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Comparative Evaluation of Apical Transportation of Three Rotary Nickel Titanium Instruments in Curved Canals- An Invitro Study

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Abstract:

Introduction: Aim of the study was to compare the apical transportation of three rotary NiTi files in curved canals of human extracted teeth

Material & Method: With the help of computer digital image analysis system, pre-instrumentation and post instrumentation radiographs of thirty curved root canals, instrumented using Protaper Next, I- Race and Mani-Silk, each as per manufacturer's instructions, were assessed for apical transportation and the data were statistically analysed using ANOVA & Post Hoc Tukey's Test.

Results: The mean apical transportation was greater in ProTaper Next followed by Mani Silk and least for I-Race, although they were not statistically significant.

Conclusion: Within the limitations of study, it can be concluded that all the files maintained canal shape equivalently.

Keywords: Apical transportation, Protaper-Next, I-Race, Mani-Silk

I. INTRODUCTION

For successful endodontic treatment, it is essential to maintain the original configuration of the root canal system without introducing any iatrogenic errors. However, in curved canals these principles are more difficult to adhere to because instrumentation techniques can divert the canal away from the original axis, and there is a greater likelihood to develop procedural errors during instrumentation.[1]

Even though the NiTi rotary files carry a disadvantage to separate in the root canal, they are being widely used to clean and shape the root canals. So, the main parameters which

should be used to evaluate a technique or an instrument that has been developed for root canal preparation should be "shaping root canal whilst protecting the curvature of the canal" and "adequately cleaning the root canal walls". In this context, over the two decades, new instruments are idealised, several techniques are modified and others are developed.[1] There have been changes in many of the instrument aspects, like cross-section design, tip, taper, cutting blades, alloys and instrument movement[2], to shape and clean the root canals but it is quite difficult to determine the best one.[1]

The ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland) is the successor of the ProTaper Universal system (Dentsply Maillefer). It has an innovative off-centred rectangular cross section that gives the file a snake-like swaggering movement as it advances into the root canal. These instruments are manufactured from M-wire alloy that is claimed to improve file flexibility whilst retaining cutting efficiency.[3]

i-RaCe (FKG, La Chaux-de-Fonds, Switzerland) NiTi rotary files have been recently introduced as a simplified sequence of the RaCe system (FKG). These instruments have the same design features and have undergone the same surface treatment as RaCe instruments, and it is claimed by the manufacturer that this new sequence provides a quick, safe and effective protocol for preparation of curved root canals.[3]

Silk's (Mani Inc, Japan) unique crosssectional tear drop design cuts exceptionally well and resists fracture, which eliminates the "screwing-in" effect common with many other systems while removing debris efficiently and reducing instrument stress.[4]

Due to the availability of numerous rotary systems it is imperative to analyse the performance of these systems that are released in the market to prove the accuracy with regard to morphologic alterations that may occur in the root canal submitted to endodontic treatment.[1]

Hence the aim of the study was to evaluate apical transportation of ProTaper Next, i-Race and Mani-Silk NiTi rotary files in curved canals.

II. MATERIALS & METHOD

90 extracted human permanent mandibular molars were selected for the study. Their surfaces were cleaned with the help of ultrasonic dental scaler and were stored in 10% formalin until use.

Inclusion Criteria:

Extracted human permanent mandibular molars with curved mesial roots

Exclusion Criteria:

Extracted human permanent mandibular molars with straight roots

Apparent Perforation or resorptive defects

Previously root canal treated mandibular molars
Mandibular Molars with calcified canals
Mandibular molars with crack or fracture

Pre-operative radiographs of all the samples were taken with the help of radiovisiography (RVG). They were homogenized and analysed statistically using ANOVA, with respect to canal curvatures ranging from 20-40 degrees for the study (Table 1 and 2).

The angle of curvature was calculated by Schneider's method which defined the angle of curvature by drawing a line parallel to the long axis of the canal and the outer line from the apical foramen to intersect with first line at a point wherein the root canal began to leave the long axis of the canal.

Customized jig was fabricated so as to get reproducible position for the sensor and x-ray tube head each time the radiographs were taken, since the superimposition of pre and post instrumentation radiographs were to be carried out.

The acrylic mounted teeth were divided randomly in three groups of 30 teeth each for canal preparation. An access cavity was prepared using a number 4 diamond round bur, diamond endoaccess bur, carbide endo-Z bur in sequence and airotor handpiece (Dentair) with water spray. Any residual caries or old restoration was removed from the teeth crowns. Straight line access was established and verified with no. 10 stainless steel k-file. The canal preparation was done with no.10 stainless steel k-file followed by no 15 stainless steel k-file. The working length was measured for the mesiobuccal canal using a no. 15 stainless steel k-file with the help of a digital radiograph (RVG), using the customised jig.

Now the Pre-instrumentation radiograph was taken for all the groups with a no. 15 stainless steel k-file in the access prepared canal.

The mesiobuccal canals of mandibular molars were then prepared with Canal Pro CL2 endomotor using three different rotary Nickel Titanium files as follows:

Group 1: **Canal preparation was done with ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland) Rotary File,** according to manufacturer's instructions, at the speed of 300 rpm and 2 Ncm torque. Protaper Sx file was used for orifice enlargement followed by protaper next X1 (17/04) file, in one or more passes untill the working length was reached. Then Protaper Next X2 (25/06) was used untill the working length was passively reached.

Group 2: **Canal preparation was done with i RaCe (FKG, La Chaux-de-Fonds, Switzerland) Rotary File,** according to manufacturer's instructions at the speed of 600 rpm and 1.5Ncm torque. R1 (15/06) file was used upto the working length followed by R2 (25/04) also used upto the working length.

Group 3: **Canal preparation was done with ManiSilk (Mani.Inc) Rotary File,** according to manufacturer's instructions, using complex pack, at the speed of 500 rpm and

3Ncm torque. Firstly 25/08 file was used as orifice opener. Then 20/04 file upto the working length and lastly 25/04 was used untill it reached working length.

During each instrumentation, EDTA gel was used as a lubricant and the canals were irrigated using side vented needle with 2.5% Sodium Hypochlorite solution and Normal Saline alternatively. The canals were recapitulated during instrumentation with no. 15 stainless steel k-file. After instrumentation of all the teeth, Post-instrumentation digital radiographs (RVG) were taken for each group with master apical file in the canal.

The pre and post instrumentation radiographs were superimposed in a computer digital analysis system (Coral draw/ Adobe Photoshop) and the apical transportation in apical 1 mm of the canal was measured (Figure 1).

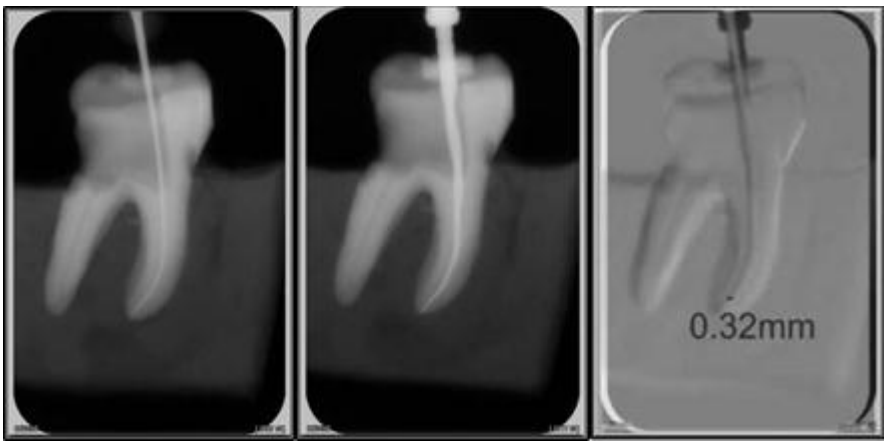

Figure 1: Super-imposition of Pre and Post Instrumentation Radiographs

The results thus obtained were submitted for statistical analysis.

III. RESULTS

1. Homogenization of samples

ANOVA (Analysis Of VAriance)

Table 1: Analysis of Variance of degree of curvature for all groups

ANOVA					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig. (p)**
Between Groups	8.622	2	4.311	0.125	0.883
Within Groups	3007.200	87	34.566		
Total	3015.822	89			

The mean canal curvature for Group 1, Group 2, Group 3 is 28.47, 27.73 and 27.93 respectively. Here, p value was set to p=0.05 to get the analysis of variance between the groups. Here, the value obtained is p=0.883 which is p>0.05 and hence the variation in canal curvature is statistically not significant.

Table 2: Post Hoc Tukey's Test of degree of curvature for all groups

POST-HOC TESTs for inter group analysis						
(I) GROUP	**(J) GROUP**	**Mean Difference (I-J)**	**Std. Error**	**Sig. (p)**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
1	2	0.733	1.518	0.890	-3.05	4.51
	3	0.533	1.518	0.940	-3.25	4.31
2	1	-0.733	1.518	0.890	-4.51	3.05
	3	-0.200	1.518	0.991	-3.98	3.58
3	1	-0.533	1.518	0.940	-4.31	3.25
	2	0.200	1.518	0.991	-3.58	3.98

The inter-group analysis was carried out to be sure about the homogenization of samples, for which Post-Hoc Tukeys test was used. The results obtained were p=0.89 and 0.940 for Group 2 and 3, p=0.890 and 0.991 for Group 1and 3 and p= 0.940 and 0.991 for Group 1 and 2.

This shows that p>0.05 for all the inter-groups as well and hence the difference in canal curvature is statistically not significant.

2. Apical Transportation

ANOVA

Table 3: Mean Value of Apical Transportation of all groups

Comparison of mean of experimental groups							
Groups	**Number of samples (N)**	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**		**Minimum**
					Lower Bound	**Upper Bound**	
1	30	0.77	0.504	0.092	0.58	0.95	0
2	30	0.50	0.630	0.115	0.26	0.74	0
3	30	0.60	0.498	0.091	0.41	0.79	0
Total	90	0.62	0.552	0.058	0.51	0.74	0

The mean apical transportation for Group 1, Group 2, Group 3 is 0.77, 0.50 and 0.60 respectively, which suggests that Group 1 showed highest apical transportation followed by Group 3 which in turn is followed by Group 2. Standard Deviation for Group 1, 2 and 3 is 0.504, 0.630 and 0.498 respectively. Here, the value was set to p=0.05 to get the analysis of variance between the groups.

Table 4: Post Hoc Tukey's test of Apical Transportation for all groups

Post-Hoc tests for inter-group analysis						
(I) Group	**(J) Group**	**Mean Difference (I-J)**	**Std. Error**	**Sig.(p)**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
1	2	0.267	0.141	0.175	-0.09	0.62
	3	0.167	0.141	0.502	-0.19	0.52
2	1	-0.267	0.141	0.175	-0.62	0.09
	3	-0.100	0.141	0.779	-0.45	0.25
3	1	-0.167	0.141	0.502	-0.52	0.19
	2	0.100	0.141	0.779	-0.25	0.45

The inter-group analysis was carried out to determine whether the mean results obtained are statistically significant or not, for which Post-Hoc Tukey's test was carried out. The results obtained were p=0.175 and 0.502 for Group 2 and 3, p=0.175 and 0.779 for Group 1and 3 and p= 0.502 and 0.779 for Group 1 and 2.

This shows that p>0.05 for all the intergroups and hence the apical transportation shown in all the groups is statistically not significant.

IV. DISCUSSION

A fundamental aim of endodontic treatment is to prevent or cure the infection due to bacteria that invade and colonize in the entire root canal system, and treatment is directed towards the elimination of micro-organisms from it and prevention of re-infection. Proper biomechanical preparation of root canal following schilder's principles is the base for successful endodontic treatment.[5]

Hand instruments have been in clinical use for almost 100 years, and they still are an integral part of cleaning and shaping procedures. To overcome the disadvantages of hand instruments like improving their speed and efficacy during biomechanical preparation of root canal treatment, rotary instruments were introduced in as early as 1885 (gates glidden bur). Wide range of new file systems has now been established in the market.[6]

Instruments made from nickel–titanium (NiTi), first described as hand instruments by Walia et al., have had a major impact on canal preparation. NiTi rotary instruments introduced later use a 360 degree rotation at low speed and thus utilize methods and mechanical principles described more than 100 years ago by Rollins. While hand instruments continue to be used, NiTi rotary instruments and advanced preparation techniques offer new perspectives for root canal preparation that have the potential to avoid some of the major drawbacks of traditional instruments and devices.[6]

The introduction of rotary nickel-titanium instruments has promoted single visit root canal therapy which was earlier a tedious procedure with conventional instruments. NiTi alloys overall are softer than stainless steel, have a low modulus of elasticity (about one fourth to one fifth that of stainless steel) but has a greater strength, are tougher, more resilient, show shape memory and superelasticity.[5]

Shaping is considered a crucial phase in root canal treatment because it is not only aimed at removing remaining pulp tissue, microorganisms, and debris but should also create the preconditions for effective irrigation and obturation. These tasks should be accomplished without altering the diameter and position of the apical foramen or excessively weakening the root in any part. Root canal transportation and the consequent procedural errors (zipping, ledging, stripping) should be avoided, to prevent a defective debridement and negative

influence on the subsequent steps of the treatment. The degree of transportation essentially depends on the severity of root canal curvature and on the flexibility and geometry of the instruments.[7]

However, clinically, a perfect straight-line access may not always be possible, a rotary NiTi instrument may well engage in a lateral cutting action while working in a curved canal. This is frequently observed during the instrumentation of molars with difficult or limited access.[1] The chances of iatrogenic errors are more in curved canals. Also for severely curved canals, hand instrumentation is recommended. So selection of canal curvature from 20-40 degrees is done according to Schneider's classification of root canal curvature[8]

Apical deviation can be evaluated by several methods and the most commonly used are radiographic methods, analysis of the histological section, scanning electron microscopy, computed tomography etc. For this study, the radiographic platform was chosen.[9] Digital radiographs were used because with a digital system, information from radiographic images is collected and can be processed in a computer digital analysis system more easily and in a more objective way. Also the radiation dose is reduced to about 80% than the conventional radiogrphs.[10]

Mesiobuccal root canals of extracted human maxillary molars were used in the present study because they usually present an accentuated curvature and mesiodistal flattening. These characteristics are additional shortcomings during chemomechanical instrumentation and make cleaning and shaping of these canals more difficult, mainly in the isthmus areas. The crowns were maintained to simulate, as closely as possible, the clinical endodontic practice, in which the interference of cervical dentin projections creates tensions on the files during root canal instrumentation.[1]

In this study, for apical transportation, the central axes of initial and final instruments were radiographically superimposed to measure transportation at 1 mm from working length.[9] To reduced bias, customised jig was fabricated to get same position of x ray tube head each time the pre and post instrumentation radiographs were taken.

During instrumentation 17% EDTA gel was used and copious Irrigation was carried out by 2.5% sodium hypochlorite and normal saline which prevents smear layer compaction resulting from the action of instruments in contact with the root canal walls, thus avoiding loss of working length and minimizing original root canal transportation.[1]

Different NiTi file systems have different characteristics in terms of the cross-sectional design, taper, depth of flutes, and number of spirals or flutes per unit length. The choice of system affects the ability to shape the root canal, particularly with curved canals.

In our study, the results show that the mean apical transportation was more for ProTaper Next followed by Mani Silk and least seen in i Race rotary files although it was not statistically significant.

The ProTaper Next System provides shaping advantages through the convergence of a variable tapered design on a given file (ProTaper Universal), innovative M-Wire technology, and a different offset mass of rotation. This rotary file system utilizes both an increasing and decreasing percentage tapered design on a single file. This design feature serves to minimize the contact between a file and dentin, which reduces dangerous taper lock and the screw effect while increasing efficiency.[11]

Given that an increase in the taper reduces instrument flexibility, the size of the taper is a key factor in root apical transportation.[1] This feature combined with more cross-sectional space for cutting and cutting a bigger envelop of motion due to its asymmetrical cross-section of ProTaper Next, can be the reason for more mean apical transportation seen in this study as compared to other two files, i Race and Mani Silk with symmetric motion, although not statistically significant.

The Race instruments (FKG Dentaire, La-Chaux-de-Fonds, Switzerland) have a triangular cross-sectional design with alternating cutting edges (ie, spiral and nonspiral segments are incorporated on the working surface). This design is said to have 2 functions: (1) it eliminates screwing in and blocking during continuous rotation and (2) it decreases the working torque. In addition, the surfaces of Race instruments are treated electrochemically to enhance cutting efficacy, and they have a noncutting tip[12].

This feature of presence of non-cutting tip and triangular cross-section with alternating cutting edge might give it an advantage for minimal dentin removal in apical area, over other two instruments, ProTaper Next and Mani Silk, used in this study.

Another rotary Nickel Titanium system used in the study is Silk (Mani, Japan). These are available as simple, standard and complex packs. Each one is a pack of three instruments with different size and taper. Silk's unique cross-sectional tear drop design cuts exceptionally well and resists fracture, which eliminates the "screwing-in" effect common with many other systems while removing debris efficiently and reducing instrument stress[11].

This can be the reason for lesser mean apical transportation shown by Mani Silk as compared to ProTaper Next, in this study although not statistically significant.

V. CONCLUSION

Within the limitations of the present in-vitro study, it can be concluded that all the rotary NiTi files showed some apical transportation which was not statistically significant amongst either of the three files.

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