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A comparative evaluation of three different file system Trunatomy, Neoendo flex file, Hyflex CM file for canal transportation and centering ability using CBCT-An invitro study.

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Abstract

Introduction: This study evaluated the canal transportation and canal centering ability of mandibular premolar by three different file systems; TruNatomy, Neoendo Flex file, Hyflex CM file using Cone Beam Computed Tomography(CBCT).

Methods: Forty-five mandibular premolars were randomized into 3 groups and prepared using the crown down technique by a controlled speed and torque recommended by the manufacturer for each file system along with rinsing with 2.5% NaOCl. GROUP-I (n=15):for TruNatomy Files, GROUP-II(n=15):for Neo Endo Flex Files, GROUP-III(n=15):for Hyflex CM Files. All teeth were scanned pre and post operatively with CBCT to determine the root canal shape. The thickness of instrumented and non- instrumented canal walls were measured at 3,6 and 9mm from the apex. Data were compared using 1-way analysis of variance (P 05) Tukeys Post hoc test, to show the difference among the groups

Results: present study showed that inter group comparison of canal transportation and canal centering values of Group 1 (TruNatomy files Dentsply, Maillfer), Group2 (Neondo flex file,Orikam) and Group3(Hyflex CM file, Coltene) were statistically significant at coronal, middle and apical sections.TruNatomy rotary file system showed least canal transportation followed by Hyflex CM file and Neo Endo Flex Files. Canal centering ratio was best observed by TruNatomy rotary file followed by Hyflex CM file and Neo Endo Flex Files.

Conclusions: three types of Ni-Ti files used that is TruNatomy rotary file, Hyflex CM file and Neo Endo Flex Files produced similar result and the type of file used had least effect on centring ability and canal transportation.

Keywords: Cone-beam computed tomography, TruNatomy rotary file, Hyflex CM file, Neo Endo Flex Files

Introduction

The objective of preparation of the root canal system is to enlarge the root canal space to facilitate disinfection by antibacterial agents and to prevent re- infection by the placement of a fluid-tight root canal filling followed by complete sealing of the access cavity with a sufficient coronal restoration[3],[5].

The ideal shape of the prepared root canal should have a progressively tapering conical shape from the coronal access cavity to the root apex which preserves the position of the apical foramen also maintains the original canal shape without any transportation, such that the instrument remains centered throughout the root canal preparation. [1],[2]

The structural durability of the tooth following endodontic therapy is directly the remaining dentin thickness is directly proportional to structural durability. The aggressive instrumentation of the root canal structure results in loss of dentin which may eventually weaken the tooth . Bender and Freeland stated that the maximum percentage of vertical root fractures occur following root canal therapy .[11],[12],[13]

Nowadays, endodontic files are made of superplastic nickel–titanium (Ni–Ti) alloys, whose thermomechanical processing includes the martensitic phase, which remains stable under clinical conditions. The literature reports that Ni–Ti files, besides allowing for conical root canal preparation, lead to a more centered shape with minimal deviations from the root canal central axis. Many systems have different designs in their structure to minimize procedural errors and achieve a predictable canal preparation. Wherefore, it is important to evaluate the mechanical action of three different file system namely Trunatomy file,Neo Endo flex file and Hyflex cm file using CBCT.[15],[16],[17],[18],[19],[20]

Material and Method

This was an in-vitro study,conducted in the department of Conservative Dentistry and Endodontic, K.D.Dental College and Hospital, Mathura, U.P. and evalutation of canal transportation and centering ability by using CBCT at P Square Advanced Maxillofacial Imaging Centre, Mathura, U.P.

Forty five permanent single rooted premolar teeth with single canal and completely formed apices ,with intact roots were included in the study. They were stored in 10% buffered formalin. Conventional access cavity was prepared by using an airotor hand piece with Access preparation kit (Dentsply, Maillefer, Ballaigues, Switzerland) .To determine the working length, a #10 K file was placed into the canal until it was visible at the apical foramen and working length (WL) was established 0.5 mm short of this length. The working length of all teeth was standardized to 15-mm by flattening the occlusal surface of the crown using a double sided diamond disk and measuring the length using a no. 10K file and endoblock. These roots were then positioned in a custom made specimen holder (specimens were positioned in template made of putty) for CBCT analysis.

All the teeth were scanned by using Cone beam computed tomography along its long axis to determine the root canal shape before instrumentation.. First section at 3mm from the apical end of the root , second section at 6mm from the apical end of root and the third section at 9mm from the apex were recorded. The shortest distance from the mesial and distal edge of the root to the respective canal was recorded at 3mm, 6mm and 9mm from the apex. The imaging settings had a voltage of 70kVp, a beam current of 10 mA, an exposure time of 13 seconds and FOV (Field of view) of 5x5cm. 3D Imaging software CS9600was used to do the image analysis for the initial and final scan.

The specimens were then randomly divided into three groups based on the file system was used for canal prepartation. Samples were prepared using the crown down technique by a controlled speed and torque recommended by the manufacturer.2.5%NaOCl solution was used for irrigation of canal after each instrument change.The smear layer was removed by using 17%EDTA and 5.25% NaOCl.

GROUP I: The sample were preparaed by using TruNatomy file at a speed of 500 rpm and 1.5Ncm torque. The canal preparation was started first with Orifice modifier (20,0.08%) which was followed by TN Small shaping file (20,0.04%) and final preparation was completed by TruNatomy Prime shaping file (26,0.04%).

GROUP II: The samples were prepared using NeoEndoFlex File at a speed of 350 rpm and 1.5 Ncm torque. Orifice opener (30-0.8%) then glide path was obtained by using (17-0.4%) NEF glide path file, and canal preparation was completed by using Neo Endo file (20-0.4%), (25-0.4%).

GROUP III: The sample were prepared by using Hyflex CM file at a speed of 400 rpm and 2.5Ncm torque. The canal preparation was started with orifice opener (25-0.8%) then glide path was obtained using HCM (20-0.4%) and the canal preparation was completed by (25-0.4%) .

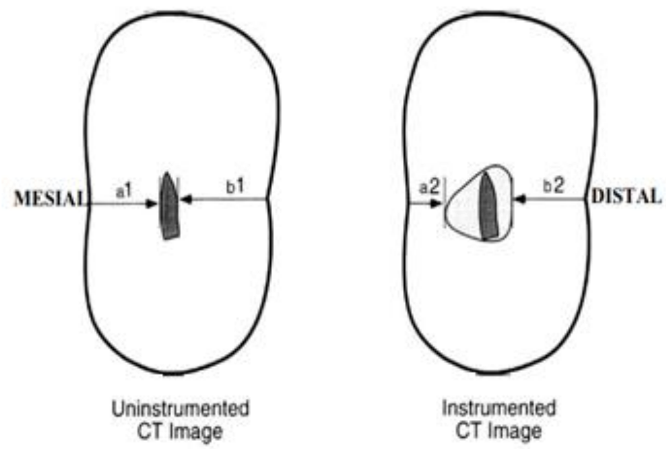
After completion of Bio Mechanical Preparation all the specimen were mounted on custom made template and imaging was done at 3mm, 6mm, 9mm for assessment of canal transportation and centering ability using CBCT.

Evaluation of canal transportation

The amount of canal transportation was determined by measuring the shortest distance from the edge of the canal to the mesial and distal periphery of the root before instrumentation and then comparing the same measurements obtained after instrumention. All the values were measured by two evaluators and a mean value was recorded.

The following formula was used for the calculation of transportation:

(a1-a2) - (b1-b2)



a1 is the shortest distance from the mesial edge of the root to the mesial edge of the uninstrumented canal.

b1 is the shortest distance from distal edge of the root to the distal edge of the uninstrumented canal.

a2 is the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal.

b2 is the shortest distance from distal edge of the root to the distal edge of the instrumented canal.

According to this formula the mesial measurement was substracted from distal measurement, negative value indicates canal transportation towards the distal portion and a positive value showed transportation towards the mesial periphery of root and zero value showed the absence of transportation.

Evaluation of Centering Ability

The mean centering ratio indicates the ability of the instrument to stay centered in the canal. It will be calculated for each section by using the following ratio:

$$\frac{(a1-a2)}{(b1-b2)} \quad \text{or} \quad \frac{(b1-b2)}{(a1-a2)}$$

If these numbers are not equal, the lower figure is considered as the numerator of the ratio. According to this formula, a result of 1 indicates perfect centering.

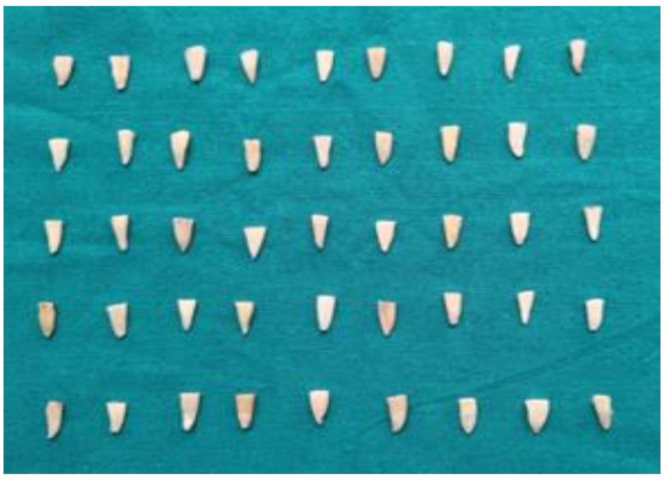


Fig 1: Sectioned specimen

Fig.2 Specimen in putty

Statistical Analysis

The data obtained were statistically analysed using software statistical package for the social sciences(SPSS) version 22.One way analysis of variance was used for multiple group comparison and post hoc tukey's test for individual group wise comparision $p<0.001$was set as statistical significance.

Discussion

The introduction of Nickel-Titanium (Ni-Ti) rotary files in endodontics almost two decades ago has changed the way root canal preparations are performed, enabling more complicated root canal systems to be shaped with fewer procedural errors. The introduction of Ni Ti rotary instruments has not only enabled easier and faster instrumentation of the root canal system, but also has provided consistent, predictable and reproducible shaping with considerably less iatrogenic damage. Curvatures and irregularities of root canal walls of teeth can be cleaned efficiently with nickel-titanium instruments with clockwise rotation resulting in removal of pulp tissue, dentin, and necrotic residues from the canals similar to manual filling.[43] Their ability to rotate on their own axes in the root canal without any risk or damage to the original anatomy is very important. This increases the ability of the file to follow the anatomy of the canal very closely and reduces the risk of transportation. A crown down instrumentation sequence has been recommended for most of these rotary nickel–titanium instruments, in which larger files precede smaller ones, which in turn progress further apically. This type of preparation is known to remove more dentin Some factors that exert an impact on the incidence of canal transportation are root canal anatomy (degree and radius of curvature), file design (helical angle, pitch, cutting angle, rake angle, radial lands), especially tip design, cross sectional design, taper, alloy of root canal instruments and instrumentation technique.[6][7][18]

The American Association of Endodontics defines transportation as “removal of the canal wall structure on the outside of the curve in the apical half of the canal due to the file's tendency to restore their original shape during canal preparation which may lead to ledge formation and possible perforation." The inappropriate pattern of dentin removal adversely affects the treatment prognosis, as it causes high risk of straightening the original canal curvature, and increases the rate of debris extrusion and subsequent postoperative discomfort.[22][24][26][33][34] Eventually, apical transportation may lead to zipping or perforation of the canal. Apical transportations that are more than 0.3 mm can jeopardize the outcome of treatment due to the significant decrease in the sealing ability of root filling material

Intraoral periapical radiographs are widely used both in research and in clinical endodontics to aid in diagnosis and management. However, they offer limited, two dimensional images of an extremely complex anatomical structure. Three-dimensional cone beam computed tomography (CBCT), in turn, can yield sequential axial images of root canals from the coronal to the apical region, or vice versa, and is extremely useful in determining the exact position of anatomic structures, revealing details of the internal root canal anatomy, and helping identify points of communication between root canals and the periodontal space. Because of both its accuracy and the possibility to preserve the tooth structure, CBCT has been increasingly used to evaluate apical transportation and centralization.

CT was used in our study to assess the canals before and after instrumentation. Considering the importance of correlating instrument characteristics and root canal anatomical aspects to ensure endodontic treatment success, the aim of this study was to evaluate, using CBCT, transportation and centralization within the root canal of different NiTi rotary instruments, namely, TruNatomy file, Neo Endo Flex file, Hyfles CM file.[45][46][50]

In the present study extracted teeth was used since they provide conditions that are close to the clinical situation. The manufacturer's recommendations have been followed (e.g.handpiece, motor, torque). Three levels (i.e 3mm,6mm and 9 mm from the root apex) were chosen representing the coronal, middle and apical thirds of root canal in which curvatures usually exist and are highly susceptible to iatrogenic mishaps.

In the present study, all root canals were uniformly prepared to size 25 with different taper; this was to maintain the uniformity in apical preparation size of 25 for all the 3 rotary system. And also studies have shown that preparation to size 25 is exceptionally safe in all canals.[6] The size of the taper is one of the main factors involved in apical root transportation because an increase in the taper reduces instrument flexibility.[21][23][27][28]

Recently, TruNatomy™ (Dentsply Sirona), a new generation of rotary files that is designed to shape root canal systems to a continuously tapering preparation with maximum preservation of peri-cervical dentin. This new file system offers the clinician more simplicity, safety, improved cutting efficiency, and mechanical properties compared to previous generations of rotating instruments. TruNatomy instruments with a smaller initial wire blank 0.8 mm diameter are manufactured using a post-manufacturing thermal process that produces a file with superelastic nickel-titanium metal properties. The TruNatomy system is comprised of an Orifice Modifier, a Glider, and three shaping files for different clinical applications. Regardless of the motor selected, all of the TruNatomy instruments are designed to run in continuous rotation at 500 rpm with a torque setting of 1.5 Ncm. So it was included in study.[10][11][17][19]

Neoendo Flex Files have excellent cyclic fatigue resistance. The triangular cross section with sharp cutting edges increases cutting efficiency. Avoiding accidental apical transportation becomes easier with the safety tip (non-cutting). The extreme flexibility of this canal favours negotiation of any canal[55][56]

HyFlex CM (HCM [Coltene-Whaledent, Allst €atten, Switzerland]) was the first system in which controlled memory treatment was used. These files have been manufactured using a unique process that controls the material's memory. This treatment gives the file extreme flexibility and the ability to follow the anatomy of the canal.

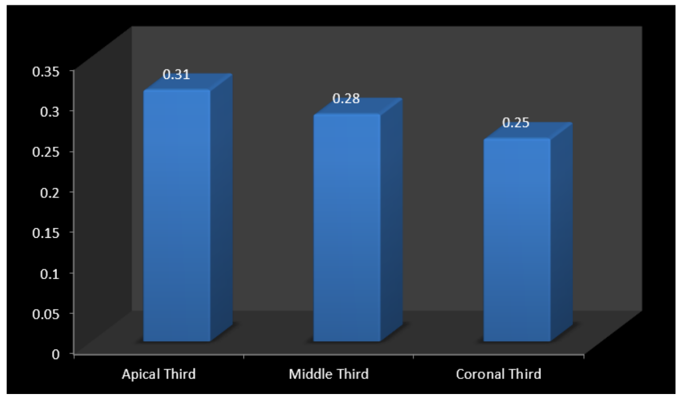
The canal transportation was calculated using a technique developed by Gambill et al The following formula was used for the calculation of canal transportation:

(a1 – a2) - (b1 – b2),

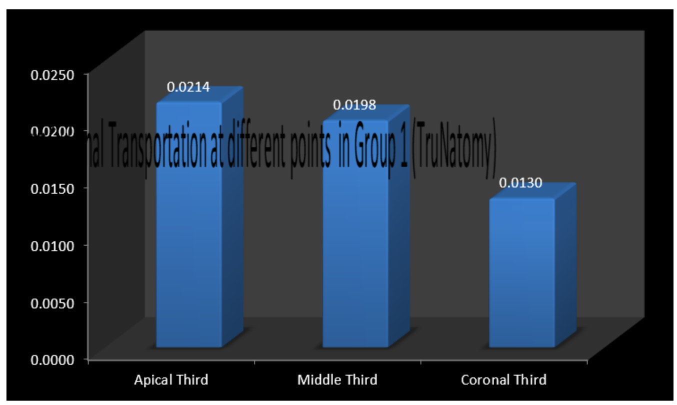
where a1 is the shortest distance from the mesial edge of the root to the mesial edge of the uninstrumented canal, b1 is the shortest distance from distal edge of the root to the distal edge of the uninstrumented canal, a2 is the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal, and b2 is the shortest distance from distal edge of the root to the distal edge of the instrumented canal.

In the current study, all the teeth were cleaned and shaped in the following sizes Hyflex CM till size #25, Trunatomy #26,and Neo Endo Flex #25. After which the post instrumentation CBCT was taken.

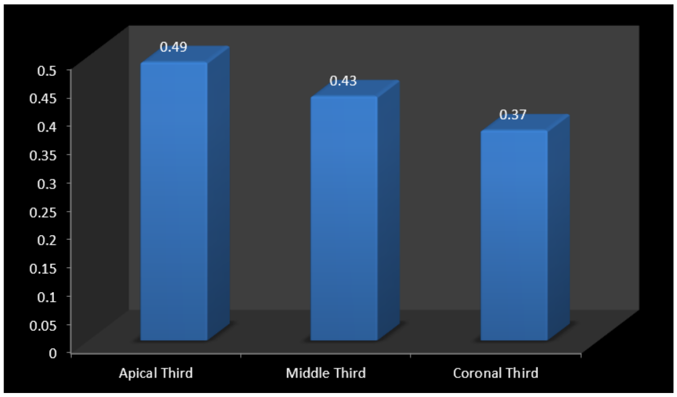
Transportation of the canal occurs due to the rigidity of the file during canal preparation. This leads to the non-uniform distribution of stresses which in turn causes straightening of the file within the canal at the canal curvature.[33]. On the outside curve of the apical region of the root canal during canal preparation, the files have a tendency to straighten and restore to their original form[35].The fact that all of the instruments have non cutting that operate with minimal apical pressure and only serve as a guide to allow easy penetration into the canal. In the present study, it was evident that the canal transportation among the three groups was statistically significant (P 0.001) implying some deviation was present but not to the extent that it could result in a deleterious effect on the tooth.[13][14][57]



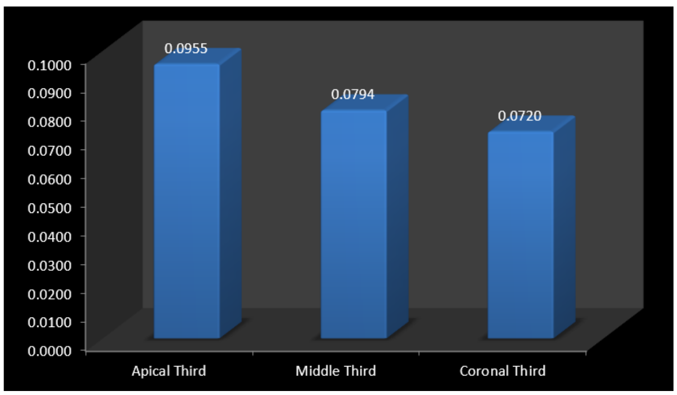
Graph 1: Centring Ratio at different points in Group 1 (TruNatomy)



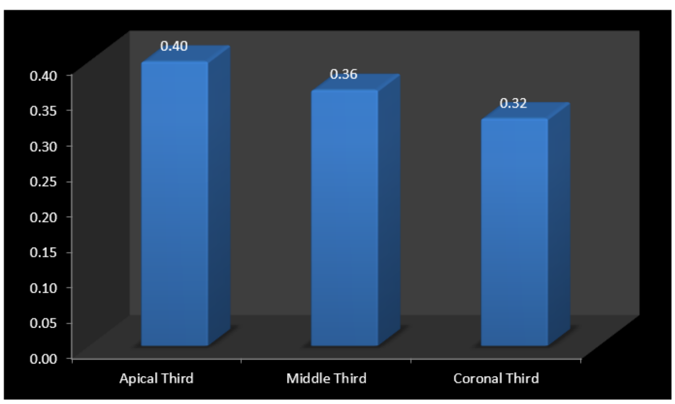
Graph 2: Canal Transportation at different points in Group 1 (TruNatomy)



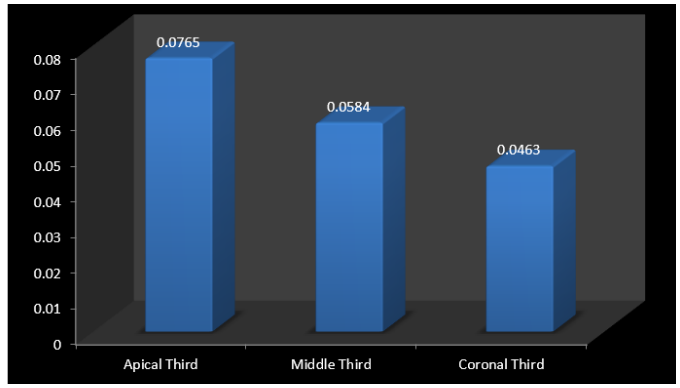
Graph 3: Centring Ratio at different points in Group 2 (Neoendo Flex)



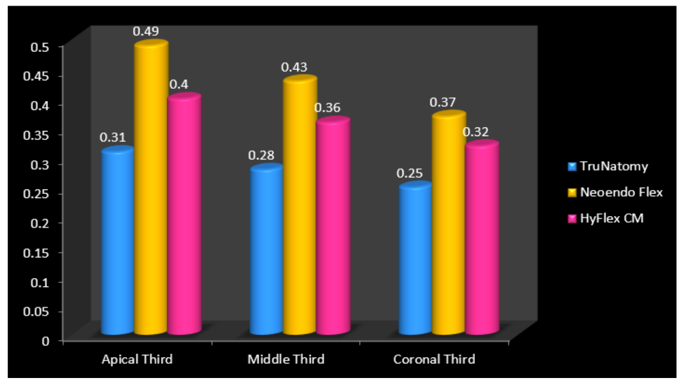
Graph 4: Canal Transportation at different points in Group 2 (Neoendo Flex)



Graph 5: Centring Ratio at different points in Group 3 (Hyflex CM)



Graph 6: Canal Transportation at different points in Group 3 (Hyflex CM)



Graph 7: Intergroup comparison of Centring Ratio at different points of Root Canal

Table 1: Intergroup Comparison of Centering ratio at different thirds of tooth

Distance from Apex	Group 1	Group 2	Group 3	F value	P Value
3 mm (Apical Third)	0.31±0.18	0.49±0.19	0.40±0.22	4.85	0.001**
6 mm (Middle Third)	0.28±0.17	0.43±0.15	0.36±0.19	3.96	0.001**
9 mm (Coronal Third)	0.25±0.14	0.37±0.16	0.32±0.11	6.29	0.001**

One way ANOVA test,*Significant, **Highly Significant

Table 2: Intergroup Comparison of Canal transportation at different thirds of tooth

Distance from Apex	Group 1	Group 2	Group 3	F value	P Value
3 mm (Apical Third)	0.0214±0.0496	0.0955±0.0210	0.0765±0.0236	22.38	0.001**
6 mm (Middle Third)	0.0198±0.0361	0.0794±0.0221	0.0584±0.0214	14.35	0.001**
9 mm (Coronal Third)	0.0130±0092	0.0720±0.0173	0.0463±0.0292	16.85	0.001**

One way ANOVA test,*Significant, **Highly Significant

When comparing the groups individually there were significant differences between TN and HCM and NEF systems in canal transportation at 3mm from the apex. TN system showed comparatively less canal transportation at the apical third of the root canal when compared with HCM and NEF system this could be due to its variable taper and offset design.This is in accordance with the study that compared shaping ability of WaveOne Gold (WG; Dentsply Tulsa Dental Specialties, Tulsa, OK), the Reciproc Blue (RB; VDW, Munich, Germany), TRUShape (TS, Dentsply Tulsa Dental Specialties), XP-endo Shaper (XP; FKG, La Chaux-de-Fonds, Switzerland), iRace (IR, FKG), and TruNatomy (TN; Dentsply Sirona, Ballaigues, Switzerland) for preparation of moderately curved canals which used micro–computed tomographic technology. This study concluded that TN and XP preserved the canal anatomy, but TN touched the lowest percentage of canal surface (50%). [12][37]This may affect the biomechanical preparation of the root canal as all the canal surfaces are not touched by the file. But on the other hand a case report published concluded that the TN system preserved original canal anatomy, dentine thickness and maintained the structural integrity of teeth which is an integral part of root canal shaping and preparation. The case report also stated that focusing on the benefits like dentine preservation, improved performance and efficacy the TruNatomy instruments offer the clinician superior debridement by respecting original canal anatomy.[13]

Centering ability was defined as the ability of an endodontic instrument or file to remain in the central axis of the root canal.[37]Canal centering ability of the file is influenced by the alloy used in the manufacturing process of the instrument, along with the file design which consists of cross-section, tip, and taper of the instrument.[38] The lower the value in the centering ratio analysis,the more centered the preparation within the canal.[13] There wasa significant difference among the three groups. ProTaper Goldshowed a lesser centering ratio compared to the other files this could be due to its variable taper (Hyfex CM 6 % taper). Trunatomy (26, 4%taper) and Neo Endo Flex file (25, 2%taper) had significant difference i.e TN had a better centering ratio than HCM and NEF, this could be due to the taper variations and offset design.

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