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A COMPARATIVE EVALUATION OF THREE ROOT CANAL INSTRUMENTATION SYSTEMS IN PREPARATION OF CURVED CANALS USING CBCT- AN IN VITRO STUDY"

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ABSTRACT : Introduction: The aim of this study is to evaluate and compare three different Ni Ti rotary file systems in shaping & cleaning of curved canals by using CBCT.
Method: A total of 60 messiobuccal root canals of maxillary first molars were prepared by Hyflex CM, K3XF and Protaper Next. Cone beam computed tomography (CBCT) was used to scan the specimen before and after instrumentation. The transportation and centering ability for coronal, middle and apical third of the canals was measured.
Results: Group 3 (Pro Taper Next) showed to be the most centered file as compared to **Group 1** (Hy Flex CM) and Group 2 (K3XF) at all the three levels, however, there was no significant difference at 3mm and 6mm from the apex. There was a significant difference in centering ability of Group 3 (Pro Taper Next) as compared to Group 1 (Hyflex CM) and **Group 2** (K3XF) file systems at 9mm. There was no significant difference in the canal transportation amongst the three groups.
Conclusion: In vitro, Hyflex CM, K3XF and Protaper Next shaped curved root canals in maxillary first molars without significant shaping errors.

Key Words :
Hyflex CM, K3XF, Protaper Next, instrumentation, CBCT, nickel titanium instruments.

Source of support : Nill
Conflict of interest : None

INTRODUCTION : Successful root canal treatment is dependent on multiple factors. These include adequate shaping, cleaning and ultimately filling of the root canal system.1, 2The most essential procedure of the root canal treatment is root canal instrumentation since it determines the efficacy of all subsequent procedures.[2]

The cleaning and shaping procedures result in removal of dentine from the root canal walls, regardless of the instrumentation technique advocated. However, excessive dentine removal in a single direction within the canal rather than in all directions equidistantly from the main tooth axis causes what is known as 'canal transportation'.[3]

It is evident that the root canals are mostly curved, however endodontic instruments are manufactured from straight metal blank whichis responsible for uneven distribution of forces within the root canal and thus the instrument tends to straighten itself within the root canal system.[2]

With this regard, in 1988, Walia proposed Nitinol. It isa NiTi alloy for shaping canals and is said to be 2-3 times more flexible; in the same file sizes as compared to the stainless steel.[4]

The uniquecharacteristics of superelasticity and shape memory makes Ni Ti, a special alloy. The property of superelasticity of nickel-titanium instruments is responsible for making them more flexible and better able to conform to canal curvature, resist fracture, and wear less than stainless steel.As a result, itis possible to carry out extremely conservative shapes which are better centered with less canal transportation and thus original canal anatomy is well maintained.[5]

In recent years, with the use of proprietary ther momechanical processes, novel kinds of Ni Ti endodontic files have been fabricated. These have shown improved flexibility and cyclic fatigue resistance to the traditional superelastic Ni Ti files.

Recently, introduced innovative systems are files made from M-Wire technology, R-phase technology and the Controlled Memory technology.[6]

M-wire technology was introduced in 2007 and is produced by applying a series of heat treatments to NiTi wire blanks.5Itis said to be based upon the proprietary NiTi composition combined with reduced core mass design. Recently, introduced Pro Taper Next rotary files(Dentsply Tulsa Dental Specialities) are based on the M-wire technology.

K3XF rotary files with R-phase technology instruments are developed by transforming the raw NiTi wire in the austenite to R-phase through a thermal process. The manufacturer claims that these files maintain the original canal curvature with minimum canal transportation in severely curved root canals.[7]

Hy Flex Controlled memory files are made from NiTi wire subjected to thermomechanical process. The manufacturer claims the files do not rebound to original shape like conventional NiTi files, which, combined with greater flexibility, results in less risk of canal transportation.8

The maxillary first molar tooth is the largest in volume and it has the most complex root canal anatomy. Moreover, on average, curved MB canals often have greater canal transportation than any other canals.[1]

Several methodologies have been suggested for assessing the action of endodontic instruments on the root canal anatomy. The currently used methods include radiographic imaging, cross-sectioning, longitudinal cleavage of the teeth and computed tomography(CT).[3]

More recently, the use of cone beam computed tomography (CBCT) has been suggested for this purpose. It is a non-invasive imaging technology that provides accurate three-dimensional images of the teeth and the surrounding dentoalveolar structures.[9]

There has been no published studies till date on the use of CBCT to assess and compare the canal transportation and centering ability of HyFlex files with that of K3XF files, and Pro Taper Next files in curved extracted mesiobuccal root canals of maxillary molars.

Consequently, the aim of this study is to investigate several parameters of root canal preparation with three different rotary Ni Tisystems : HyFlex CM files (Coltene/Whaledent, Inc, Cuyahoga Falls, OH), Pro Taper Next files(DentsplyMaillefer, Ballaigues, Switzerland), K3XF files(SybronEndo) using Cone Beam Computed Tomography(CBCT).

MATERIALS AND METHOD : Sample Preparation : A total of sixty freshlyextracted human maxillary first molars of similar root lengths were collected.The samples were stored in 0.1% thymol. For the present study, strict anatomical protocol was followed in which teeth with mesiobuccal roots free of caries, restoration and structuraly intact with completely formed apices and angle of curvature ranging between 20 to 30 degrees (according to criteria described by Schneider), roots with fully formed apices and with similar root lengths were selected whereas teeth with calcified roots, roots with MB 2 canal, roots with open apices, partially obliterated root canals and grossly decayed teeth were excluded.

PREPARATION OF TEETH FOR STUDY : All specimen were decoronated followed by sectioning of radicular portion in order to separate out the mesiobuccal root using a diamond disc to attain the standard length of 11 mm each. Access cavity was prepared with a #2 Endo-access round carbide bur and an Endo-Z bur (Dentsply Maillefer, Ballaigues, Switzerland) using Air-turbine handpiece (NSK, Kanuma, Japan). Root canal orifice was located with the DG-16 endodontic explorer. The patency of the root canal was maintained with size 10 K-file (Dentsply Maillefer). A size 15 K-file (Dentsply Maillefer) was placed into the canal until it is visible at the apical foramen, and the working length (WL) was established 0.5 mm short of this length. The apices of the roots to be evaluated were then sealed with wax.

PRE-OPERATIVE EVALUATION: Specimen were randomly assigned into three different instrumentation groups of 20 roots each and were consequently mounted on an acrylic block. Three sections from each root were scanned by CBCT before instrumentation at 3mm, 6mm and 9mm from the apex to evaluate the apical third, middle third and coronal third, respectively of each rootusing CS 9300 CBCT machine. Ten specimen were scanned simultaneously at 5*5 FOV, 90 Voxel Size, 80 kV, 3.2 mA, for 18.40 seconds with the radiation dosage of 27.5 mGycm2.

INSTRUMENTATION: After initial scans, specimen were instrumented by using hand files till ISO size 20 followed by rotary instrumentation.Group1 canals were prepared using a set of Hyflex CM Endorotaryfiles (Coltene/Whaledent, Inc, Cuyahoga Falls. OH). The specimens were prepared according to the manufacturer's recommendation upto size 25

with 0.06 taper. In this study group #25/0.12 was used to enlarge the orifice followed by #20/0.06 Hy Flex CM upto the working length followed by #25/0.06 Hy Flex CM rotary file. Group 2 canals were prepared by using K3XF files(Sybron Endo, Orange, CA) according to the manufacturer's recommendation upto size 25 with taper 0.06. In this study group #25/0.10 K3XF was used to enlarge the orifice followed by #20/0.06 K3XF and then #25/0.06 K3XFupto the working length. Group 3 canals were prepared by using Protaper Next file system(DentsplyMaillefer, Ballaigues, Switzerland) according to the manufacturer's recommendations upto X2(25/0.06). In this study group, SX orifice enlarger was used for orifice opening followed by X1(17/0.04) and then X2(25/0/0.06) Protaper Next rotary file. In all the groups, canals were irrigated with 2ml of 5.2% NaOCl after each instrument, delivered by means of a side-vented 30 gauge needle, allowing for adequate back flow.

EVALUATION: Post-instrumentation, the specimen were again scanned similar to pre-operative scanning position and specification. The slice data were stored and pre and post instrumentation scanned images were compared and analyzed using Carestream dental software. The amount of canal transportation was determined by measuring the shortest distance from the edge of uninstrumented canal to the periphery of the root (mesial and distal) and then comparing this with the same measurements obtained from the instrumented images. The following formula was used for the calculation of transportation at each level for all the three groups: (A1 – A2) - (B1 – B2),where,A1 - shortest distance from the mesial edge of the root to the mesial edge of the uninstrumented canal, B1 - shortest distance from distal edge of the root to the distal edge of the uninstrumented canal, A2 - shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal, B2 - shortest distance from distal edge of the root to the distal edge of the instrumented canal. According to this formula, a result other than 0 indicates that transportation has occurred in the canal . Centering ability was calculated for each section by using the following ratio: (A1 – A2)/(B1 – B2) Or (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. Post-instrumentation scans are shown below. (figures 1, 2 and 3).

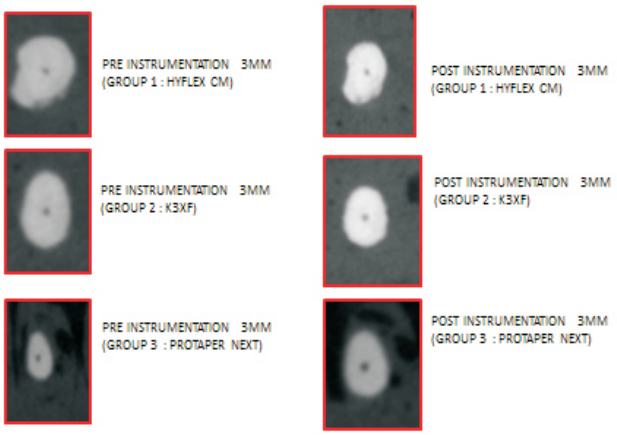

Figure 1: Pre And Post-Instrumentation Scans For Group 1 (Hyflex CM) At 3mm, 6mm And 9mm)

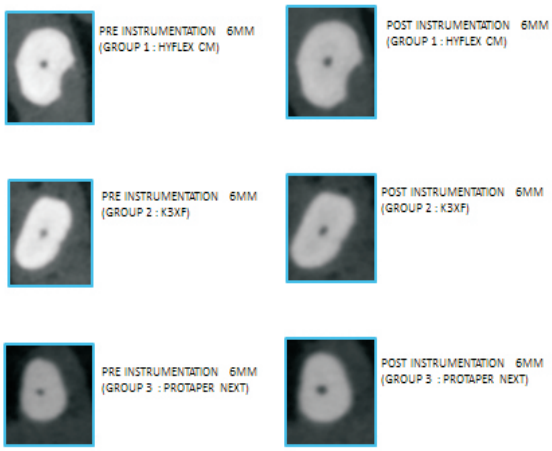

Figure 2: Pre And Post-Instrumentation Scans For Group 2 (K3XF) At 3mm, 6mm And 9mm)

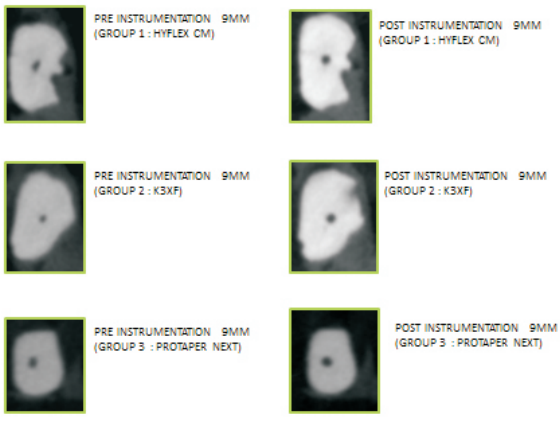

Figure 3: Pre And Post-Instrumentation Scans For Group 3 (ProTaper NEXT) At 3mm, 6mm And 9mm)

STATISTICAL ANALYSIS: The statistical analysis was done using SPSS (Statistical Package For Social Sciences) Version 15.0 statistical Analysis Software. The values were representated in Number (%) and Mean±SD. The Analysis of variance (ANOVA) test was used to compare within groups and between group variances amongst the study groups i.e. the three different rotary instrument groups. The tukey post hoc test was used for pair wise comparisons between the groups when the analysis of variance test was significant. The significance level was set as $P \leq 0.5$.No statistically significant difference was noted between the three groups at 3mm and 6mm.

RESULTS : At 9mm, centering ability was shown maximum by Group 3 (Protaper Next) and least by Group 2 (K3XF). There was a statistically significant difference at 9mmie., p=0.022. Though centering ability of Group 1 (Hyflex CM) was more than that of Group 2 (K3XF) and of Group 3 (Protaper Next) more than that of Group 1 (Hyflex CM) but there was no statistically significant difference between them. When centering ability was compared at 3mm, 6mm and 9mm, all three groups were found to be more centered at 3mm and least at 9mm.There was statistically significant difference between Centering ability at 3mm and 9mm ie., p=0.002. There was no statistically significant difference was noted in canal transportation between the three groups at 3mm, 6mm and 9mm.

DISCUSSION : Success of root canal therapy is majorly dependent amongst other factors on the removal of microorganisms through chemo-mechanical instrumentation of the root canal.10Stainless steel hand files were used for the instrumentation of the root canal, historically.[11]

A higher success rate of the root canal therapy was found after preparation with Ni Ti files than with stainless steel K-type files.[12]

The results of instrumentation with Ni Ti rotary instruments have shown an inherent problem of apical canal transportation in curved root canals, although, it is less than that with stainless steel files.[13]

Recently, new methods of manufacturing have been developed which has led to novel ther momechanical processing. As a result, the file systems developed with optimized microstructure of Ni Ti alloys are able to overcome the various problems encountered with the rotary Ni Ti file systems.[1]

The methodologies for evaluation of the action of the endodontic files on the canals of the root have advanced remarkably, which have improved the search for safe and efficient instrumentation techniques. In recent times, the use of cone beam computed tomography (CBCT) has been suggested for this purpose with good results because it has been specifically designed to reproduce undistorted 3D information of the maxillofacial skeleton. This includes the teeth being examined as well as their surrounding tissues, with an effective radiation dose which is significantly lower than the conventional computed tomography (CT).[9, 14, 15]

To our knowledge till date there has been no study reported to compare and evaluate the shaping ability of new generation Ni-Ti system ie. HyFlex CM, K3XF and ProTaper Next file systems using CBCT in terms of canal transportation and canal centering ability preparing the curved canals. This has been reviewed by extensive research through Medline.A degree of caution should be exercised in the interpretation of the data because of the nature of the experimental model.

In our study, an extracted teeth model was used as experimenting file systems under realistic conditionsin natural dentine will give results relevant to clinical use.[16]

The maxillary first molar was used for this study as it is the largest tooth in volume and the most complex tooth in root canal anatomy. Messiobuccal root canals of extracted human maxillary molars were used in particular as they usually present an accentuated curvatures and messiodistal flattening. These features make the instrumentation of such canals even more challenging.[3]

Three levels (ie, 3mm, 6mm, and 9mm from the root apex) were chosen for evaluation as they represent the apical, middle and coronal thirds of root canal out of which apical and middle thirds are highly susceptible to iatrogenic mishaps.[17]

The readings were taken and results were drawn. The results were subjected to one way analysis of variance (ANOVA) with post hoc analysis (TUKEY) in order to find the significance among the three groups.

Canal transportation of Group 3 (Pro Taper Next) was found to be least at all the three levels however there was no significant difference between the values of canal transportation amongst Group 1 (Hyflex CM), Group 2 (K3XF) and Group 3 (Pro Taper Next) NiTi file systems at all the three examined levels.

In the present study, all tested rotary systems resulted in canal transportation at all examined levels, a finding that is

consistent with other studies.[17]

In a study by Wu and Wesselink, effects of apical transportation on the seal of root fillings was noted. It was found that severe apical canal transportation in curved canals resulted in an hour-glass shaped canal apically due to the instrumentation procedure. Such canal contour allowed a limited number of accessory cones to pass leaving unfilled voids.

Also, such canal transportation results in unusual taper which leads to voids and lacuanae in the canal when obturated with cold lateral compaction. This causes more apical leakage and thus hampers the apical seal.

The apical transportation >0.3 mm resulted in more apical leakage and thus jeopardized apical healing.18In the present study, the apical transportation value at all levels in all the groups was not more than 0.3mm.

This might also be because of the noncutting tip design they all possess which works to only guide and allow easy penetration with minimal apical pressure and the standardized master apical file size.[19]

Previous studies showed that Twisted File (TF) and Hyflex CM files had less transportation than K3 file at the apical third of canals.[1]

The good centeralization capacity of all the three instruments might have contributed to thelimited canal transportation in this study.[20]

Group 3 (ProTaper Next) showed to be the most centered file as compared to Group 1 (HyFlex CM) and Group 2 (K3XF) at all the three levels, however, there was no significant difference at 3mm and 6mm from the apex. There was a significant difference in centering ability of Group 3 (ProTaper Next) as compared to Group 1 (Hyflex CM) and Group 2 (K3XF) file systems at 9mm.

This can be attributed to the off-centred rectangular cross section of ProTaper Next file system. This provides a snake-like "swaggering" movement of the file in the root canal. It is designed so that the center of mass and/or the center of rotation are offset as result of which the file remains centered and uniform while the file is spinning. Also, the M-Wire NiTi material makes the file more flexible as well as makes it more resistant to cyclic fatigue.[4]

At the apical and middle third no significant difference was recorded amongst all the groups which are considered to be most susceptible to iatrogenic mishaps in the root canals in which curvatures exist which can be attributed to the typical design features and the manufacturing techniques of all the three rotary groups used in this study.

Saber et al compared the shaping ability of ProTaper Next, iRace and Hyflex CM rotary NiTi files in severely curved root canals. It was concluded that ProTaper Next resulted in significantly greater canal straightening than IR and HF ($P < 0.05$), with no significant differences between IR and HF ($P > 0.05$). There were no significant differences between the three groups with respect to apical transportation ($P > 0.05$).[21]

This study shows results contradictory to the results of the present study. These divergent results might be explained by differences in methodologies, such as tooth type, methods of use of instruments, and instrumentation techniques.

However, Peters et al concluded that variations in canal anatomy before preparation had more influence on the postoperative canal geometry than rotary system itself.

The current results could not be compared with other reports, as, to our knowledge, no previous published data are available comparing these 3 rotary file systems.

Thus, the results of present study indicate that all tested rotary instruments produced some amount of canal transportation. The innovative method of manufacturing the ProTaper Next files system resulted in superior shaping ability in curved canals, with the instruments remaining more centered and therefore resulting in less canal transportation than the other systems. Therefore, further research extrapolates the finding of the present study to clinical use.

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