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Comparative Evaluation of Canal Transportation, Centering Ratio and Volumetric Changes Associated with Two Rotary Systems -ProTaper Next and HyFlex EDM- A CBCT Study

Ramesh Bharti[*1], Pragya Pandey[2], Aseem P Tikku[2], Anil Chandra[2]
[1]Associate Professor, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, King George's Medical University U.P., Lucknow, India
[2]MDS, Department of Conservative Dentistry and Endodontics, Faculty of Dental Sciences, King George's Medical University Lucknow, India

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***Corresponding author**
Ramesh Bharti

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Abstract: The endodontic preparation of curved and narrow root canals is challenging. Aggressive preparation of the root canal with rotary file systems may result in canal transportation and excess removal of dentine, a major reason for poor prognosis of root canal treated tooth. The purpose of the present study was to compare the canal transportation and centering ability of Rotary ProTaper Next (PTN) and HyFlex EDM file systems using cone beam computed tomography (CBCT) in curved root canals. Forty extracted human mandibular first molars were mounted on acrylic blocks. Specimens were divided into two groups: Group PTN (ProTaper Next) and Group HF (HyFlex EDM). Mesiobuccal canals were instrumented with ProTaper Next and HyFlex EDM rotary files. Pre-instrumentation and Post-instrumentation scans were performed using CBCT under similar conditions. Canal transportation, centering ratio and volume of the dentine removed were evaluated at 3 cross-section levels; 3-mm, 6-mm and 9-mm from the root apex. The data were statistically analyzed and the level of significance was set at $p \leq 0.05$.Canal transportation was seen minimal with HyFlex EDM (0.021±0.009) at 3mm from the apex and maximum with ProTaper Next (0.028±0.021) at 9mm from the apex. Mean centering ratio was lower for HyFlex EDM to ProTaper Next at all levels. Both Pro Taper Next and HyFlex EDM systems shaped the canals with adequate centering ability and minimal canal transportation. Hyflex EDM better maintained canal centricity but the difference was not statistically significant.
Keywords: Canal transportation, Centering ratio, Endodontics, Root canal preparation.

INTRODUCTION

Proper cleaning and shaping is a significant aspect in endodontic treatment [1]. The critical aspect in cleaning and shaping is that the instrumented root canal should have a taper from apex to coronal end besides maintaining original canal shape [2]. Such endodontic preparations are challenging especially in curved and narrow root canals, with a tendency of the prepared canals to deviate from their natural axis [3].

There has been an increased use of nickel titanium rotary instruments in contemporary endodontic practice. Nickel titanium rotary instruments permit easier and faster preparations with a lower risk of procedural errors compared to stainless steel hand instruments [4]. This is owing to their unique property of superelasticity and shape memory. NiTi instruments have demonstrated to better preserve the original anatomy of the canal, the shape of apical foramen and the position of the apical foramen [5]. Few NiTi rotary systems have demonstrated acceptable canal shaping ability such as ProTaper and Hero 642 [6]. However, the quest for improved performance, better predictability and safer rotary files, has steered a constant search for new instruments.

During the past years, innovations have been achieved through new instrument design and metallurgical thermal processing. The latest generation file system ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland) and HyFlex EDM (HyFlex EDM; Coltene/Whaledent, Switzerland) have unique geometric design and manufacturing method [7, 8].

HyFlex EDM, the latest generation rotary file, was developed with patented manufacturing treatments and controlled memory technology which considerably increasing the flexibility and cyclic resistance. The unique combination of flexibility and fracture resistance also makes it possible to reduce the number of files required for shaping of the root canal without deviating from the original root canal anatomy [8, 9].

The ProTaper Next (PTN) (DentsplyMaillefer, Ballaigues, Switzerland) is 5th generation NiTi file; which has three significant design feature including progressive percentage tapers, M-Wire technology (Sportswire LLC, Langley, OK) and a unique off-set mass of rotation. These design features enhance flexibility and debris removal, avoid unnecessary dentin removal, limit taper lock, screw in, and torque [10, 11].

Cone-beam computed tomography (CBCT) imaging is a non-invasive technique for analysing and assessing the shaping performance of different instruments without the destruction of samples [12]. CBCT gives a high quality three dimensional image for geometric analysis of root canals.

Earlier studies have investigated the shaping abilty of PTN [6, 10, 12] but no study has compared the performance of PTN with newest HyFlex EDM file using cone beam computed tomography. The purpose of the study is to evaluate the two latest generation rotary files HyFlex EDM and PTN in regards to canal transportation, centering ability and volume of the dentine removed.

MATERIALS AND METHOD

Selection and Specimen Preparation

Forty extracted human mandibular first molars with fully formed roots, two separate canals and apical foramina were selected. Teeth extracted because of periodontal, prosthetic and orthodontic reasons were taken for the study. Teeth with calcified root canal system, open apex, apical resorption, third molar and previous endodontically treated teeth were excluded from the study. No teeth were extracted specifically for the study purpose. After cleaning, teeth were stored in 10% formaldehyde until use. Radiographs were taken in both buccolingual and mesiodistal directions for identifying teeth with two separated mesial canals and no significant calcifications. Canal curvatures were assessed according to Schneider's technique [13]. Root canals with curvatures in the range of 25-30° were included in the study. Coronal access was made by using an Endo-Access bur (Dentsply Maillefer) in a high speed handpiece and canal exploration was done. Patency was checked with a size 10 K-file (Dentsply Maillefer). Specimens were coded and randomly divided equally into two experimental groups, according to the rotary NiTi file system used: ProTaper Next (n=20) and HyFlex EDM (n=20). The study has been approved by the Institutional Ethical Committee (IEC).

Scanning Procedure

Teeth were embedded into auto polymerizing transparent acrylic resin using silicon moulds. The pre-instrumentation specimens were scanned using a Planmeca Promax 3D CBCT machine with romexis (3.2.2.20 software version) and following settings: 90 kV, 4 mA, 51 × 51 mm field of view and 0.1/voxel (mm) size. Measurements and calculations were performed on three cross sections located 3mm, 6 mm and 9mm from the root apex.

Root Canal Preparation

The root canals were instrumented according to the manufacturer's instructions for the file system used [7, 8]. Root canal preparation was performed by a single operator. Only the mesiobuccal canals were instrumented. Periapical radiograph were taken to allow for determination of working length. Irrigation was done with 2ml of 2.5% sodium hypochlorite solution after change of each instrument. For every tooth prepared new files were used.

Group PTN- The canals were prepared as recommended by the manufacturer using PTN X_1 followed by PTN X_2 at 2 N/cm torque and 300 rpm. Files were used in brushing motion.

Group HyFlex EDM- The canals were prepared using HyFlex EDM at 2.4N/cm torque and 500 rpm. Enlargement of canal to the working length was done to HyFlex EDM 25/ One File.

Image Analysis

After instrumentation specimens were scanned under same conditions as pre-instrumentation scans and the images were captured using same parameter. Figure-1 shows a pre (a) and post (b) instrumentation scanned image. Canal transportation and centering ratio were calculated at 3 cross-section- 3-mm, 6-mm and 9-mm from the apical end of the root by using the following equations [14].

$$(M_1-M_2) - (D_1-D_2) \text{ for canal transportation}$$
$$(M_1-M_2) / (D_1-D_2) \text{ for centering ratio}$$

Where, M_1 is the shortest distance from the mesial edge of the root to the mesial edge of the uninstrumented canal, M_2 is shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal, D_1 is the shortest distance from the distal edge of the root to the distal edge of the uninstrumented canal, and D_2 is the shortest distance from the distal edge of the root to the distal edge of the instrumented canal.

Volume of the Dentine Removed

Volume of dentin removed was determined for each sample by subtracting the uninstrumented canal volume from the instrumented one.

Statistical Analysis

All the data was statistically analysed using the SPSS 21.0. Data were presented as means and standard deviation values. One way of variance was used for comparing centering ratio and canal transportation. The Post Hoc Tukey test was used for pair-wise comparisons between the groups. The Kruskal-Wallis test was used for comparison between volume changes. The level of significance was set at p≤0.05.

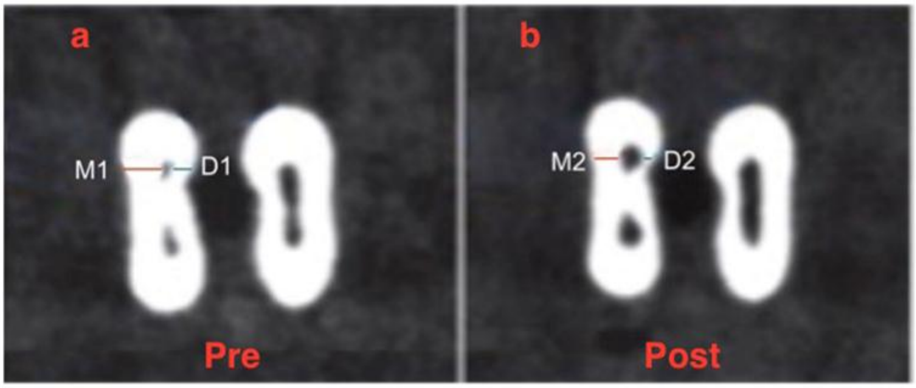

Fig-1: Scan image of the sample, (a) Pre-instrumentation and (b) post-instrumentation CBCT images with markings showing points of measurements used for determination of canal transportation and centering ratio

RESULTS

The mean and standard deviation values for canal transportation and centering ratio for both group at 3, 6 and 9 mm from root apex are presented in Table 1, 2 and 3 respectively.

Table-1: Mean of canal transportation (mm) and standard deviation among the groups and root section levels

	ProTaper Next	HyFlex EDM	p value
3mm	0.024±0.009	0.021±0.009	0.465
6mm	0.026±0.015	0.023±0.013	0.638
9mm	0.028±0.021	0.025±0.017	0.621

Table-2: Mean of centering ratio (mm) and standard deviation among the groups and root section levels

	ProTaper Next Mean±SD, N=20	HyFlex EDM Mean±SD, N=20	p-value
3mm	2.028±0.326	1.886±0.340	0.353
6mm	2.050±0.470	2.030±0.478	0.925
9mm	2.078±0.510	2.114±0.521	0.821

Table-3: Mean values for the volume of removed Dentin (mm^3) for HyFlex EDM and PTN

Level	Mean±SD		P Value
	PTN	HFEDM	
3mm	2.82±1.60	2.85±1.42	0.41
6mm	3.12±1.40	2.80±1.30	0.77
9mm	3.14±1.13	2.91±1.41	0.71

Canal Transportation (mm)

Statistical analysis showed no differences in the amount of transportation between the two rotary instruments at 3mm, 6mm and 9 mm from the apex. However least canal transportation was seen at 3 mm level with the HyFlex EDM (0.021±0.009mm). The PTN files recorded highest canal transportation at 9mm level (0.028±0.021mm).

Centering Ratio (mm)

At the 9 mm level HyFlex EDM recorded the mean centering ratio of 2.114±0.521 while PTN showed 2.078±0.510. At 6 mm level, HyFlex EDM showed (2.030±0.478) and PTN showed (2.050±0.470). At the 3mm level the HyFlex EDM yielded the lowest centering ratio (1.886±0.340) in comparison to PTN (2.028±0.326). In all the levels Hyflex EDM files better maintained canal centricity as compared to Pro Taper Next but the difference was not statistically significant (p>0.05).

Volume of Removed Dentin

Table-3 shows mean and standard deviation values of volume of removed dentin for each rotary system used at different level. The PTN at 6 mm level showed the lowest mean value of removed dentin (3.12 ±1.40mm^3) and highest at 9 mm (3.14±1.13mm^3)while HyFlex EDM at 6 mm level showed lowest (2.80±1.30mm^3) and at 9 mm Level it is (2.91±1.41mm^3).No significant difference was noted between PTN and HyFlex EDM at all the three level(p>0.05).

DISCUSSION

The key for a successful biomechanical preparation is controlled instrumentation, i.e. balancing between avoiding unnecessary removal of root canal dentine and removing complete infected dentine [15, 16]. Concomitantly, the natural root canal anatomy after instrumentation should be well preserved [17].

The Hyflex EDM files and Protaper next are the latest generation file systems that are distinctly different in their geometric motif and manufacturing technique which impacts the performance of the files [7, 8]. Hence the purpose of the study was to compare the effects of these new rotary instruments on canal transportation, centering ratio and volume of the dentine removed using CBCT.

Multi-rooted teeth have been choosen for the study as they offer a more complex anatomy and are tougher to instrument than single rooted teeth. We evaluated the mesio-buccal roots of mandibular first molars as these canals are usually curved and are narrow, making the preparation more challenging [18].

Canal transportation results in inadequate cleaning of the main canal as the original part of the canal remains untouched and unprepared, more specifically in apical third region [19]. The risk of canal transportation increases with increase in the degree of curvature and decrease in the radius of curvature [1]. Previous studies have shown that almost all the canals with small curvature radius and large curvature angle showed some canal transportation regardless of the file system used [19].

The occurrence of canal transportation of 0.15 mm has been considered acceptable at the apical end [1]. Wu *et al*., reported that apical transportation of more than 0.30 mm could adversely affect the sealability of filling material [20]. In the present study, both groups showed canal transportation in the range of 0.021mm to 0.028mm, which is well within the acceptable limits.

Few studies suggested that taper of the file is one of the factors responsible for canal transportation, with increase in canal transportation with increase in taper [21]. Both ProTaper Next and HyFlex EDM have variable taper throughout their cutting part [7, 8]. Paque *et al.*, conducted a study in simulated curved canals using Protaper and RaCe and suggested that RaCe follows the original curvature of canal better than Protaper [22]. This was attributed to the variable taper along the cutting surface in Protaper files. Increased tendency for canal transportation was also seen with increase in file diameter [23, 24]. In the present study same file diameter was used for both HyFlex EDM (25/ OneFile) and ProTaper Next (PTN X_2) to make realistic comparisons.

HyFlex EDM showed slightly less transportation at all the three levels and stayed a little more centered in comparison to PTN. The reason can be attributed to the innovative EDM (electrical discharge machining) process, used to manufacture the Hyflex files resulting in extremely flexible and fracture resistant file. Moreover due to the controlled memory properties, HyFlex EDM files well follow the anatomy of the canal [9].

Centering ability is influenced by the design of the instrument (taper, flexibility, tip, cross section and type of alloy), manufacturing metallurgy and the root canal anatomy. The instrument receives lesser constraint and is more centered in cases of straighter root canals [25]. Better canal centering ability of HyFlex EDM can be attributed to its controlled memory property in contrast to the classical shape memory. Controlled memory files retain their shape in canal and do not have the spring back action thereby avoiding any perforation. The built-in shape memory prevents stress during canal preparation by changing their spiral shape. Hyflex EDM files also have a unique regenerative property which allows the files to return to their original shape after autoclaving [8].

Both HyFlex EDM and PTN have a non-cutting blunt transition angle in the tip which does not engage and screw the dentinal walls. This design make them more centered and lowers the consequence of apical transportation [7, 8]. Over-reduction of intracanal dentine is another consequence of canal transportation. In canal transportation, outside wall i.e. convex wall of the curved root canals in the apical third may get over-instrumented and more amount of dentin will be removed and the inside wall i.e. concave wall may remain untouched. This would lead to residual infected dentinal debris. Mean value for the volume of dentine removed was greater for the protaper next. The reason could be to the hardened surface plus controlled memory which improved cutting efficiency. The results of our study were similar to earlier studies which showed acceptable shaping ability of Protaper and HyFlex files.

CONCLUSION

Within the limitations of the study, the two file systems shaped root canal curvature acceptably. Hyflex EDM better maintained canal centricity than PTN but the difference was not statistically significant.

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