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Comparative evaluation of efficiency of different file systems in terms of remaining dentin thickness using cone-beam computed tomography: An In Vitro Study

[1]Dr. Anisha Sinha, Department of Endodontics & Conservative Dentistry, Peoples College of Dental Science & Research Centre, Bhopal India

[2]Dr. Anu Narang, Department of Endodontics & Conservative Dentistry, Peoples College of Dental Science & Research Centre, Bhopal India

[3]Dr. Manish Agarwal, Department of Endodontics & Conservative Dentistry, Peoples College of Dental Science & Research Centre, Bhopal India

[4]Dr. Jyoti Saket, Department of Endodontics & Conservative Dentistry, Peoples College of Dental Science & Research Centre, Bhopal India

[5]Dr Ritwik Shyamal, Department of Endodontics & Conservative Dentistry, Saraswati Dental College and Hospital, Lucknow India

Corresponding Author: Dr. Anisha Sinha**,** Department of Endodontics & Conservative Dentistry, Peoples College of Dental Science & Research Centre, Bhopal India

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Abstract

Introduction: Root canal treatment is the combination of complete debridement of canal, its mechanical instrumentation, thorough chemical disinfection and filling it with an inert material.The success of Endodontic therapy based on the combination of all, and one of the most important among the aforesaid is biomechanical preparation,which is the key stage of Root canal therapy.

Aim: The aim of the study is to evaluate and compare the cleaning efficiency of different file systems in terms of remaining dentin thickness using Cone-Beam Computed Tomography.

Materials and Methods: 30 Extracted permanent anterior teeth were taken for the study and then divided into three groups according to the different file systems used i.e Group I – Protapers, Group II – Mtwo, and Group III – Wave One. Preinstrumentation cone-beam computed tomography (CBCT) scan was taken as baseline against which the parameter of remaining dentin thickness has been calculated after biomechanical preparation by

various file system. Postinstrumentation CBCT scan was taken and then pre- and post-instrumentation images were compared and evaluated and data were analyzed by ANOVA at P = 0.001.

Statistical Analysis Used:

ANOVA test was used in this study.

Results: Protaper file system has shown the minimum reduction in dentin thickness when compared to Mtwo and WaveOne file system.

Keywords: Cone beam computed tomography, Protaper, Mtwo ,Wave one.

Introduction

Root canal shaping is a key stage of endodontic treatment with a predictive success factor if performed properly. Root canal shaping is a key stage of endodontic treatment with a predictive success factor if performed properly[1]. It aims to achieve complete removal of the vital or necrotic tissue to create sufficient space for irrigation[1-2]. Furthermore, shaping tends to preserve the integrity and location of the canal and apical anatomy in preparation for an adequate filling. However, over shaping leads to excessive removal of residual dentin thickness which in turn weakens the root structure[3].The need to enlarge curved canals and at the same time preserve dental anatomy will always involve the challenge of selecting appropriate endodontic instruments. After the introduction of instruments manufactured from Ni-Ti alloys[4] there was a significant improvement in the quality of root canal shaping, with predictable results and less iatrogenic damage, even in severely curved root canals[5].

The residual dentin thickness following intraradicular procedures correlates to fracture resistance of the root. In case the preinstrumentation canal wall thickness is very less, it plays a vital role in selecting the file system which reduces the canal wall to a minimum level while doing biomechanical preparation to an acceptable level.

To meet this challenge, NiTi rotary technique has been developed to improve 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 shaping8.

Variable shapes and systems of engine driven NiTi files are available in the market and Mtwo (VDW, Munich, Germany 2003) is among the most commonly used systems. Some advantages of Mtwo system are the ability to preserve the working length and canal curvature and better cutting efficacy9.

The reciprocating motion of the NiTi rotary instrument has been shown to decrease the impact of cyclic fatigue compared with rotational motion10-12. Therefore, it has been recently proposed that the single-file shaping technique may simplify instrumentation protocols and avoid the risk of crosscontamination. Moreover, the use of only one NiTi instrument is more cost-effective, and the learning curve is considerably reduced12.

The new WaveOne NiTi single-file system has been recently introduced by Dentsply Maillefer (Ballaigues, Switzerland)21. The system is designed to be used with a dedicated reciprocating motion motor. It consists of 3 single-use files: small (ISO 21 tip and 6% taper) for fine canals, primary (ISO 25 tip and 8% taper) for the majority of canals and large (ISO 40 and 8% taper) for large canals. Thus, the dissertation has been undertaken to evaluate the efficiency of various file systems, Hand Protapers, Rotary Mtwo, and Reciprocating WaveOne file systems, in terms of remaining dentin thickness.

Materials And Methods

A total of thirty permanent extracted anterior teeth were taken and divided according to the file system used – Group I – Protapers, Group II – Mtwo, and Group III – WaveOne to evaluate the remaining dentin thickness after

biomechanical preparation. The group samples were mounted in wax rims.

Inclusion criteria included extracted teeth with no external or internal pathological root resorption and presence of apical closure and exclusion criteria included presence of pathological root resorption, severe root angulation, and immature tooth.

Preinstrumentation cone-beam computed tomography (CBCT) scan was taken for all the samples to serve as baseline against which we could calculate the parameter of remaining dentin thickness after biomechanical preparation by various file system.

Access cavity was prepared with round bur and patency of canal was established by K-file no. 10. The working length was calculated by subtracting 0.5 mm (millimetre) from actual root canal length. The pulp was removed with the help of barbed broach no. 15. All the samples were prepared in the same manner. Thereafter, their biomechanical preparation was done with various file systems according to the various groups divided.

Group I (Protaper) (n = 10) – In this manual file system, first, the canal was explored by no. 10 K-file followed by no. 15 K-file manually with stepback technique. The basic sequence used in Hand Protaper files is – SX (orange), S1 (purple), S2 (white), F1 (yellow), F2 (red), andF3 (blue). All root canals were prepared with the Protapers system in a crown-down technique. Biomechanical preparation was considered complete when the largest diameters file of the respective file system stopped getting engaged in the canal. The time taken for biomechanical preparation of a sample was about 5–6 min.

1. Group II (Mtwo) (n = 10) – The basic sequence of this rotary file system consisted of four files – 10 purple (Taper. 04), 15 white (.06), 20 yellow (.08), and 25 red (.08) with an endomotor (Speed 150–300 rpm) which was used in a crown-down motion. The time taken for biomechanical preparation of a sample was about 4–5 min.

Group III (WaveOne) (n = 10) – This reciprocating file system is available in three different single file system – small yellow 21 mm (ISO 21 tip and 6% taper) for small canals, primary red 21 mm (ISO 25 tip and 8% taper) for majority of canals, and large black 25 mm (ISO 40 and 8% taper) for large canals. All root canals were prepared using WaveOne large file (8% taper) with an endo motor (speed 300 rpm) using crown-down technique. The time taken for biomechanical preparation of a sample was about 2 min.

Postinstrumentation CBCT scan was taken and the dentin thickness was checked after biomechanical preparation [Figure I]. The pre- and post-instrumentation images of the teeth were compared and evaluated for remaining/residual dentin thickness after biomechanical preparation of the root canal [Figure III]. Data were analyzed by ANOVA at P = 0.001 It took around 5 days to complete the study.

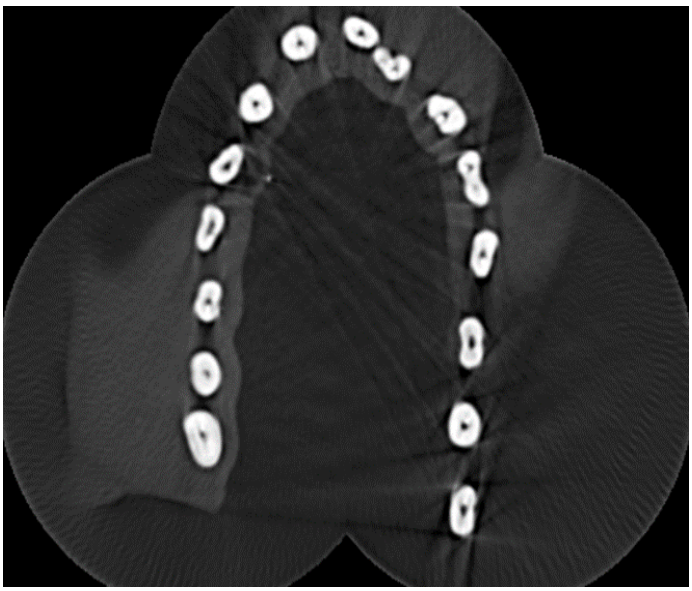


Figure 1: Pre-Instrumentation

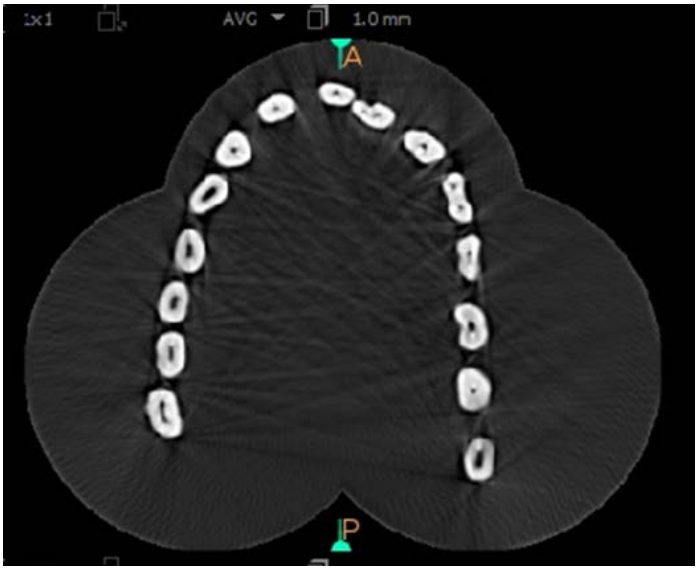


Figure 2: Post-Instrumentation

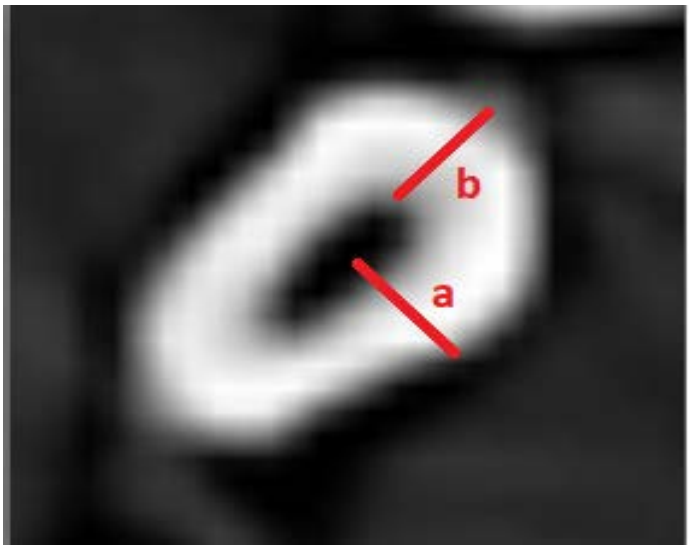


Figure 3: Determination of remaining dentin thickness of pre- and post-instrumentation cone-beam computed tomography images. a: Preinstrumentation b: Postinstrumentation.

Results

For different Groups the mean value of reduced Dentin thickness after biomechanical preparation with various file systems at 3 mm from apical foramen in Group I (Protaper) was 0.18 ± 0.10, Group II (Mtwo) was 0.23 ± 0.13, and Group III (WaveOne) was 0.24 ± 0.13. Minimum and maximum values of reduced dentin thickness in group I were 0.10 mm and 0.40 mm, in group II were 0.10 mm and 0.50 mm and; in group III were 0.10 mm and 0.50 mm. It was noted that the mean value of reduced dentin thickness was highest in Group III (WaveOne) and least in Group I (Protaper) as mentioned in the Table I. Kruskal-Wallis test showed no significant difference between the groups reduced dentin thickness after biomechanical preparation at 3 mm (χ^2 = 1.137, df= 2, P >0.05).

Groups	Reduced dentin thickness at 3 mm (mm)	
	Mean ± SD	Min-Max
Group I	0.18 ± 0.10	0.10-0.40
Group II	0.23 ± 0.13	0.10-0.50
Group III	0.24 ± 0.13	0.10-0.50
Kruskal-Wallis test	χ^2 = 1.137, df= 2, P = 0.566 (>0.05) Not significant	

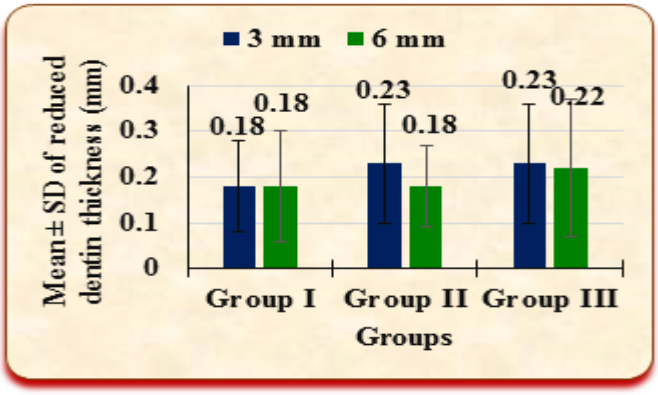
Table 1: Comparison of reduced dentin thickness after biomechanical preparation with various file systems at 3 mm.

The mean value of reduced dentin thickness after biomechanical preparation with various file systems at 6 mm from apical foramen in Group I (Protaper) was 0.18 ± 0.12, Group II (Mtwo) was 0.18 ± 0.09, and Group III (WaveOne) was 0.22 ± 0.15. Kruskal-Wallis test showed no significant difference between the groups reduced dentin thickness after biomechanical preparation at 3 mm (χ^2 = 0.653, df= 2, P >0.05).

Groups	Reduced dentin thickness at 6 mm (mm)	
	Mean ± SD	Min-Max
Group I	0.18 ± 0.12	0.10-0.40
Group II	0.18 ± 0.09	0.10-0.40
Group III	0.22 ± 0.15	0.10-0.60

Table 2: Comparison of reduced dentin thickness after biomechanical preparation with various file systems at 6 mm.

Groups	Reduced dentin thickness at 3 mm (mm)		Reduced dentin thickness at 6 mm (mm)		Wilcoxon Signed Ranks test
	Mean ± SD	Min-Max	Mean ± SD	Min-Max	
Group I	0.18 ± 0.10	0.10-0.40	0.18 ± 0.12	0.10-0.40	Z = -0.061, P = 0.952 (>0.05) Not significant
Group II	0.23 ± 0.13	0.10-0.50	0.18 ± 0.09	0.10-0.40	Z = -0.962, P = 0.336 (>0.05) Not significant
Group III	0.23 ± 0.13	0.10-0.50	0.22 ± 0.15	0.10-0.60	Z = -0.171, P = 0.864 (>0.05) Not significant



Graph 1: Intragroup comparison of reduced dentin thickness between 3mm and 6mm after Biochemical preparation with various file systems

Statistical Analysis

Data was entered in Microsoft excel 2016 for Windows. Mean, standard deviation (SD), minimum and maximum values of reduced dentin thickness after biomechanical preparation with various file systems at 3 mm and 6 mm were calculated. Shapiro-Wilk test showed that reduced dentin thickness values in different groups did not follow normal distribution. Hence non-parametric tests were applied for further data analysis.

For comparison of reduced dentin thickness after biomechanical preparation between various file systems at 3 mm and 6 mm, Kruskal-Wallis test (non-parametric equivalent of one-way ANOVA) was applied. For Intragroup comparison of reduced dentin thickness between 3 mm and 6 mm after biomechanical preparation with various file systems, Wilcoxon Signed Ranks test (paired t-test) was applied.

P value <0.05 was considered statistically significant. Data analyses were performed using version 21.0 of the Statistical Package for Social Sciences (IBM Corporation, Armonk, New York, USA).

Discussion

Endodontic therapy treats inside of the tooth and its success is based upon the triad of thorough canal debridement, effective disinfection, and obturation of the canal space[13]. Thus, one of the most important steps is biomechanical preparation, which is the key stage of endodontic treatment with a predictive success factor, if performed properly.

The thickness of the remaining dentin following intraradicular procedures may be the most important iatrogenic factor that correlates to incoming fracture resistance of the root[14].

The preparation of apical third can also reduce residual dentin resulting in weakened apical root structure which is

mainly important in a root with an oval cross-section. A recent study suggests that 3 mm dentin as a minimum thickness of canal walls should remain for canal preparation[6].

Protaper file system has shown minimum reduction in dentin thickness when compared to Mtwo and Wave One file system because it is a manual file system with convex triangular cross-section, sharp cutting edges with positive angle, no radial lands with progressive taper and advanced U-shaped flute design to increase flexibility, noncutting tip design, more positive rake angle variable taper among the length of the instrument, and pitch-helix angle balanced to prevent the instrument screwing into the canal[15].

Foschi *et al*. (2004) did a similar study on scanning electron microscopy evaluation of canal wall dentine following the use of Mtwo and Protaper NiTi file systems and found Protaper to show more value of remaining dentin thickness than Mtwo but with a nonsignificant difference.

Mtwo has shown more reduction in dentin thickness when compared to Protaper because it is a rotary file system with a speed of 150–300 rpm, one active cutting edge, and a noncutting tip. It has italic S-shaped cross-section which increases its cutting efficiency, low risk of fracture, and enhances engagement of file edges to canal walls that provide smooth surface, taper toward the apex. This system has small instrument core, positive rake angle for high flexibility, large constant helical angles, and various depth of flutes so causes less removal of root canal dentin coronally[16].

Zameer (2016) did an *in vitro* study on evaluation of radicular dentin remaining and risk of perforation after manual and rotary instrumentation in primary teeth where he found more remaining dentin thickness value for manual file system with a nonsignificant difference between manual and rotary file systems.

Mtwo has shown less reduction in dentin thickness when compared to WaveOne file system because it is a rotary file system with only one active cutting edge, fixed taper of files (0.04, 0.05) causes least changes in root canal anatomy[16].

Wave One has shown maximum reduction in remaining dentin thickness when compared to Protaper and Mtwo file systems because it is a reciprocating file system with a large rotating angle that increases its cutting efficiency. It has a modified convex triangular cross-section with a noncutting tip that provides more flexibility, high shaping ability which can result in removal of more root canal dentin[13].

All the intergroup comparisons were found to be nonsignificant in terms of reduced dentin thickness after biomechanical preparation with various file systems at 3 mm and 6 mm from apical foramen when Group I (Protaper), Group II (Mtwo), and Group III (WaveOne) were compared at $P = 0.001$. Thus, based on the above findings, WaveOne file system is recommended as alternative file systems when compared to conventionally used hand and rotary file systems because it has been recommended by Aditi Jain *et al*. and Priyanka Puri *et al*. Although it has shown maximum reduction in remaining dentin thickness after biomechanical preparation, but when compared with other file systems it has shown a nonsignificant result, further studies with larger sample size are required to authenticate the results.

Conclusion

Protaper file system has shown minimum reduction in dentin thickness when compared to Mtwo and WaveOne file system. All the intergroup comparisons were found to be nonsignificant in terms of reduced dentin thickness after biomechanical preparation with various file systems

at 3 mm and 6 mm from apical foramen when Group I (Protaper), Group II (Mtwo), and Group III (WaveOne) were compared at $P = 0.001$.

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