Original Article

An Evaluation of Biomechanical Preparation of Root Canals using Protaper Hand File, MtwoNiTi Rotary File and NeoNiTi Single File Systems with Cone Beam Computed Tomography - An Invitro Study

Jasmine Kaur[1], *Kanika Gupta Verma[2], Virinder Goyal[3], Suruchi Juneja[4], Puneet Kumar[4], Jasvir Kaur[1]

[1]Department of Pediatric & Preventive Dentistry, B.J.S Dental College, Hospital & Research Institute, Ludhiana (Punjab), India. [2]Department of Pediatric & Preventive dentistry, Teerthankar Mahaveer Dental College and Research Centre, Teerthankar Mahaveer University, Moradabad, UP, India. [3]Department of Pediatric & Preventive dentistry, Guru Nanak Dev Dental College & Research Institute, Sunam (Punjab), India. [4]Department of Pediatric & Preventive Dentistry, Surendera Dental College & Research Institute, H.H. Gardens, Power House Road, Sri Ganganagar (Rajasthan), India.

Abstract

Background: Root canal therapy is the most widely accepted treatment modality for pulpally involved teeth. Rotary NiTi instruments improve the root canal preparation because of the unique properties of the alloy. Cone beam computed tomography (CBCT) permits non-destructive and metrically exact analyses of variable such as volume, surface area, cross sectional shape, and taper. Thus the present study was conducted to evaluate the effect of biomechanical preparation of root canals using different file systems on cervical dentinal thickness at coronal level; canal transportation, and surface area at coronal, middle and apical levels using CBCT.

Methodology: Forty-five single rooted premolars were randomly divided into three groups (n=15), (Protaper hand file, MtwoNiTi rotary file and NeoNiTi single file). CBCT scans were taken before and after the preparation. Dentinal thickness was measured in all four directions to assess cervical dentin thickness and canal transportation. Surface area was evaluated in Adobe Photoshop both before and after preparation.

Results: The data obtained was subjected to statistical analysis. The total mean change in cervical dentin thickness and total mean canal transportation at coronal and apical was found to be maximum in Group III. The maximum increase of surface area was observed in Group I at coronal level whereas in Group III at middle and apical levels.

Conclusion: It was concluded that the change in cervical dentin thickness was maximum in Group III. The canal transportation at coronal level and apical level was found to be maximum in Group III; at middle level it was maximum in Group II. The maximum increase of surface area at coronal level was observed in Group I, at middle and apical levels it was seen in Group III.

Keywords: Cervical Dentinal Thickness; Canal Transportation; Surface Area; Cone Beam Computed Tomography.

Introduction

Root canal therapy is the most widely accepted treatment modality for pulpally involved teeth. Successful endodontic therapy depends on many factors, one of the most important is the root canal

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Corresponding Author: *Kanika Gupta Verma
Department of Paediatric & Preventive dentistry
Teerthankar Mahaveer Dental College and Research Centre, Teerthankar Mahaveer University, Moradabad, UP, India **Email:** drguptakanika@yahoo.co.in

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preparation.[1] The quality guideline of the European Society of Endodontology (2001) states that the root canal preparation is aimed to maintain original canal curvature during enlargement without creating any iatrogenic events such as instrument fracture, external transportation, ledge, or perforation.[2,3]To reduce risk of canal blockage, instrument breakage, and insufficient canal debridement with stainless steel instruments, nickel-titanium (NiTi) instruments have been introduced.[4]Rotary NiTi instruments improves the root canal preparation because of the unique properties of the alloy. These instruments are able to improve both the morphological characteristics and safety of canal shaping.[5]

Conventional hand held Protaper file is a comprehensive system specifically designed to meet the needs of clinicians. It also makes an ideal choice for treatment of difficult canal situations. A newer system, MtwoNiTi rotary file system includes four instruments with variable tip sizes ranging from #10 to #25 and tapers ranging from 0.04 to 0.06–0.07.[6] A more recent advancement, NeoNiTi is intended to prepare root canal with a single file. It is an efficient file system to shape the root canal completely to a continuously tapering funnel shape.[7]Single file rotary systems are available as rotating and reciprocating files. NeoNiTi A1 is manufactured in three different sizes (20/0.08, 25/0.08 and 40/0.08), offering many advantages such as progressive flexibility, sharp cutting edges, and built−in abrasive properties.[8]

NiTi file system have been developed to improve root canal preparation in terms of amount of dentin being removed and canal transportation during the instrumentation which are important parameter to consider in order to avoid procedural mishaps, because of the unique properties of the alloy.[9,5] The canal transportation is basically the movement of the canal while shaping and over cutting in any particular direction. The thickness of the dentinal wall at the root circumference is critical parameter, and there is a direct correlation between the root thickness and ability of the tooth to resist lateral forces and avoid fracture.[6]

To overcome the shortcomings of conventional radiographs, Cone beam computed tomography (CBCT), a 3 D technique, can be used for measurements before and after instrumentation of the root canals and for determining the amount of dentin removed during cleaning and shaping of root canals. It permits non-destructive and metrically exact analyses of variable such as volume, surface area, cross sectional shape, and taper.[2]

Thus, the aim of the present *study* was to evaluate and compare cervical dentin thickness, canal transportation and surface area after biomechanical preparation of the root canals by using Protaper hand file system, MtwoNiTi rotary filesytem and NeoNiTi single file system using CBCT.

Materials and Method

A total 45 human single rooted premolars were used in the study, which were extracted for orthodontic purpose. The study samples were cleaned with an ultrasonic scaler. Teeth with single canal and straight root canal were included in the study. The teeth with external and internal root resorption (determined through conventional radiograph), cracks, root caries, calcified and curved canals were excluded. All the study samples were stored in solution of 0.05% thymol crystals dissolved in distilled water to maintain aseptic condition till they were further needed. The study samples were decoronated at the level of cemento enamel junction as it would create discrepancy at coronal level removing the dentin during access opening with diamond bur. The samples were then coded numerically and were divided (n=15) into three experimental groups (ProtaperNiTi hand file, MtwoNiTi rotary file, NeoNiTi single file).

The samples were mounted in wax sheet and were stabilised with clear acrylic resin. Then they were subjected to CBCT at 90 kV, 3 mA, 8x5 field of view, 0.3/voxel (mm) size, for measuring the working length of the root canal, initial dentinal thickness and surface area of the canal at coronal, middle and apical level. After the initial scans, the samples were biomechanically prepared (1mm short of predetermined working length) using the respective three different file systems.

Preparation of samples

Group I: samples were prepared with Protaper NiTi hand file with instrumentation sequence of SX at two-third of the working length, followed by S1, S2, F1 and F2 at the determined working length, maintaining the 0.06 taper.

Group II: Samples were prepared with MtwoNiTi rotary instruments with SX up to half of the working length, proceeded with S1 up to two third of the working length, and S2 followed by F1 and F2 to 1mm short of the determined working length.

Group III: All the study samples were prepared with NeoNiTi file system. Firstly, NeoNiTi C1 was used to enlarge the canal orifice and then complete canal shaping with one single file NeoNiTi A1 file in continuous rotation.

During preparation of the canals, standard irrigation protocol was followed. Then, study samples were subjected to CBCT scans. The pre and post instrumentation CBCT scans were analyzed by NNT viewer software (NewTomGiANO, Italy) and dentinal thickness was measured in all four directions at cervical, middle and apical level; and the surface area was analyzed by transferring CBCT scan in Adobe photoshopCC 2014 using elliptical marquee tool.

Calculation of the parameters

Cervical dentinal thickness The dentinal thickness was calculated from medial point from inner to outer dentin in four directions, mesial, distal, buccal and lingual. The pre and post instrumentation dentinal thickness (M1, D1, B1, L1) and (M2, D2, B2, L2) respectively was evaluated (**Figure No.1**). The cervical dentin thickness was calculated by difference of pre and post instrumentation distance.

Canal transportation was calculated with formula, {(M1-M2)-(D1-D2)} and {(B1-B2)-(L1-L2)}[10]

Surface area: Initial surface area was calculated mathematically and the difference of uninstrumented (S1) and instrumented canal (S2), gives the final surface area of the canal.[1]

All the values were taken by single observer in triplicate at interval of one week to calculate the intra observer bias which indicates higher internal consistency.

Results

The results of the study were obtained and subjected to statistical analysis using SPSS version 22.0.Total mean ± SD of the Pre and post instrumentation dentinal thickness was calculated at mesial, distal, buccal and lingual direction for all study groups at cervical, middle and apical level (Table No. 1).Intra-rater reliability was determined and Cronbach's Alpha (α) values for the three groups were evaluated at coronal, middle and apical level, which showed higher internal consistency. The intergroup comparison for remaining cervical dentin thickness in mesial, distal, buccal and lingual directions was done with ANOVA statistical analysis and the values obtained were statistically insignificant for all directions. (Table no. 2)

The intergroup comparison for canal transportation was done using Kruskal Wallis test in mesiodistal and buccolingual directions at coronal, middle and apical levels. (Table no. 3). The chi square values obtained were not statistically significant. Mean change in surface area was calculated at coronal, middle and apical level for the study groups and intergroup comparison was also calculated between all three levels for each group in both the directions. (Table no. 4) The ANOVA test was applied and the values obtained were statistically significant ($p>0.05$).

Table 1: Pre and post instrumentation dentinal thickness mean ± SD values at mesial, distal, buccal and lingual direction for all study groups at cervical, middle and apical level

		M1	M2	D1	D2	B1	B2	L1	L2
Group I	cervical	1.960 ± 0.298	1.35 = 0.51	2.044 ± 0.341	1.36 ± 0.46	2.406 = 0.339	1.81 ± 0.36	2.606 = 0.759	1.94 = 0.38
	middle	1.45 + 0.311	0.79 – 0.21	1.26 + 0.321	0.70 + 0.18	2.07 – 0.295	1.62 + 0.26	2.25 – 0.275	1.68 – 0.42
	apical	0.955 + 0.301	0.53 – 0.15	0.968 + 0.177	0.58 + 0.16	1.137 – 0.352	0.64 + 0.23	1.288 – 0.827	0.64 – 0.44
Group II	cervical	2.100 ± 0.286	1.74 = 0.31	2.048 ± 0.414	1.65 ± 0.50	2.620 = 0.488	0.63 ± 0.16	2.611 ± 0.504	0.60 = 0.18
	middle	1.43 ± 0.23	0.91 = 0.28	1.36 ± 0.14	0.87 ± 0.27	2.18 = 0.42	1.75 ± 0.31	2.21 = 0.51	1.67 = 0.49
	apical	1.21 ± 1.33	0.61 = 0.18	0.86 ± 0.19	0.60 ± 0.17	1.09 = 0.36	0.84 ± 0.30	1.14 = 0.26	0.80 = 0.45
Group III	cervical	2.29 ± 0.26	1.73 = 0.19	2.31 ± 0.36	1.67 ± 0.27	2.53 = 0.30	1.88 ± 0.34	2.62 = 0.31	1.86 = 0.34
	middle	1.59 ± 0.23	0.95 = 0.27	1.57 ± 0.25	0.98 ± 0.18	2.40 = 0.35	1.63 ± 0.22	2.37 = 0.36	1.75 = 0.20
	apical	0.81 ± 0.13	0.64 = 0.16	0.79 ± 0.19	0.64 ± 0.09	1.05 = 0.34	0.71 ± 0.16	0.96 = 0.32	0.70 = 0.22

Table 2: Intergroup comparison for Change in Cervical Dentinal Thickness in mesial, distal, buccal and lingual direction

GROUPS	M1-M2	D1-D2	B1-B2	L1-L2
GROUP I	0.60±0.42	0.67±0.23	0.59±0.31	0.63±0.47
GROUP II	0.64±0.30	0.50±0.23	0.78±0.43	0.62±0.46
GROUP III	0.56±0.34	0.64±0.37	0.76±0.33	0.85±0.37
F	0.200	1.551	1.178	1.337
P	0.81	0.22	0.31	0.27

*Statistically significant, p<0.05

Table 3: Comparing canal transportation at coronal, middle and apical levels in mesiodistal and buccolingual direction for group I, II, III

		Group I	Group II	Group III	Chi-square	p
Coronal	(M1-M2)-(D1-D2)	0.25±0.22	0.36±0.24	0.36±0.18	1.159	0.32
	(B1-B2)-(L1-L2)	0.41±0.41	0.34±0.24	0.40+0.27	0.222	0.80
Middle	(M1-M2)-(D1-D2)	0.26±0.22	0.25±0.16	0.22±0.19	0.160	0.85
	(B1-B2)-(L1-L2)	0.34±0.34	0.36±0.25	0.30±0.28	0.155	0.85
Apical	(M1-M2)-(D1-D2)	0.18±0.20	0.18±0.19	0.18±0.20	0.005	0.99
	(B1-B2)-(L1-L2)	0.27±0.24	0.23±0.21	0.32±0.27	0.467	0.63

Table 4: Inter group comparisons of the mean surface area at coronal, middle and apical for all study groups

GROUPS	SA2-SA1		
	Coronal	Middle	Apical
GROUP I	18.82±1.44	7.85±1.09	5.89±1.65
GROUP II	7.39+1.58	5.96+1.58	4.27−1.23
GROUP III	13.68+2.16	8.63+2.16	7.87−2.21
F	119.097	9.776	15.532
P	0.00*	0.00*	0.00*

*Statistically significant, p<0.05

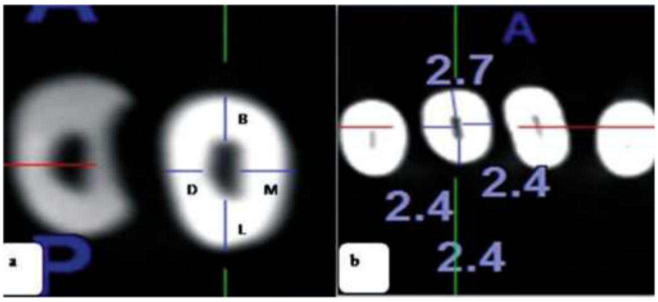

Figure 1: The pre and post instrumentation dentinal thickness (M1, D1, B1, L1) and (M2, D2, B2, L2)

Discussion

Since mid-90s, the introduction NiTi instruments has proved to be advantageous with the increasing taper from a two-fold (0.04 taper) to six-fold (0.12 taper) while retaining flexibility.[2] The ProTaper files have a changing percentage tapers over the length that improves flexibility, cutting efficiency and safety. Their convex, triangular cross-section enhances the cutting action.[11] Mtwo system includes four instruments with variable tapers ranging from 0.04 to 0.06–0.07.[6]M-two files possess progressive pitch and absence of radial lands that produces less dentinal debris.[12]Singlefile rotary systems are available as rotating and reciprocating files.

To investigate the efficiency of instruments and techniques radiographs are used. CBCT is a newer diagnostic method with 3-dimensional imaging, low−dose radiation and allows evaluation of detailed images in all three planes i.e. coronal, sagittal and axial. It is useful in comparing the anatomy of root canal system before and after biomechanical preparation, allowing detecting deviations and transportation.[13]

The total mean change in cervical dentin thickness for all the four directions was compared, it was found that group III showed the maximum change in cervical dentin thickness, followed by group II and group I. This change in dentine could be attributed to the taper of the file systems. As, NeoNiTi has the maximum taper of 12% amongst all the three systems[8], it has done the maximum cutting. A study by Nagaraja S *et al.*[14]showed similar results, where hand Ni-Ti K-file maintained greater dentine thickness than the rotary ProTaper technique at middle and coronal third. In contrast to this study, Musale P K *et al.*[15]reported that a significantly higher amount of dentin was removed in manual instrumentation compared to rotary instrumentation in both primary mandibular first and second molars. The canal transportation was also calculated in the same way i.e. in mesial, distal, buccal and lingual directions at cervical, middle and apical levels. But the results showed no significant differences during intergroup comparison. Shivashankar *et al.*[16]did a study and reported that there was no statistically significant difference between Mtwo, ProTaper (PT) and ProTaper Next (PTN) file system. In a similar study, Waly AS *et al.*[17] reported no significant differences between hand instrumentation using K-files and both rotary systems Kedo-S and Pro AF Baby Gold for canal transportation and dentin thickness at all three levels of prepared canals.

In the present study, when we compared the total mean canal transportation at all three levels, it was found that at coronal and apical level, maximum canal transportation was seen by NeoNiTi, and at middle level by Mtwo files. Vallabhaneni S *et al.*[13]stated that Wave One Gold single reciprocation file maintained original canal anatomy better than Neoniti single continuous file and produced less canal transportation. Cross section of Neoniti is a non- homothetic rectangle, the built‑in abrasive property of the flutes, hard cutting edges, all these factors may have led to aggressive cutting and caused canal transportation.[13]

The results for surface area analysis depicted that the maximum increase of surface area was observed in protaper hand file system at coronal level whereas at middle and apical levels it was seen with NeoNiTi file system. This could be attributed to the taper size of NeoNiTi file system i.e 8% of A1 file[15], which is though similar to protaper hand files but being rotary NeoNiTi did more aggressive cutting. Plotino*et al.*[18]compared Mtwo and Protaper and found that Protaper showed more change in surface area at coronal level, though the results were not statistically significant.

Limitations of the study

The variation in shape of root canals of extracted teeth affected the study parameters. Also in the present study, the radiographic analysis used was CBCT: though it gives 3-dimensional images, but the images produced were blurred.

Conclusion

The present study concluded that NeoNiTi single file system did more dentin cutting in relation to Protaper hand file and MtwoNiTi file systems, giving more shaped canals, free of debris and infected dentin.

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