Original Article

Comparative Evaluation of Efficiency of Different File Systems in Terms of Remaining Dentin Thickness Using Cone-Beam Computed Tomography: An *In vitro* Study

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Abstract

Background: 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. 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. **Aim:** The aim of the study is to evaluate and compare the cleaning efficiency of different file systems in terms of remaining dentin thickness. **Materials and Methods:** A total of thirty permanent extracted anterior teeth were taken for the study and was divided into three groups – Group I – Manual Protapers, Group II – Rotary Mtwo, and Group III – Reciprocating WaveOne file systems. Pre-cone-beam computed tomography (CBCT) scan was taken followed by biomechanical preparation by the respective file groups. Post-CBCT scan was taken and the pre- and post-CBCT scans were compared for remaining dentin thickness. Data were analyzed with ANOVA (P = 0.001). **Statistical Analysis Used:** ANOVA test was used in this study. **Results:** Protaper showed minimum reduction in dentin thickness followed by Mtwo and WaveOne showed maximum reduction in dentin thickness, but the intergroup comparison was found to be highly insignificant. **Conclusion:** WaveOne is a highly recommended rotary endodontic instrument which does not cause significant lowering in remaining dentin thickness after biomechanical preparation.

Keywords: *Cone-beam computed tomography, Mtwo, Protaper, WaveOne*

Introduction

The most common treatment done in the dental practice is root canal treatment that is performed to treat endodontic disease by eradicating bacteria and to remove the infection from the root canal space. Success of the root canal treatment depends on many factors such as method and the quality of instrumentation, irrigation, disinfection, and three-dimensional obturation of the root canal.[1]

Thus, root canal shaping is one of the most important steps in canal treatment. It is essential in determining the efficacy of all subsequent procedures, including chemical disinfection and root canal obturation.[2] Furthermore, it aims to achieve complete removal of the vital or necrotic tissue to create sufficient space for irrigation. Furthermore, shaping tends to preserve the integrity and location of the canal and apical anatomy in preparation for an adequate filling. However, overshaping leads to excessive removal of residual dentin thickness which in turn weakens the root structure.[3]

The specialty of endodontics has evolved and got revolutionized over the years.[4] The modern endodontic specialty practice has little resemblance to the traditional endodontic practice. Traditional endodontic treatment technique was done by hand instrumentation. Initially, the endodontic files were made with carbon steel that was susceptible to fracture, tarnish, and corrosion, so stainless steel files were introduced. Soon the nickel–titanium (NiTi) files became popular.[5] Typically, stainless steel had 2% taper and NiTi files now have 12% taper. But biomechanical preparation with manual instruments was time-consuming and often causes fatigue to the operator and patient. The introduction of NiTi rotary instrumentation in 1980s has made endodontics easier and faster

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than manual instrumentation, resulting in consistent and predictable root canal shaping.[6]

The residual dentin thickness following intraradicular procedures correlates to fracture resistance of the root.[7] 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 shaping.[8]

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 efficacy.[9]

The reciprocating motion of the NiTi rotary instrument is introduced recently (WaveOne, 2011) to decrease the impact of cyclic fatigue compared with rotational motion. Therefore, it has been recently proposed that the single-file shaping technique may simplify instrumentation protocols and avoid the risk of cross-contamination.[2]

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. The ethical clearance reference number is DJD/IEC/2016/A-030.

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 systems [Figure 1a]. The common steps followed in all four groups were as follow:

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 (millimeter) 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.

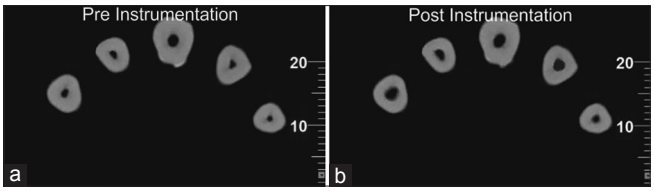

Figure 1: Group I Protaper (a) pre- and (b) post-instrumentation cone-beam computed tomography images (axial view)

i. 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
ii. 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
iii. 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 1b]. 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. Data were analyzed by ANOVA at P = 0.001 [Figure 2]. It took around 5 days to complete the study.

Results

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 0.38 ± 0.04, Group II (Mtwo) was 0.42 ± 0.06, and Group III (WaveOne) was 0.44 ± 0.02 [Table 1]. 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. All the intergroup comparisons were found to be highly nonsignificant in terms of reduced dentin thickness after biomechanical preparation with various file systems at 3 mm from apical foramen at $P = 0.001$ [Table 2].

Mean value of reduced dentin thickness after biomechanical preparation with various file systems at 6 mm from apical foramen in Group I (Protaper) was 0.44 ± 0.04, Group II (Mtwo) was 0.49 ± 0.05, and Group III (WaveOne) was 0.83 ± 0.02 [Table 1]. 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. All the intergroup comparisons were found to be highly nonsignificant in terms of reduced dentin thickness after biomechanical preparation with various file systems at 6 mm from apical foramen at $P = 0.001$ [Table 2].

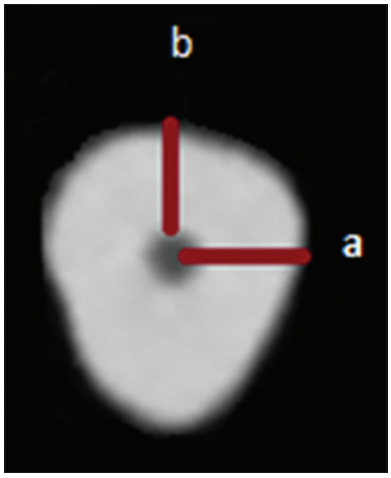

Figure 2: Determination of remaining dentin thickness of pre- and post-instrumentation cone-beam computed tomography images. a: Preinstrumentation b: Postinstrumentation

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.[10] 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.[3]

The quality guidelines of the European Society of Endodontics state that elimination of residual pulp tissue, removal of debris, and maintenance of the original canal curvature during enlargement are the main objectives of root canal instrumentation.[11] Maintaining the original canal shape using a less invasive approach is associated with better endodontic outcomes.

An ideal prepared root canal should have a progressively tapering conical shape which preserves the apical foramen and the original canal curvature without transportation.[12] 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.[13] 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.[7]

In this study, the mean value of reduced dentin thickness after biomechanical preparation with various file systems at 3 mm and 6 mm from apical foramen was found

Table 1: Mean value of reduced dentin thickness after biomechanical preparation with various file systems at 3 mm and 6 mm

Group	*n*	Reduction in dentin thickness at 3 mm	Percentage reduction in dentin thickness at 3 mm	Reduction in dentin thickness at 6 mm	Percentage reduction in dentin thickness at 6 mm
Group I (Protaper)	10	0.38±0.04	22.85±7.01	0.44±0.04	27.35±7.32
Group II (Mtwo)	10	0.42±0.06	31.50±4.22	0.49±0.05	39.20±6.35
Group III (WaveOne)	10	0.44±0.02	33.50±7.87	0.83±0.02	49.50±10.90

Table 2: Intergroup comparison of reduced dentin thickness after biomechanical preparation with various file systems at 3 mm and 6 mm

Group	Group	Mean difference at 3 mm	*t*	Mean difference at 6 mm	*t*	Significance
Group I (Protaper)	Group II (Mtwo)	4.55	1.808	4.15	1.552	Nonsignificant
	Group III (WaveOne)	6.15	0.708	6.15	1.480	Nonsignificant
Group II (Mtwo)	Group III (WaveOne)	1.60	1.552	2.00	1.808	Nonsignificant

to be highest in Group III (WaveOne) followed by Group II (Mtwo) and least in Group I (Protaper).

Protaper file system has shown minimum reduction in dentin thickness when compared to Mtwo and WaveOne 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.[14]

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.[15]

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.[15]

Aditi Jain *et al*. (2016) also did a similar study on comparative evaluation of canal transportation, centering ability, and remaining dentin thickness between reciprocating and rotary file systems using CBCT and found similar results of rotary system showing more remaining dentin thickness than reciprocating system but with a nonsignificant difference.

WaveOne 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.[10]

Priyanka Puri *et al*. (2016) did a similar study on comparative evaluation between Protaper and WaveOne file systems using CBCT and found similar results of more value of remaining dentin thickness for protaper file system when compared to reciprocating file system but with a nonsignificant difference.

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

Within the limitation of the study, we can conclude that minimum reduction in dentin thickness during biomechanical preparation of root canal was seen in Protaper file system followed by Mtwo and maximum was seen in WaveOne. When intergroup comparison was done there is a nonsignificant difference between all the groups in terms of reduction in dentin thickness during biomechanical preparation of the root canal.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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