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COMPARATIVE EVALUATION OF THE ROOT CANAL PREPARATION EFFICIENCY USING PROTAPER NEXT, ENDOSTAR E3 AND PLEX V ROTARY FILE SYSTEMS (AN IN VITRO STUDY)

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Abstract

Introduction: Mechanical instrumentation is quite effective at reducing the numbers of bacteria in the canal. There are three main areas in which engine driven instrumentation has been modified over the years as more and more file systems are introduced to the market. **Aim of the study:** The aim of this study is to compare Protaper Next, Plex v and Endostar E3 as regarding the root canal preservation in the form of canal transportation in mesial roots of mandibular molars. **Material and Methods**: A total of 45 mandibular molars were selected and randomly divided into three experimental groups (n=15) according to the instrumentation technique: ProTaper next, Endostar E3 and Plex V rotary file systems. Specimens from each groups were scanned using CBCT before and after instrumentation to evaluate the canal preparation, number of prepared and unprepared surfaces at three thirds of root canal in each instrument system. Data were statistically analyzed, and the significance level was set at $p<0.05$. **Results**: The results showed no statistically significant difference between the groups with P-values of 0.562, 0.83 and 0.732 for Curvature, Radius and apex-CEJ distance respectively. **Conclusion:** All systems; can effectively shape curved root canals with minimal transportation, produce well centered preparations, with sufficient enlargement of root canals and without excessive removal of dentin. Plex V rotary file system is preferred over other systems in cases with insufficient dentin thickness at the coronal level.

Keywords: Cone-Beam Computed Tomography, ProTaper Next, Ni-Ti Instruments, Root Canal Preparation, Canal Transportation.

INTRODUCTION

The endodontic treatment goal is to manage pulpal/periradicular pathosis and preservation of the natural healthy dentition of the patient[1]. The meticulous preparation of the root canal system is one of the most significant determinants for the success of endodontic treatment. For efficient root canal shaping, it's crucial to preserve the canal anatomy and dentine thickness. Procedural errors such as instrument fractures, ledges, perforations and apical blockage might result in insufficient debridement, which can cause endodontic failure[2].

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The anatomy of the root canals has a great influence on the risk of canal transportation. The radius and degree of canal curvature affect the risk of canal transportation; the risk of canal straightening increases with decreasing radius and increasing degree of canal curvature[2].

Lots of innovations in NiTi instruments have been achieved in the last decade by improvements in the design, physical properties, metallurgy, kinematics, and thermal treatment of the NiTi alloy. Continuous modifications and production of new instruments need more research on the efficiency of these instruments to enable clinicians to make proper decisions using evidence-based practice [1].

MATERIALS AND METHODS

A descriptive comparative research design was utilized for the conduction the current study

1 Selection of Samples

Forty five human mandibular molar teeth, extracted for clinical reasons such as periodontal disease, were collected. Teeth cleaned & stored in 0.9% saline solution till use.

Eligibility criteria of the collected teeth

The inclusion criteria:

1) Mandibular molars with two separate mesial canals & separate apical foramina.
2) Mesial canals are curved, with angle of curvature ranging between 25-35 degrees (according to Schneider's method).
3) Teeth with complete formation of apices & apical foramina (Mature root apices).

The exclusion criteria:

1) Extensive root caries.
2) Calcified root canals.
3) Internal or External root resorption.

2- Preparation of Samples

Sample preparation and Sterilization

The selected samples were planned with an ultrasonic scaler (Suprasson P5 Booster, Satelec, France) to remove any calculus hard deposits and soft tissue remnants on the root or remaining bone. Length of selected samples was adjusted to be fixed at 19 mm. samples after that were immersed in 5.25 % NaOCL solution for 14 minutes then sterilized by autoclaving at temperature 121◦C for 30 minutes , two cycles .

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Standard endodontic access cavity preparation done in the selected teeth using diamond round bur and diamond tapered stone with rounded end. A #10-15 K-File used to check canal patency.

- **Measuring the Curvature Angle**

#10-15 K-File file is to be placed in the mesiobuccal canal of each molar tooth, and adjusted to the apical foramen. Then using direct digital radiography, mesiodistal & buccolingual views were taken for each tooth.

An x-ray machine with exposure parameters 70 kVp, 7 mA and 0.04 sec exposure time used. Digital images were captured using Digora imaging plate. The Digital images were analysed using the Digora software to determine the angle of curvature using **Schneider's method 1971**[3]

- **Schneider's Method**

A file was inserted as an indicator of the canal orientation and direction throughout the length of the root. One line was drawn in the coronal straight portion of the canal, and the Second line was drawn from the apical foramen to intersect the first line, at the point the canal begins to leave the long axis. The intersection of the two lines forms an angle which was considered to be the **Angle of Curvature**. The larger of the two angles (mesiodistal or buccolingual) was considered as the angle of curvature.

Sample grouping

Forty five teeth were selected according to the previously mentioned eligibility Criteria. All to be shortened to the length of 19mm, by using a diamond Stone to flatten the occlusal Surface. The working length adjusted 1mm shorter, i.e. working length was adjusted to be 18mm. The distal root of each tooth resected at the level of the furcation using astainless steel disk under coolant, and the mesial root was placed in an acrylic resin mold.

Teeth then divided into three groups (15 teeth each) according to the type of instrument used in the root canal preparation.

Group A) using Protaper Next files.

Group B) using Endostar E3 files.

Group C) using Plex V files.

Irrigation used between files by 2.5% sodium hypochlorite solution during instrumentation.

- **Placement of the sample in the resin mould**

A mould of acrylic resin was made, in the form of a circle of 8mm diameter. Mesial roots were vertically placed in the acrylic resin before complete polymerization, with the buccal surfaces of all teeth facing at the same direction. An orthodontic wire used to identify the buccal surfaces.

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- **Pre-instrumentation imaging**

Each sample scanned using Cone Beam Computed Tomography, Using thei-CAT vision software, coronal and sagittal planes were adjusted so that the long axis of each tooth was aligned vertically.

In the axial plane, dentin thickness measured mesially, distally, buccally, and lingually, from the root canal boundary to the root surface boundary for each tomogram.

Fig 1: The mould placed in the CBCT machine for scanning.

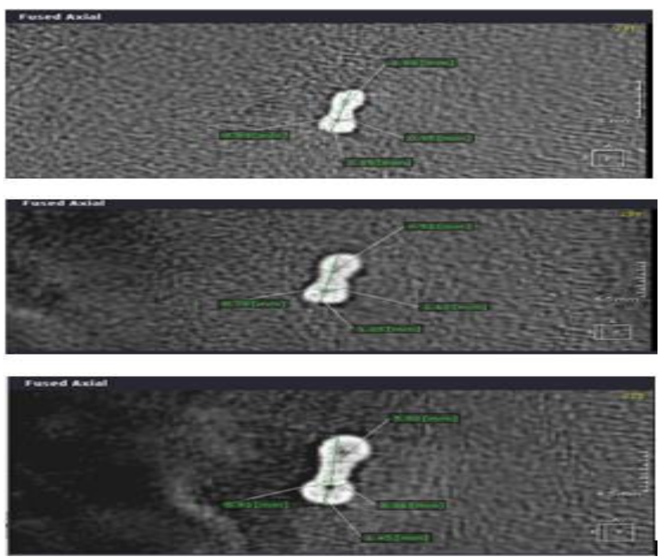

Fig 2: Pre-instrumentation measurement of the dentin thickness at 3-5-8 mm levels respectively in a selected specimen

- **Instrumentation**

Mesiobuccal canals of all teeth checked by #10 K-file for patency and irrigated by 2.5% sodium hypochlorite solution before instrumentation, then complete instrumentation by the three groups of files according to manufacture instructions.

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- Using NaOCl irrigation and Ethylene Diamine Tetra-Acidic Acid (EDTA) gel (META BIOMED, Chungcheongbuk-do, Korea), size #10 then #15 glide path K-Files were inserted in the canal till working length was reached, and worked until they were loose.
- Cleaning and Shaping was done in a Crown-Down technique, with a slow in and-out pecking motion of about 3mm until reaching the full working length, and the instrument was cleaned after every 3 pecks[4].
- EDTA gel was used on each file as a lubricant.
- After every 3 pecks, files were withdrawn to clean its flutes and inspect the file for any deformities. Irrigation was done, patency was maintained using #15 k-file and then irrigation again before inserting the file in the canal once more.
- Irrigation was done with 2ml of 5.25% NaOCl solution, using a 30-gauge max-i-Probe needle (Densply-Rinn, Elgin, IL), that was inserted as apical as possible[5] .

Post-instrumentaion imaging

Each mould scanned, to obtain tomograms for each specimen, using Cone Beam Computed Tomography (CBCT), by the same parameters used for the pre-instrumentation imaging section, to compare the images.

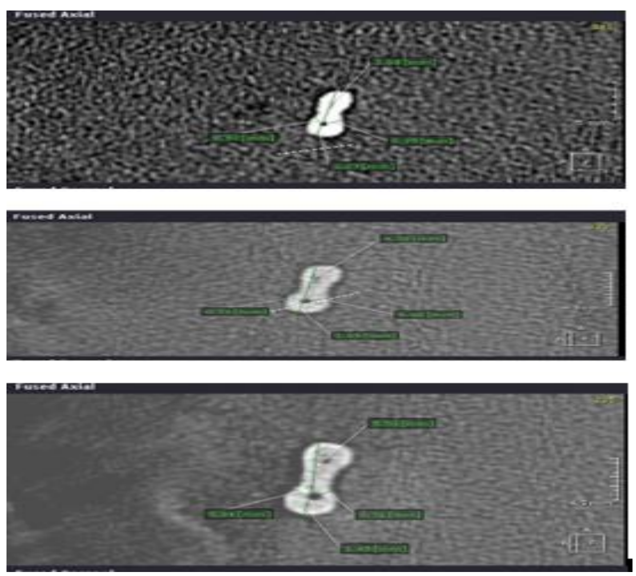

Fig. 3: Post-instrumentation measurement of the dentin thickness at 3- 5- 8 mm levels respectively in the same selected specimen

Intervention group: Plex V and azure E3 rotary files

Control group: Protaper Next rotary files

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Canal Transportation and centering ability

Canal transportation corresponds to the deviation in the axis (in millimetres) after instrumentation, compared with the original axis of the canal before instrumentation. To measure Canal Transportation, formula introduced by **Gambill et al (1996)** [6] was used.

The values used are the measurements of the shortest distance from the edge of the instrumented canal to the periphery of the root surface (mesially, distally, buccally & lingually), and comparing these measurements with the same measurements before Canal instrumentation. **The Formula used for calculation of Canal Transportation:**

mesiodistally: (M1-M2)-(D1-D2)

buccolingually: (B1-B2)-(L1-L2)

RESULTS

The characteristics of the root canals used for the current study as regarding the curvature, the radius and distance between apex-CEJ are shown in (***Table 1***). The results showed no statistically significant difference between the groups with P-values of 0.562, 0.83 and 0.732 for Curvature, Radius and apex-CEJ distance respectively. Data were collected, tabulated and statistically analyzed.

Table 1: The Characteristics of curved root canals (n=15 per group)

Groups	Curvature (°)	Radius (mm)	Distance apex-CEJ (mm)
Protaper Next (PTN)	*28.7 ± 1.86*	*6.21 ± 1.42*	*13.3 ± 0.5*
Endostar (E3)	*30.26 ± 3.02*	*7.25 ± 1.43*	*13.4 ± 0.7*
Plex V (PV)	*29.4 ± 3.30*	*6.29 ± 2.67*	*12.80 ± 0.77*
P-value (ANOVA)	*0.562*	*0.823*	*0.732*

Root Canal Anatomy Preservation

Canal Transportation

The mean values and standard deviation of the Canal transportation (mm) are shown in (***Table 1)***. For all the test groups the middle third showed a higher value of canal transportation compared to the coronal and apical thirds. Canal transportation values were 0.030 ± 0.0188, 0.112± 0.0437 and 0.0521 ± 0.0358 for the coronal, middle and apical thirds of the Protaper Next Group respectively.

The mean canal transportation values were 0.0284± 0.0199, 0.103 ± 0.0377 and 0.0388 ± 0.0299 for the coronal, middle and apical thirds of the Endostar Group respectively.

As for the Plex V Group, the mean canal transportation values were 0.0275± 0.0227, 0.0958± 0.0412 and 0.0435± 0.0361 for the coronal, middle and apical thirds respectively. There was a significant difference between coronal, apical levels and the middle level at all groups. Considering the direction of canal transportation, all groups showed a tendency toward transport to the mesial (outer) direction, with the distal wall acting in anti-furcation direction

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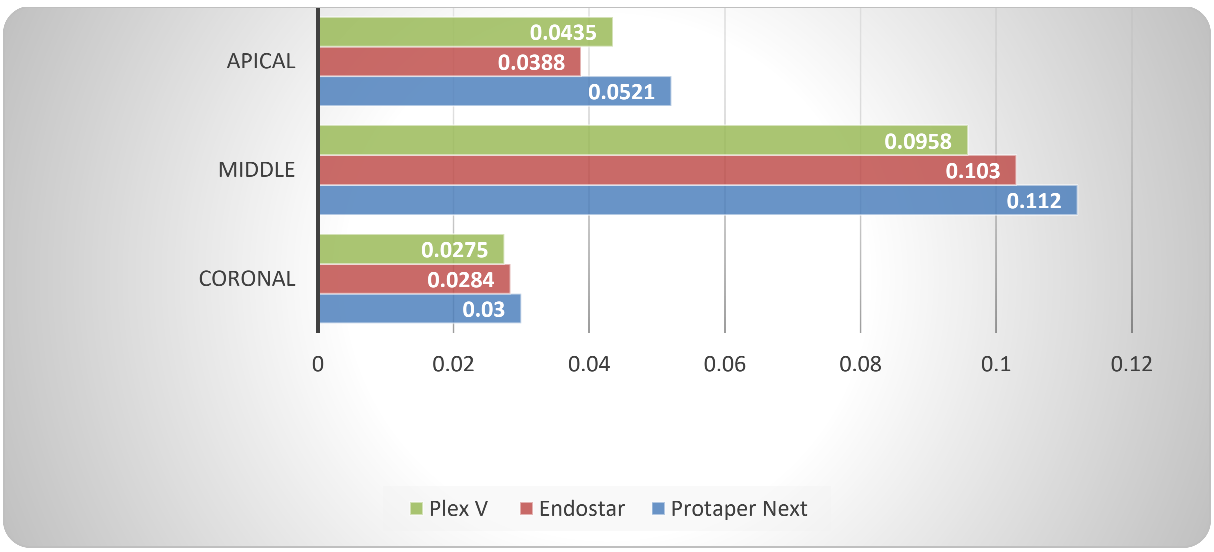
Table 2: The mean and SD values and results of Anova and Tukey pairwise comparison test for comparison between canal transportation for different groups and root levels

Level / Groups	Coronal Mean ± SD	Middle Mean ± SD	Apical Mean ± SD	F-value	P-value
Protaper Next (PTN)	0.03 ^{A} ±0.019	0.112 ^{B} ±0.044	0.0521 ^{A} ±0.036	22.78	<0.001*
Endostar (E3)	0.0284 ^{A} ±0.02	0.103 ^{B} ±0.038	0.0388 ^{A} ±0.03	26.86	<0.001*
Plex V (PV)	0.0275 ^{A} ±0.023	0.0958 ^{B} ±0.041	0.0435 ^{A} ±0.036	16.34	<0.001*
F-value	0.258	2.684	0.651		
P-value	0.855	0.055	0.611		

***:** significant at P≤ 0.05, Different superscripts denotes significant different between root level in the same group



Graph 1: A bar chart showing mean values of canal transportation (mm)

DISCUSSION

Considerable progress in rotary nickel-titanium (NiTi) instruments has been achieved, including instruments designs, alloy processing as well as movement kinematics. These advancements aim at providing easier and faster techniques and better maintaining the original canal shape with considerably less iatrogenic errors. Continuous precise research has become mandatory to facilitate clinical decision making by the clinician, in order to be able to choose the system and technique most suitable for the individual case.

Mesiobuccal root canals of extracted mandibular molars were selected in the present study following several previous authors. Mesial roots are usually curved, with the greatest curvature in the mesiobuccal root canals. Moreover, mesiobuccal root canals can have a significant curvature in the buccolingual plane that may not be apparent on radiographs.

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Therefore, mesiobuccal root canals usually show more significant root canal transportation on instrumentation than other canals It was important to select teeth that were similar regarding preoperative geometric parameters length characteristics, root canal curvatures, and initial root volumes. Specimens included in the studies comparing the effect of root canal instrumentation on canal anatomy should possess similar preoperative geometry.

Digital radiography was used in several previous studies Despite being a nondestructive method with no physical intervention required, it provides only two dimensional images. In addition, it has a significant drawback that the cross section of the root canal cannot be observed, Cone beam computed tomography (CBCT) was chosen as the evaluation method in the present study following several previous studies. It has been widely used in the research field of endodontics, and has proved to be an accurate, reliable and reproducible method of measuring dentin thickness and volume of root canals. It provides three dimensional imaging of tooth structure, and without destruction of the specimens.

CBCT provides improved image accuracy, less image artifacts, requires lower radiation dose, shorter scanning time and lower cost when compared with conventional computed tomography. Moreover and compared to micro CT, it is less time consuming and less costly. In addition, it is an available method, unlike micro-CT which is accessible only for military research work in Egypt. Shaping ability of three systems was assessed in terms of canal transportation. These was important parameter to be examined on studying shaping ability of endodontic files, as they significantly affect the final outcome of root canal treatment .

In the present study, root canal transportation and centering ability were assessed at 3,5,8 mm from the apical end of the root. The first level, at 3 mm from the apical end, represents the apical third where elbows and zips often develop. While, second and third levels, at 5 and 8 mm from the apical end, represent the middle and coronal thirds, where stripping may occur. Extent and direction of canal transportation, as well as centering ratio were calculated using the formula introduced by Gambill et al, following previous studies. It is an effective method of measuring canal transportation and centering ability.

Concerning the root Canal Anatomy Preservation, the canal curvature at all the test groups instrumentation led to decrease in the canal curvature nevertheless such decrease was statistically insignificant. The difference in canal curvature due to instrumentation for Groups Protaper Next, Endostar, and Plex V respectively. Which agreed with the finding of **Silva et al (2016)** [7], **Simone Staffoli et al(2018)**[8] and **Mahmoud R. Kamal et al (2023)**[9] The percentage change was higher with group Protaper Next while the least change was recorded with Group Plex V. The percentage decrease was statistically insignificant between different groups (Friedman Repeated Measures Analysis of Variance on Ranks, Chi-square= 2.760, P-value =0.430).

Concerning the canal transportation, For all the test groups the middle third showed a higher value of canal transportation compared to the coronal and apical thirds, There was a significant difference between coronal, apical levels and the middle level at all groups.

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Considering the direction of canal transportation, all groups showed a tendency toward transport to the mesial (outer) direction, with the distal wall acting in anti-furcation direction which was in agreement with the finding of **Han Jiang et al (2018)**[10]. However, the results were in disagreement with the finding of **Dalia et al (2020)**[11] and **Rana Mohamed Ewis et al (2023)**[12] This could be attributed to the differences in methodologies between studies, as the latter studies used simulated resin blocks as experimental models, different ranges of curvatures for the included samples and different evaluation methods. There are several instrument-related factors that are believed to affect canal transportation including; instrument design (degree of taper, cross sectional design , radial lands and cutting / noncutting tip design), metallurgy of NiTi alloy of the instrument, movement kinematics, and instrumentation technique (previous creation of glide path , coronal pre-flaring, and size of apical preparation). The absence of significant difference between both systems could be attributed to several similarities between both systems including; similar degree of taper, similar cross-sectional design, modified noncutting tips of both systems, and same size of apical preparation for all groups.

CONCLUSION

In review of the results and under the limitations of this study, the following was concluded:

- CBCT scanning is an efficient method for the assessment of root canal instrumentation techniques for its accuracy.
- All systems; can effectively shape curved root canals with minimal transportation, produce well centered preparations, with sufficient enlargement of root canals and without excessive removal of dentin.
- Plex V rotary file system is preferred over other systems in cases with insufficient dentin thickness at the coronal level, to preserve the dentin structure at this area and direct the whole preparation towards the “Safe zone” of the root canals

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