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CBCT EVALUATION OF CANAL TRANSPORTATION USINGNEWER ROTARY NI-TI FILE SYSTEMS-AN IN VITRO STUDY.

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ABSTRACT

The present study was done to compare canal transportation using three newer rotary Ni-Ti file systems; Protaper Next, Twisted file & Neo Ni-Ti using CBCT. In this study 90 freshly extracted mandibular premolars were de-coronated and divided into three groups of 30 samples each for instrumentation with Twisted file, Protaper Next & Neo Ni-Ti file systems. The roots were embedded in modelling wax and scanned by CBCT to determine pre and post instrumentation measurements at three levels (3, 7 and 11 mm) from the apex respectively. Canal transportation was least in Protaper Next group at all the three levels while Neo Ni-Ti showed highest transportation followed by the Twisted file system. Neo Ni-Ti group showed significant transportation at all levels when compared with Protaper Next. Amongst the three file systems, Protaper Next group showed the best result within limitations of this study.

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Introduction

Root canal preparation should present a flare shape from apical to coronal, preserving the apical foramen and without altering the original canal curvature as emphasized by Schilder. During instrumentation, maintaining the canal centering is difficult in curved canals compared to straight canals and can cause procedural errors such as transportation of the apical foramen, creation of zips, elbows, ledges which may

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lead to loss of working length, perforation or even instrument separation.[1] Canal transportation occurs due to the lack of flexibility of the instruments, insufficient designed access cavities, alloy and design features of root canal instruments or due to the instrumentation technique used.[2] Various root canal preparation techniques have been developed with changes being made in the materials and designs of the root canal instruments to overcome these problems. Reports from the various studies show that with the use of stainless steel instruments, the incidence of transportation and straightening of the canal is common. [3-7]With the introduction of newer Ni-Ti based file systems over the past two decades rotary files have gained predominance over hand files. Apart from its superior bio-compatibility and corrosion resistance, the super-elasticity of the Ni-Ti rotary files may allow less lateral force to be exerted against the canal walls, especially in curved canals, reducing the risk of canal aberrations and better maintaining the original shape. [8,9]

The Pro Taper Next, a fifth generation Ni-Ti rotary file system; has three significant design features, including progressive percentage tapers on a single file, M-wire technology, and the off-set design. These files have been claimed to generate an enlarged space for debris hauling and has a progressive and a regressive taper on a single file. Another new single rotary file system is Neo Ni-Ti, which claims to have superior flexibility in curved canal that respects the canal anatomy while its electrical discharge machined (EDM) manufacturing makes it highly resistant to cyclic fatigue in curved canals. The Twisted file system, a third generation Ni-the file, manufactured by a unique process of twisting in the R-phase, is claimed to have a high cyclic fatigue resistance which makes it better performing in curved canals. [10] The aim of the present study was to compare canal transportation using above three newer rotary Ni-Ti file systems.

In the past literature, numerous assessments contain a range of experimental models with regards to cleaning and shaping. Various types of hand and rotary instruments for root canal shaping have been compared and contrasted by these studies for root canal shaping, cleanliness, canal transportation. Methods such as serial sectioning and scanning electron microscope, radiographic evaluation, photographic assessment and computer manipulation have been used for assessment of canal transportation in the past. As the above-mentioned methods are invasive in nature, accurate repositioning of pre-and post-instrumented specimen is difficult, thus the information acquired by these methods could be inaccurate, hence CBCT was used for evaluation of canal transportation in the present study. [11,12]

Aim: To evaluate and compare Canal transportation using three newer rotary Ni-Ti file systems using Cone Beam Computed Tomography.

Objectives of the study: To evaluate:

1. Canal transportation in curved root canals following use of Twisted rotary Ni-Ti file system.
2. Canal transportation in curved root canals following use of Pro Taper Next rotary Ni-the file system.
3. Canal transportation in curved root canals following use of Neo Ni-Ti rotary file system.
4. To compare canal transportation in curved root canals between Twisted file, Pro Taper Next & Neo Ni-Ti rotary file system.

Materials And Methodology

The present in-vitro study was carried out in the department of Conservative Dentistry and Endodontics, A.B. Shetty Memorial Institute of Dental Sciences, Derelakatte, Mangaluru for analysis of canal transportation using three different rotary file systems by CBCT.

Source & Collection Of Sample:

- Freshly extracted 90 mandibular premolars were selected for this study. Collection, storage, sterilization and handling of extracting teeth were followed according to the Occupational Safety and Health Administration (OSHA) and Centre for Disease Control and Prevention (CDC) recommendations and guidelines.

Selection of Sample:

Inclusion Criteria:

1. Permanent teeth with completely formed apices
2. Non-caries or minimal carious mandibular premolars with one root and the single canal with canal curvature 10^o-15^o measured according to the criteria described by Schneider.

Exclusion Criteria:

1. Grossly decayed tooth
2. Restored tooth
3. Calcified canals
4. Teeth with root curvatures $< 10^o$ & $>15^o$
5. Teeth with resorptive defects
6. Root canals with double curvatures

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Assessment of Root Canal Curvature (Fig. 1)

Assessment of root canal curvature was done by Schneider's method. [13]

Sampling Procedure:

90 teeth were randomly divided into three groups of 30 samples each for instrumentation by the following rotary file systems respectively:

1. GROUP I	2. PROTAPER NEXT; 25/0.6	3. DENTSPLY MAILLEFER
4. GROUP II	5. NEO-Ni-Ti ; 25/0.6	6. CREATIVE DENTAL NEOLIX
7. GROUP III	8. TWISTED FILE; 25/. 6	9. KAVO KERR

Preparation of Samples:

1. **Sectioning of Teeth:**

The crowns of the teeth were sectioned at the level of CEJ for straight line access to the root using a diamond disc.

2. **Working Length Estimation:**

A size #10 K-file was inserted into the root canal of each tooth until it was visible at the apical foramen; and working length was calculated to be 1mm less than the length obtained from the initial file.

3. **Positioning of the Samples: (Fig. 2)**

Ten teeth were embedded in one block customized out of modelling wax in a simulated jaw form such that the teeth had some distance between them. The wax block was then mounted on the CBCT machine to capture image in jaw mode. Each tooth was placed in the block in such a way that they could be easily removed and positioned back. Thus, after pre-operative scan the teeth were maintained in their respective positions for instrumentation with respective files and post-operative positioning of the samples was standardized.

4. **Preoperative Scan: (fig. 3)**

The embedded teeth were scanned using CBCT Planmeca Romexis Promax 3D MID scanner as follows: Area of scan: 5*5 cm at Kv: 90, mA: 8 and mGy cm^2: 610

- Three levels were chosen for evaluation 3mm, 7mm, & 11 mm from the apex respectively.
- The images were scanned for further comparison between pre –instrumentation and post instrumentation, data by using PLANMECA ROMEXIS 4.3 Software.

5. **Instrumentation of the Samples:**

Group I [Protaper Next]

- After checking the patency of the canal Sx file was used to pre-flare the orifice followed by passive insertion of X1 file for instrumentation at the manufacturer's recommended speed of 350 rpm and torque 2 Ncm.
- After every few millimeters of file progression, the file was removed to inspect and clean the flutes.
- The PTN X2 file was used after X1.
- Patency was again checked with #10 file.

Group II[Neo Ni-Ti]

- After checking the potency of the canal, Neo Ni-Ti A2 (25.06) was used with slow and unique downward motion in a free progression and without pressure. Recommended rotation speed: 350 rpm, torque: 2 N.cm was used.
- The file was then slowly instrumented (up and down movement) up to the working length without pressure.

Group III[Twisted File]

- Teeth were instrumented using Twisted file (25.06) after checking the patency of the canal. The instrument was used with slow and unique downward movement in a free progression and without pressure.
- Recommended rotation speed: 400 rpm, torque: 2 Ncm was used.

In all three groups, one file was used for 5 canals. The canal was irrigated copiously with 5ml 3% Sodium Hypochlorite and 5ml normal saline in between and after preparation for final irrigation. EDTA was used as a canal lubricating medium. There was no instrument separation in any of the samples in all the groups. All the samples were prepared by the same operator.

Post-Instrumentation Scans:

Post-instrumentation scan was done using the same parameters as pre-operative scans to maintain

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standardization throughout the procedure.

Canal Transportation Evaluation:

The amount of transportation was determined by using the formula given by Gambill, [15] measuring the shortest distance from the edge of the un-instrumented canal in the most peripheral part of the root and then comparing this with the same measurements obtained from the instrumented images.

Formula for Calculation of Transportation at Each Level: (Fig. 4)

{(A1-A2) - (B1-B2)}

A1- shortest distance from the mesial edge of the curved root to the mesial edge of the un-instrumented canal.

B1- shortest distance from distal edge of the curved root to the distal edge of the un-instrumented canal.

A2- shortest distance from the mesial edge of the curved root to the mesial edge of the instrumented canal.

B2- shortest distance from distal edge of the curved root to the distal edge of the instrumented canal.

Results

At 3 mm

The mean measurement of Canal transportation was least in Protaper group (0.09± 0.08), followed by twisted file (0.14±0.09) and highest in Neo Ni-Ti (0.16±0.12). The mean measurement of Canal transportation differed significantly between 3 file systems at 3mm (p value =0.01). (TABLE I) (GRAPH I)

At 7 mm

The mean measurement of Canal transportation was least in Protaper group (0.13±0.12), followed by twisted file (0.15±0.09) and highest in NeoNiTi (0.26±0.15). The mean measurement of Canal transportation differed significantly between 3 file systems at 7mm (p value =0.001). (TABLE II) (GRAPH II)

At 11 mm

The mean measurement of Canal transportation was least in Protaper group (0.14±0.10), followed by twisted file (0.17±0.11) and highest in NeoNiTi (0.22±0.09). The mean measurement of Canal transportation differed significantly between 3 file systems at 11mm (p value =0.021). (TABLE III) (GRAPH III)

Statistical Analysis:

Mean measurement of Canal transportation between Protaper group, Neo Ni-Ti and Twisted file group were compared using one way ANOVA and Tukey Multiple comparison test at 3mm, 7mm and 11mm. $P<0.05$ is considered to be statistically significant. Microsoft Excel and SPSS Software version 22 was used for statistical analysis.

Discussion

In the present study canal transportation associated with instrumentation of canals with three different rotary file systems was compared using CBCT at the levels of cervical, middle & apical third of the root canal which correspond to 3 mm, 7mm & 11mm respectively. Amongst all the groups, Pro Taper Next showed the lowest canal transportation followed by the Twisted files and Neo Ni-the group at all the levels. This was statistically significant between Pro Taper Next and Neo Ni-Ti at apical and cervical third, and at middle third between the Twisted files and Neo Ni-the group.

This result could be associated with factors like instrument design, instrumentation technique and the alloy used as demonstrated in a study by Guelzow in 2005. [10] The Pro Taper Next file system created more contoured shapes with less canal straightening respecting the original root canal morphology compared to other systems. This may be attributed to the rectangular off-center cross-sectional shape, the variable file, taper and M wire technology or a combination of these factors. In this study, Pro Taper Next showed the lowest canal transportation when compared with other file systems which is in agreement with several studies [15,16]

Protaper Next is a fifth generation rotary file system manufactured with the M-wire Ni-the material where each file has variable taper along the length, and an off-centered rectangular cross section with center of mass and the axis of rotation differing from each other. [15] The M-Wire alloy used in ProTaper Next files, has also been proposed to improve file flexibility while retaining the cutting efficiency in addition to resistance to cyclic fatigue.[17] This is in agreement with a recent study by Saber, where Protaper Next files demonstrated enhanced resistance to cyclic fatigue compared with Protaper Universal and HyFlex CM.[18] The low incidence of canal transportation by the ProTaper Next files could also be due to the conservative removal of dentin compared with other instruments. This may be because of the asymmetric offset design of this instrument, which further minimizes the engagement between the file and

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dentin, improve the strength and enhance the torsional resistance. [19]

In this study canal transportation using Twisted file was greater than Protaper Next, this could be attributed to the increased taper, thicker core and centric core design with a higher cutting efficiency when compared to Protaper Next as described in a study done by Gergi R.[20] The Twisted file is manufactured by unique process of twisting of the alloy in R-phase which imparts high flexibility and cyclic fatigue resistance, which could be the reason for its lower canal transportation in comparison with Neo Ni-Ti.

Neo Ni-Ti files showed the highest canal transportation amongst the three file systems which could be attributed to its high cutting efficiency, which is an important factor for straightening of curved canals. This result cannot be compared as Neo Ni-Ti is a relatively new file system introduced recently with no other studies published in the literature as yet. Neo Ni-Ti is a single file system developed with M-wire technology and manufactured with a new electrical discharge machining (EDM) technology which makes the instrument resistant to cyclic fatigue. There is no evidence in the literature of this file system being tested for its clinical efficiency; thus further studies are required to test clinical performance.

During routine biomechanical preparation, transportation of the root canal is practically unavoidable; however, minimizing the incidence of procedural errors being the ultimate goal, the use of in-vitro and in-vivo analysis help in comparative evaluation and selection of the appropriate file system for clinical use. Wu et.al. [19] found that apical leakage occurs more frequently when apical transportation is >0.3mm. In the present study, none of the file systems evaluated resulted in transportation exceeding this critical limit at any point; thus, all the three file systems can be effectively used for clinical application with appropriate precautions, however, further studies are needed to evaluate the performance of these newer generation files. Other variables like selection of instrumental technique and force exerted by an individual operator may influence the result outcome.
Canal transportation in root canals has been compared and evaluated by various methods which include conventional radiography, microscopy, Silicone impression technique and Computerized Tomography[21]. In Radiographic method, the images obtained are two dimensional images of three dimensional objects leading to certain discrepancies; while, microscopic investigation requires canal sectioning which is unsuitable to provide an accurate comparative analysis between pre-and post-instrumentation features of the same root canal.

Recently, CBCT has gained popularity as an effective diagnostic tool in Endodontics over conventional radiographs for its major advantage in imaging the 3-dimensional details of the tooth anatomy. [22] Although, its routine use in clinical dentistry is restricted due to its drawback of high radiation exposure; its superior precision renders it to be a valuable tool for in-vitro evaluation of canal transportation without the inherent limitation of high radiation issues. [23]

Conclusion

Amongst the three file systems compared in terms of canal transportation Pro Taper Next group showed the most promising result within limitation of this study. Following were the conclusions drawn from the results of the present study:

- For Intergroup comparison at 3mm, 7mm & 11mm Pro Taper Next had minimum transportation followed by Twisted file.
- Neo Ni-Ti showed highest transportation at all the levels.
- None of the groups showed transportation more than the critical level.
- CBCT is a non-invasive, accurate and efficient method to evaluate pre and post-instrumentation of root canals.

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International Journal of
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Tables

Table I: Comparison of mean measurement of canal transportation at 3mm between three groups

	N	Mean	Std. Deviation	Minimum	Maximum
Protaper Next	30	0.09	0.08	.00	0.20
Neo- NiTi	30	0.16	0.12	.00	0.40
Twisted File	30	0.14	0.09	.00	0.30

Table II: Comparison of mean measurement of canal transportation between three groups at 7mm

Dependent variable : 7mm

	N	Mean	Std. Deviation	Minimum	Maximum
Protaper Next	30	0.13	0.12	0	0.40
Neo- NiTi	30	0.26	0.15	0	0.50
Twisted File	30	0.15	0.09	0	0.30

F=10.088 P=0.001

Table III: Comparison of mean measurement of canal transportation between three groups at 11mm

	N	Mean	Std. Deviation	Minimum	Maximum
Protaper Next	30	0.14	0.10	.00	.30
Neo- NiTi	30	0.22	0.09	.00	.40
Twisted File	30	0.17	0.11	.00	.40

F=4.062 P=0.021

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Figures

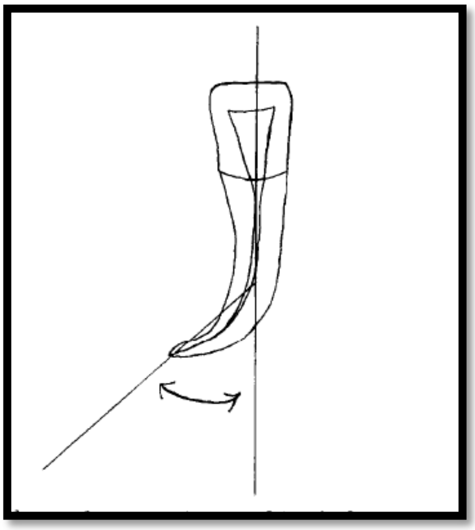

Fig. 1) Schneider's method for measurement of root curv

A- line drawn parallel to the long axis of the canal B- line drawn from apical foramen to intersect with the point where the canal begins to leave the long axis of the tooth

Fig. 2) Teeth mounted in modelling wax to simulate jaw

Fig. 3) Samples Mounted on CBCT Machine for Pre And Post Instrumentation Scan

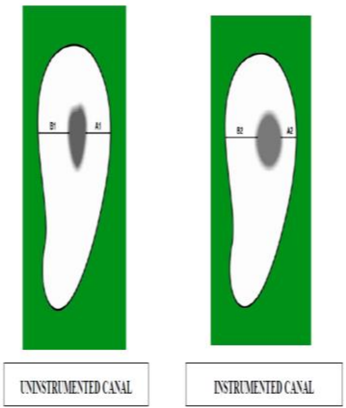

Fig. 4) Measurement of Canal Transportation

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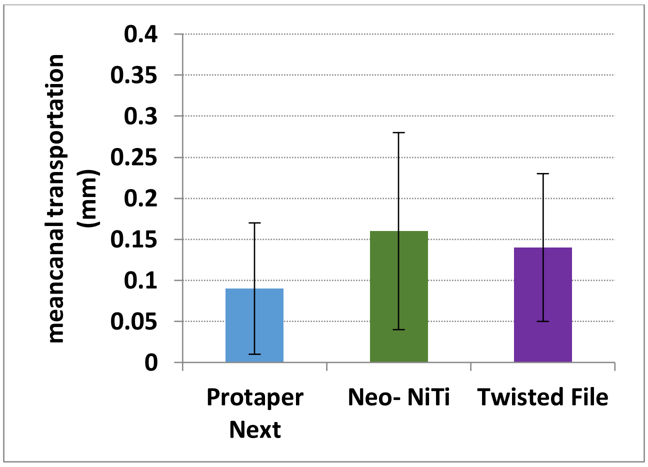
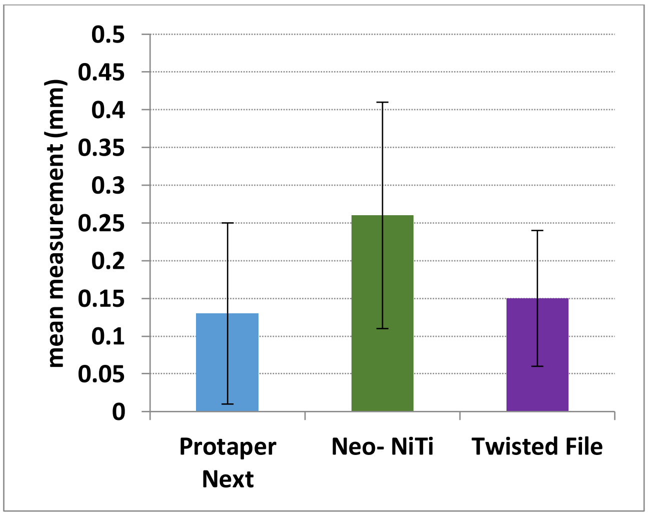
Graphs

Graph-I showing mean ± sd values of Canal transportation between 3 groups at 3 mm.



Graph-II showing mean ± sd values of Canal transportation between 3 groups at 7 mm.



Graph-III showing mean ± sd values of Canal transportation between 3 groups at 11 mm.