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A CBCT study of three rotary file system in canal transportation - An In-vivo study

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Abstract

Background: Canal transportation refers to iatrogenically moving the physiologic terminus to a new location on the external root surface due to the tendency of files to restore themselves to their actual linear shape during canal preparation and it may lead to formation of ledge and possible perforation. This study was carried out to compare canal transportation in three new rotary file system namely TruNatomy (TRN) , ProTaper Gold (PTG) and Hyflex EDM (HFEDM) file system using CBCT.

Material and Methods: The study was conducted on 60 extracted mandibular first molars and 45 mandibular second premolars involving mesiolingual canal of mandibular first molar and root canal of second premolar. The teeth were randomly divided into three groups of 35 out of which each group consisted of 20 mandibular first molars and 15 mandibular second premolars. TruNatomy rotary file was used in group one, ProTaper Gold was used in group two, and Hyflex EDM was used in group three. CBCT scan images were obtained both before and after instrumentation. Changes occurred during canal preparation were determined by CBCT scans and the

Kruskal–Wallis test were analyzed where significance level was set as $P \leq 0.05$.

Results: TruNatomy (TRN) showed least amount of canal transportation as compared with other two file systems at all the three levels of canals. The difference was statically significant at middle one third level (p= 0.3) and at coronal level (p= 0.2).

Conclusion: The TruNatomy system has least amount of canal transportation as compared with ProTaper Gold and Hyflex EDM system. With potential to preserve tooth structure, this file has an added advantage over other rotary file systems.

Keywords: Canal transportation, CBCT, TruNatomy, ProTaper Gold, Hyflex EDM

Introduction

The main strategic in root canal treatment is canal shaping and achieving three dimensional root filling while removing remnants of pulp, necrotic tissues, debris and microorganisms. The shaping of canal should maintain the actual anatomy of canal without changing the apical foramen position or exceedingly weakening the root.[1] However, canal transportation can occur through preparation using the manual as well as rotary instrumentation techniques. Canal transportation refers to iatrogenically moving the physiologic terminus to a new location on the external root surface due to the tendency of files to restore themselves to their actual linear shape during canal preparation and it may lead to formation of ledge and possible perforation with reduced remaining dentin thickness.[2]

Although NiTi rotary files assumedly achieving the actual canal anatomy better than stainless-steel hand files, instrumentation of severely curved canals remains challenging for most endodontic practitioners. The manufacturers have developed several new technologies, such as M-wire, R-phase, and the newly introduced controlled memory (CM) and proprietary thermal technology[3] to improve the mechanical properties, action, and safety of NiTi instruments.[4]Thermal metallurgical processing and new instrument cross-sectional designs are considered major developments. Hyflex EDM (HFEDM) , ProTaper Gold (PTG) , and Trunatomy (TRN) file system are examples of the latest generation of rotary instruments.[5]

HFEDM (Densply Sirona Switzerland) is a third-generation single file that was introduced with an innovative manufacturing process using electric discharge machining (EDM) followed by CM treatment.[6] CM is a proprietary metallurgical thermal treatment that reduces the shape memory of NiTi files and enhances the flexibility and cyclic fatigue resistance of instruments.[7] The cross-sectional design of HFEDM instruments is variable, toward the tip it is rectangular and toward the shaft it is triangular. In previous studies, these instruments showed very high resistance to cyclic fatigue compared to instruments produced by CM technology and M-wire.[8]

ProTaper Gold (PTG, Dentsply Sirona Switzerland) is also a new system. These instruments are made of M-wire, a unique NiTi alloy manufactured by a thermal treatment process that reportedly increases flexibility and resistance to cyclic fatigue.[9] These instruments incorporate a unsteady regressive taper design, distinctive offset mass of rotation, and triangular cross section, which according to the manufacturer are designed to reduce points of contact with the canal walls generating less fatigue in the instrument during use. PTG is manufactured by proprietary metallurgy that reportedly increases its flexibility and its resistance to cyclic fatigue.[10]

TruNatomy instruments (TRN,Dentsply Sirona Switzerland) has been named derived from the design of the files that take the natural anatomy of the root canal and the tooth into account. TRN shaping files have three

different working lengths and sizes . These NiTi files heat-treated, slim wire (MFD 0.8) and are designed to operate at higher speed for greater efficiency requiring less torque. The design helps the file to progress trouble freely into the canal. With seamless transitions from file-to-file, the clinician is always in full control.[12,20]

No study has been conducted before to compare canal transportation in these three file systems. There can be various methods for this analysis but CBCT (Cone Beam Computed Tomography) imaging is most reliable technique because this procedure creates a reliable baseline and ensures the comparability of the groups by standardization of the 3D canal morphology in each sample, enhancing internal validity and potentially eliminating significant anatomic biases that may confound the outcomes.[13]

Hence this study has been conducted to compare canal transportation in three new rotary file system namely ProTaper Gold (PTG) , Hyflex EDM (HFEDM) and Trunatomy (TRN) file system using CBCT.

Methods and Materials

The study was conducted on 60 extracted mandibular first molars and 45 mandibular second premolars having apical closure and curvature of root 20–40° mesially (Schneider's method), average root length 19 – 22 mm, collected from department of orthodontics and oral & maxillofacial surgery. All teeth were cleansed to remove calcific debris and the disinfected in 0.1% thymol solution for 24 hours at 9°C. After that teeth were rinsed under tap water to remove thymol residues, and then immersed in saline at 4°C. Primary radiographs were obtained to determine the degree of root curvature. Teeth with one apical foramen and no sign of calcification or internal resorption were included in the study. Then evaluation under 12x stereomicroscope was done to achieve fracture less, crack & craze line free roots and if found they were put back with defect free teeth.

Before root canal preparation an exposure of 89 kVp, 5.4 mA, 50 × 50mm field of view, 0.08 mm voxel size for 10 seconds with Vatech 3D system (Ez3D Plus, Korea) were done. A high-speed handpiece with diamond bur under air and water spray were used to access cavity preparation. To determine working length, a #10 K file (Densply) was introduced into the canal so that it was viewable at root apex. The working length was determined to be 1mm shorter than this length.

The teeth were randomly divided into three groups of 35 out of which each group consisted of 20 mandibular first molars and 15 mandibular second premolars.

TruNatomy rotary file (Densply Sirona, Switzerland) was used in group one, ProTaper Gold (Densply Sirona, Switzerland) was used in group two, and Hyflex EDM (Densply Sirona, Switzerland) was used in group three.

All three groups were instrumented their corresponding file system to the working length using the crown-down technique with a handpiece (X-Smart plus Endomotor (Dentsply Maillefer, USA) as manufacturers guidelines. The irrigation of canal were done using 2.5% sodium hypochlorite with 30-gauge needle after that final rinsing were done to remove smear layer with 17% EDTA and 5.25% sodium hypochlorite.

After canal preparation silicon impression material was used to cover the cementum to replicate periodontal ligament. Then the apices of root were sealed with dental wax and mounted in putty was block (5mm× 5mm) upto the level of cemento-enamel junction. To achieve pre and post instrumentation image teeth were immersed in a mould in a parallel fashion. To guide the direction of scanning a bit of ortho wire was put on silicone block corner.

CBCT scanning was performed for pre and post instrumentation of the teeth measured at 3, 6, and 9mm from the apex.

Fig 1: X-Smart plus Endomotor (Dentsply Maillefer, USA)

Fig 2: ProTaper gold rotary file(Densply Sirona, Switzerland)

Fig 3: TruNatomy rotary file (Densply Sirona, Switzerland)

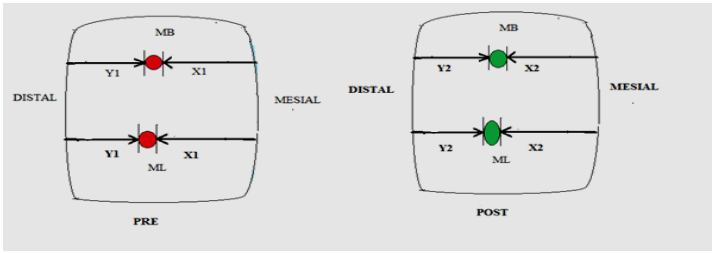


Fig 4: Representative CBCT coronal plane sample of a pre- and post-instrumentation depicting the measurement of mesial and distal dentin thicknesses according to Gambill et al using the equation: [(X1 − X2) − (Y1 − Y2)].

Pre Instrumentation Post Instrumentation

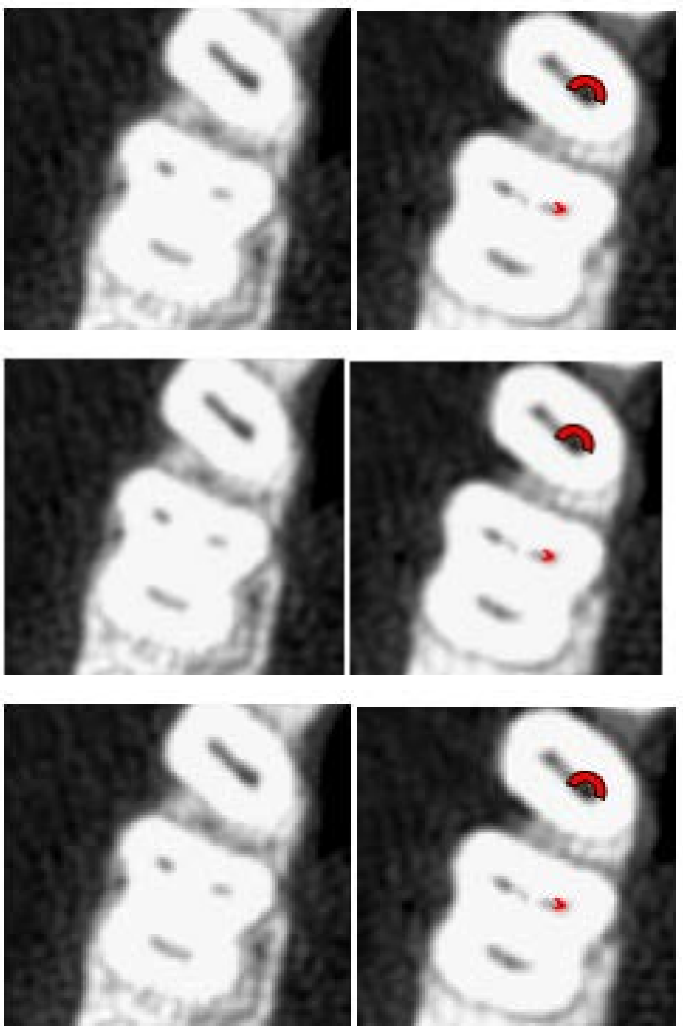


Fig 5: CBCT scan images before (left column) and after (right column) instrumentation. Red marks indicate canal transportation

Canal Transportation

Canal transportation was determined in the mesiodistal direction. Where X1 & X2 discloses the amount of dentin before and after instrumentation, whereas Y1 & Y2 discloses the distance from the furcation of the curved root to the periphery of the uninstrumented and instrumented canals. Mesio-distal (X, Y) dentin thicknesses were measured from pre-and post-instrumentation images in both groups at the three cross-sectional levels (3, 6, and 9 mm from apex). Canal transportation at each level was calculated as described by Gambill et al. (Fig. 4), using the following equation: $[(X1 - X2) - (Y1 - Y2)]$.[13] A transportation value of zero indicates no transportation; a positive value indicates transportation directed to the mesial side; and a negative value indicates transportation to the distal side of the canal.

Statistical Analysis

The statistical analysis were done using IBM® SPSS® Statistics 20 software (IBM SPSS Inc., Chicago, USA). Kruskal–Wallis test for mean and standard deviation were analyzed, where significance level was set as $P \leq 0.05$.

Results

Figures 4 and 5 show the schematic view and CBCT scan images pre and post instrumentation in the coronal, middle, and apical cross sections, respectively. Table 1, Graph 1 shows the mean amount of canal transportation by three file systems at the apical level (3mm from apex). TruNatomy rotary file system showed minimum transportation of 0.011± 0.006 mm while ProTaper gold showed maximum mean transportation of 0.016±0.004 mm. Hyflex EDM showed transportation of 0.014±0.005 mm.

Table 2, Graph 1 represent mean amount of canal transportation by three file systems at the middle one third (6mm from apex). Here, again TruNatomy file system was found to have produce least transportation of 0.012± 0.004 mm while ProTaper Gold produced maximum transportation of 0.056±0.006 mm. Hyflex EDM rotary file system showed transportation of 0.044±0.008 mm which was more than that of TruNatomy file system while it was less than that of ProTaper Gold. The difference was statically significant with p value 0.03 ($p \leq 0.05$).

Table 3, Graph 1 highlight mean amount of canal transportation by three file systems at the middle one third (9mm from apex). The mean amount of transportation for trunatomy file system was minimum i.e 0.023± 0.002 mm while it was maximum in case of protaper gold file system i.e 0.106±0.007mm. The mean amount of transportation for hyflex edm file system was 0.104±0.007mm. The difference was statically significant with p value of 0.02 ($p \leq 0.05$).

File system	Mean Amount of transformation (mm)	p-value
TruNatomy	0.011± 0.006	0.07
ProTaper Gold	0.016±0.004	
Hyflex EDM	0.014±0.005	

Table 1: Mean amount of canal transportation by three file systems at the apical level (3mm from apex)

File system	Mean Amount of transformation (mm)	p-value
TruNatomy	0.012± 0.004	0.03*
ProTaper Gold	0.056±0.006	
Hyflex EDM	0.044±0.008	

Table 2: Mean amount of canal transportation by three file systems at the middle one third (6mm from apex)

File system	Mean Amount of transformation (mm)	p-value
TruNatomy	0.023± 0.002	0.02*
ProTaper Gold	0.106±0.007	
Hyflex EDM	0.104±0.005	

Table 3: Mean amount of canal transportation by three file systems at the coronal one third (9mm from apex)

* : statically significant

Discussion

One of the main goals during root canal instrumentation is the achievement of a shape that tapers from apical to coronal, maintaining the original root canal anatomy. However, several procedural errors such as canal transportation can occur when shaping curved root canals. Canal transportation refers to iatrogenically moving the physiologic terminus to a new location on the external root surface due to the tendency of files to restore themselves to their actual linear shape during canal preparation and it may lead to formation of ledge and possible perforation with reduced remaining dentin thickness.[2,14]

In the recent years, numerous nickel titanium (NiTi) instruments like TruNatomy file system, ProTaper Gold file system, Hyflex EDM etc were introduced. They have functional differences such as stress applied, cleaning ability and competence with canal shape.[15]

Since no study has been carried out to compare TruNatomy file system, Hyflex EDM, and ProTaper Gold therefore, this study was carried out with the purpose of evaluating canal transportation in these three new rotary file system. Teeth used in this study were anatomically matched in terms of preoperative geometric parameters determined by CBCT imaging. This procedure creates a reliable baseline and ensures the comparability of the groups by standardization of the 3D canal morphology in each sample, enhancing internal validity and potentially eliminating significant anatomic biases that may confound the outcomes.[16]

In present study mean amount of canal transportation was evaluated at apical level (3mm from apex), at middle one third (6mm from apex), and at coronal level (9mm from apex). At apical level TruNatomy rotary file system showed minimum transportation of 0.011± 0.006 mm while ProTaper Gold showed maximum mean transportation of 0.016±0.004 mm. Hyflex EDM showed transportation of 0.014±0.005 mm. When evaluation was carried out at middle third (6mm from apex) again trunatomy file system was found to have produce least transportation of 0.012± 0.004 mm while ProTaper Gold produced maximum transportation of 0.056±0.006 mm. Hyflex EDM rotary file system showed transportation of 0.044±0.008 mm which was more than TruNatomy file system while it was less than that of ProTaper gold. The difference was statically significant with p value 0.03 ($p \leq 0.05$).

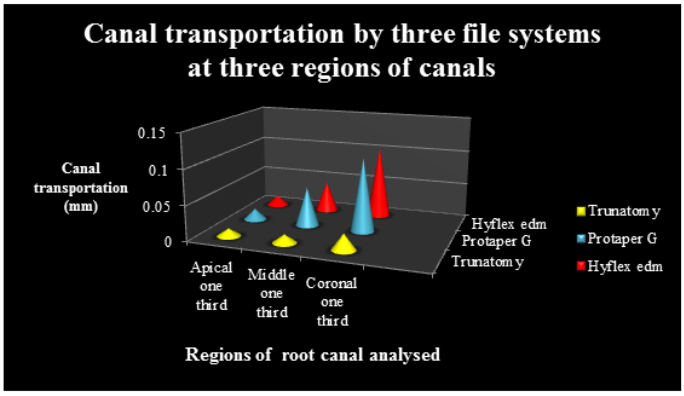
Finally when analysis was carried out at coronal level (9mm from apex) then the mean amount of transportation for Trunatomy file system was minimum while it was maximum in case of protaper gold file system . The mean amount of transportation for hyflex edm file system was greater than trunatomy file system but less than that of Protaper gold . The difference was statically significant with p value of 0.02 ($p \leq 0.05$).

It was observed in the current study that TruNatomy file system showed least transportation as compared with ProTaper Gold and Hyflex EDM rotary file system. Similar results were observed when Elnaghy AM et al in 2020 conducted a study to compare the Trunatomy file system with HyFlex CM (HCM), Vortex Blue (VB) and RaCe(RC) instruments. It was observed that TRN was found to have better cyclic resistance to fracture.[17] Riyahi AM et al in 2020 conducted a study to compare the cyclic resistance of Trunatomy file system with Twisted file and Protaper next rotary file system and concluded that Trunatomy file system showed better cyclic resistance as compared with other file system.[18,19] Vyver VD et al produced a series of case reports and found that

Trunatomy file systems showed better results in root canal preparation.[20]

TruNatomy instruments (TRN,Dentsply Sirona Switzerland) has been named derived from the design of the files that take the natural anatomy of the root canal and the tooth into account. TRN shaping files have three different working lengths and sizes . These NiTi files heat-treated, slim wire (MFD 0.8) and are designed to operate at higher speed for greater efficiency requiring less torque. The design helps the file to progress trouble freely into the canal. With seamless transitions from file-to-file, the clinician is always in full control.[12,20]

TRN instruments reportedly maintaining the integrity of tooth as well as preserve dentinal structures due to its design, taper, geometry and heat treatment. This new file system offers the clinician more simplicity, safety, improved cutting efficiency and mechanical properties compared to previous generations of rotating instruments.[21]



Graph 1: Canal transportation by three file systems at three regions of canals

Conclusion

The TruNatomy system has least amount of canal transportation as compared with ProTaper Gold and Hyflex EDM system. With potential to preserve tooth structure, this file has an advantage over other rotary file systems. However, further studies are required to assess the other properties of this file and its clinical performance.

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