FKG 3D Shaper, Edge Endo, and Mani Silk Files.

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