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Evaluation of Centering Ability of Four Thermally Treated Nickel Titanium Rotary Files For Root Canal Preparation In Moderately Curved Root Canals: An Invitro Cone Beam Computed Tomography Assessment.

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ABSTRACT

Background: The ability of an endodontic rotary file to stay centered in the curved root canal system is one of the most important aspects of shaping of root canal as it influences the outcome of the subsequent phases of irrigation, disinfection, obturation and overall success of root canal treatment. Objectives: The purpose of this study was to evaluate root canal centering ability of four thermally treated rotary nickel titanium (NiTi) instrument systems (ProTaper NEXT, ProTaper Gold, Dia-X Files and Neoendo Flex Files) on extracted human teeth. **Methods**: Forty eight separate mesial root canals from extracted mature mandibular first molars identified with having apical curvature angles of 20°–35° were selected. A cone beam computed tomography (CBCT) was performed and canals were randomly divided into 4 groups of 12 teeth each. Group 1: ProTaper Gold (PTG) rotary files, Group 2: ProTaper NEXT (PTN) rotary files, Group 3: Dia-X (D-X) Rotary Files and Group 4: Neoendo Flex (NE) rotary Files. Root canal instrumentation was performed with all the four NiTi rotary files. Post instrumentation CBCT was performed. Root canal centering ratios were assessed by a standardized technique for individual groups at 9, 6 and 3mm levels of root canals. **Results**: ProTaper Gold files and Dia-X files resulted in significantly better canal centering ability than the Neoendo files and ProTaper NEXT files. ($P<0.05$). **Conclusion**: ProTaper Gold files and Dia-X files exhibited better centering ability than Neoendo files and ProTaper NEXT files at all levels of the root canal.

Keywords: Centering Ability; Nickel titanium alloys, Rotary files.

INTRODUCTION

The instrumentation of the infected root canal is the primary method of canal debridement. The goal of instrumentation is to produce a continuously tapered preparation that maintains the canal anatomy without any deviation from the original canal curvature and keeping the foramen as small as possible.[1-3] Deviation from the original canal curvature can lead to excessive and inappropriate dentin removal, straightening of the canal and creation of a ledge in the dentinal wall or an elbow coronal to the apical seal.[4,5] Over the past few decades, the trend toward using rotary NiTi instruments for root canal preparation has resulted in a multitude of instrumentation systems in the marketplace. This has significantly improved root canal shaping greatly both in terms of quality and time. Rotary NiTi instruments have been reported to allow a more rapid and more centered canal preparations than stainless steel instruments.[6] Moreover, some modifications to rotary instruments like thermal treatment have been done to increase their reliability and effectiveness in controlling the instrumentation in curved canals. Thermal treatment of NiTi alloy has significantly improved its mechanical properties compared to superelastic (SE) NiTi wire that has been previously used to fabricate these instruments, thereby, adding to its overall flexibility and still demonstrating a greater resistance to cyclic fatigue.[5-9] This greater resistance to cyclic fatigue and increased flexibility may affect file centering ability of an endodontic rotary file in curved root

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canals which in turn may influence the outcome and overall success of root canal treatment. Other parameters that affect canal centering ability of NiTi rotary files are Cross-section, Taper and Tip.[10-14] ProTaper NEXT files (Dentsply Maillefer, Ballaigues, Switzerland) has been introduced with an off-centered rectangular design and progressive and regressive percentage tapers on a single file and are made from memory wire (M-wire) technology processed by a proprietary thermo-mechanical procedure for increased flexibility and a greater resistance to cyclic fatigue. The off-centered rectangular design decreases the screwing effect, taper lock, and torque on the file by minimizing the contact between the file and the dentin.[15] Recently ProTaper Gold files (Dentsply Tulsa Dental, Tulsa, OK, USA) has been introduced which according to the manufacturer has the same geometry as that of ProTaper Universal, but have been thermally treated for enhanced metallurgy which offers increased flexibility and increase in cyclic fatigue resistance. Dia-X Rotary Files (Dia-Dent, Burnaby, Canada) are thermally treated NiTi having convex triangular cross-section. According to the manufacturer it offers extreme flexibility and good centering ability in curved canals. Neoendo Flex Files (Neoendo, London, England) utilizes a proprietary thermal treatment which gives it a very unique flexibility. Neoendo Flex Files have a convex triangular cross-section. Manufacturers' claim that heat-treated NiTi instruments are expected to perform better by remaining centered in the canal during root canal instrumentation because of their increased flexibility. Recently, Cone beam computed tomography (CBCT) has been advocated for pre- and post-instrumentation evaluations of centering ability of rotary files in root canals. CBCT is a nondestructive technology and renders highly accurate, high resolution, cross-sectional and 3D images that are fully quantifiable and reliable.[16-18] To the best of our knowledge there are no comparative studies in the literature evaluating the centering ability of thermally treated teeth in natural teeth. The aim of the present study was to compare the centering ability of ProTaper NEXT, ProTaper Gold, Dia-X and Neoendo Flex rotary systems by CBCT in mesiobuccal root canals of first mandibular molars using extracted human teeth.

MATERIALS AND METHODS

Freshly extracted mandibular molars, extracted for periodontal reasons in a tertiary care hospital were used for the study. Forty eight teeth with completely formed apices having a separate mesiobuccal and a canal curvature between 20º and 35º, assessed according to Pruett et al technique, were selected.[19] Each tooth was decoronated to a standardized root length of 12 mm. The working length was established by inserting a size 10 K-file till the root canal terminus and subtracting 1 mm from this measurement. Glide path was prepared up to size 15 K-file. The selected roots were embedded in a transparent acrylic and then mounted horizontally in a customized silicon jig to facilitate their precise positioning on the chin rest of CBCT machine with occlusal plane parallel to the plate. This was done to ensure standardization. Pre-instrumentation CBCT scans of the roots were performed. The CBCT NewTom GiANO CBCT device (Quantitative Radiology SRL Co., Verona, Italy) operating at 90 kV, 10 mA with an FOV 5 cm × 5 cm, voxel size of 90 μm, and exposure time of 18.6 s was used, along with NewTom GiANO scanner software (NewTom, Verona, Italy). The mesiobuccal root canals were then divided randomly into four equal groups (n = 12) as Group–ProTaper Gold system, Group 2– ProTaper NEXT system, Group 3–Dia-X system and Group 4–Neoendo Flex system. Root canal instrumentation was done by a single experienced operator using a standardized endodontic technique following manufacturer's instructions for each group of rotary files.

Group1: In this group, canals were prepared using ProTaper Gold files at 300 rpm and 5 N cm following a sequence of S1>S2>F1>F2 (25/08V).

Group 2: In this group, canals were prepared using ProTaper Next at 300 rpm and 5 N cm following a sequence of ProTaper Next X1> X2(25/06).

Group 3: In this group, canals were prepared using Dia-X files at 350 rpm and 3 N cm following a sequence of D1>D2>D3>D4(25/07V).

Group 4: In this group, canals were prepared using Neoendo Flex Rotary Files at 350 rpm and 1.5 N cm up to file size 25/06.

The final apical size kept was 25 in all the groups. An electric endomotor (X-Smart plus; Dentsply Maillefer) with a 16:1 reduction handpiece was used. Copious irrigation with 3ml of 5% sodium hypochlorite (NaOCl) solution using 30 gauge side-vented close ended needles after use of each file. Finally, the canals were irrigated with 1 ml of a 17% ethylene diamine tetra acetic acid (EDTA) for 1 minute, followed by a final flush 3 ml of 0.9% saline. After instrumentation, all the root canals were scanned using CBCT using the same protocol and setting and in the same manner as initial pre-instrumentation scans.

Evaluation of Canal centering ratio

Canal centering ratio has been defined as the measurement of the ability of the instruments to stay centered in the canal.[4] Canal centering ratio was calculated at the 3mm(apical), 6mm(middle), and 9mm(coronal) axial cross-sections obtained from each CBCT scans from the apical end of the mesio buccal root by calculating the ratio of (a1-a2)

÷ (b1-b2) or (b1- b2) ÷ (a1-a2) according to the method developed by Gambil et al.[4] in this formula, a1 and b1 represent the mesiodistal thickness of the internal and external sides of the canal wall, respectively, before instrumentation and a2 and b2 after instrumentation. [Figures 1 and 2a&b] The bigger dimension was taken as the denominator. A ratio close to or equal of one indicated an a high centering ability and a result closer to or equal to zero indicated poor centering ability at a given root section.

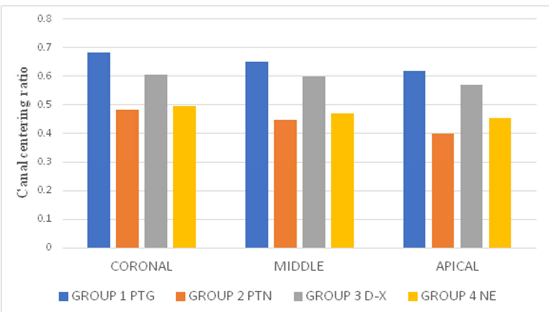
Statistical Methods

Statistical software SPSS (version 20.0) and Microsoft Excel were used to carry out the statistical analysis of data. Descriptive statistics of data including mean, standard deviation were reported. The normality test of Kolmogorov-Smirnov (K-S) and Levene's variance homogeneity test were applied to the data. Analysis of variance (ANOVA) and the post hoc Tukey-HSD test were used for analysis of data. Graphically the data was presented by bar diagrams. A P-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1: Descriptive statistics of canal centering ability among various groups.

		Mean	SD	P-value
Coronal	Group 1(PTG)	0.682	0.161	<0.001*
	Group 2(PTN)	0.483	0.086	
	Group 3(D-X)	0.605	0.104	
	Group 4(NE)	0.496	0.105	
Middle	Group 1(PTG	0.652	0.107	<0.001*
	Group 2(PTN)	0.449	0.087	
	Group 3(D-X)	0.600	0.122	
	Group 4(NE)	0.471	0.056	
Apical	Group 1(PTG)	0.619	0.069	<0.001*
	Group 2(PTN)	0.400	0.089	
	Group 3(D-X)	0.572	0.172	
	Group 4(NE)	0.456	0.06	



Graph 1: Showing canal centering ability among various groups.

In all the groups a statistically significant intergroup difference was observed at 3, 6 and 9mm levels (P <0.05). At all levels, ProTaper Gold files (0.636±0.084) showed better canal centering ability than Dia-X files (0.572±0.071), Neoendo files (0.446±0.066) and ProTaper NEXT files. (0.449±0.087m). The difference was statistically significant. At 3, 6, and 9 mm levels, there were no significant differences at different levels within the groups. The order of centering ability in different groups was as follows: ProTaper Gold files>Dia-X files>Neoendo files> ProTaper NEXT files.

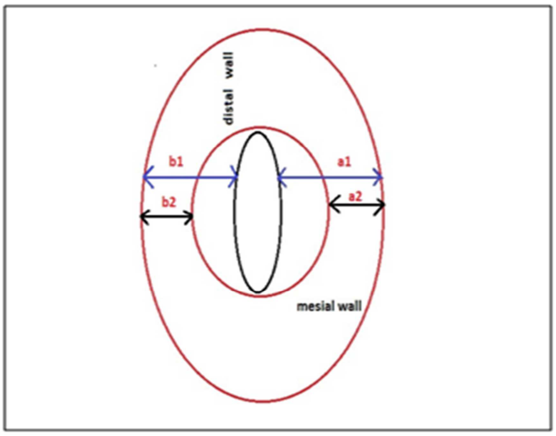


Figure 1: A schematic figure, showing the cross-section of non- instrumented canal (black small ovoid) and prepared canal (red circle). In this diagram, b1 and a1 are wall widths before instrumentation, while b2 and a2 are wall widths after instrumentation.

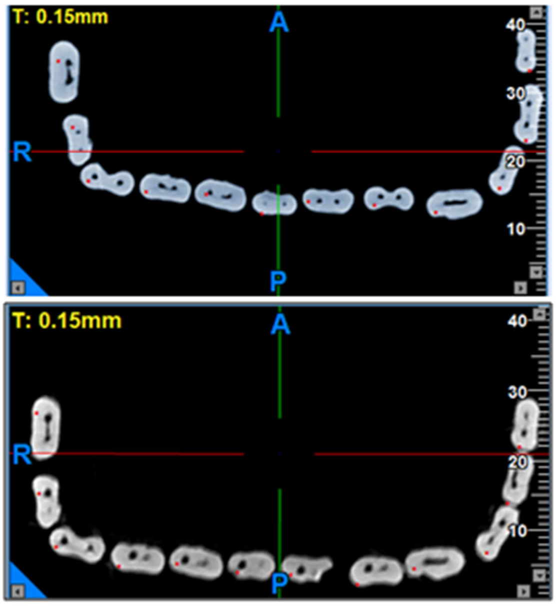


Figure 2: Measurement of root canal centering ability before (2a), and after instrumentation (2b). Red dot represents instrumented mesiobuccal canal.

DISCUSSION

Root canal shaping is one of the important steps in endodontics to develop a continuously tapered form maintaining the original canal shape as well as the position of apical foramen.[15] The presence of canal curvatures may pose a difficulty in order to achieve this goal. The introduction of NiTi instruments allowed a safer and easier preparation of such canals. Many studies have shown better efficacy of rotary instruments in comparison with hand instruments.[20-23] This study evaluated the centering ability of four different NiTi file systems in mandibular molars using CBCT. Several methods have been used to compare the root canal shape before and after instrumentation like radiography, serial sectioning, micro-CT and CBCT.[24-28] CBCT was used in the present study as it is a noninvasive and uncomplicated method unlike other techniques for the analysis of canal geometry and efficiency of shaping techniques. Human teeth were chosen in this study as they simulate clinical conditions better than acrylic blocks. Therefore its results could be better generalizable to the clinical practice. Acrylic resin is not an optimum material to reproduce the micro hardness of testing rotary instruments because it does not emulate dentin or the anatomic variations (enlargements, oval root canals, etc.).[29] Despite the variations in the morphology of natural teeth, attempts were made in the present study to ensure standardization of the experimental groups. Therefore, the teeth in all groups were balanced with respect to the canal curvature, apical diameter (confirmed by initial CBCT scan), length (distance between apex and CEJ) of the root canal and the master apical file. The master apical file size in all systems was kept #25 because this size is considered to be safe for use in curved canals.[30,31] It has also been reported that F2 rotary ProTaper Universal files have better centering ability and lesser apical canal transportation than F3 in moderately curved canals.[32-34] ProTaper Gold files have the same file sequence as that of ProTaper Universal. So in group 1, we prepared the canals till F2 ProTaper Gold in order to produce better centered preparations. The mesiobuccal roots of mandibular first molars were chosen in this study as significant canal curvatures are present in these canals which allows for a realistic evaluation of centering ability of a particular file system. In addition, the mesiobuccal root canals are relatively narrower in width which significantly increases the challenge of preparing these canals using rotary files. Cone beam computed tomography (CBCT) was used to evaluate centering ability in this study as it is nondestructive and can render high resolution cross-sectional with 3D imaging that are highly accurate, fully quantifiable and provides repeatable results.[23,29,35] Although the gold standard for examination of the centering ability of endodontic shaping files is micro-CT, however, micro-CT has the major disadvantage of not being suitable for clinical use.[35,36] It can only be used in laboratory-based studies, whereas CBCT is appropriate for patient care.[22] The results of the present study revealed that the canal centering ability of ProTaper Gold files is better than Dia-X files followed by the Neoendo files and ProTaper Next file. The differences may be explained by the different design features of the instruments used. ProTaper Gold file has a non-landed convex triangular cross-section and modified guiding tip with an angle of approximately 39°.[37] The instruments also have a continuously changing helical angle and pitch over their entire cutting surface that prevents the instrument from screwing in to the canal. They are manufactured from a proprietary heat treated NiTi alloy. PTG files are significantly more flexible and resistant to fatigue than PTU files.[38,39] The ProTaper NEXT instruments are non-landed and have a noncutting tip similar to ProTaper Gold, but the unique characteristics include being manufactured from M-wire alloy and design features include variable progressive tapers and an off-centered rectangular cross-section.[40-42] Dia-X Rotary Files have convex triangular cross-section, have a noncutting tip and are heat treated. Neoendo Flex Files have a convex triangular cross-section and utilizes a proprietary gold thermal treatment. As PTN and PTG systems feature an identical geometric architecture and operation mode, this results obtained may be solely explained by their different manufacturing processes (metallic alloy), which clearly affect their stress-strain distribution patterns and bending behaviors, making PTG files more flexible and decreasing their tendency to straighten in curved canals.[43] Despite our attempts to standardize the groups using the exclusion/inclusion criteria, extracted teeth cannot be completely standardized in terms of canal shape, canal size and hardness.[44] Since a better centering ability of NiTi files compared to that of stainless steel hand instruments is already established,[6] we focused on NiTi engine-driven instruments only. Further studies are required to provide more information about the preparation technique, instrument characteristics, and methodologies used to evaluate the action of the rotary endodontic files inside the root canals, aiming at solving the problems inherent to such an important and difficult phase of endodontic therapy.

CONCLUSION

Within the limitations of the study, it can be concluded that ProTaper Gold files and Dia-X files were better centered and respected the original canal curvature better than Neoendo files and ProTaper NEXT files.

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