EVALUATION OF SHAPING EFFICACY AND CANAL CENTERING ABILITY OF RECIPROCATING HANDPIECE WITH STAINLESS STEEL K FILE, NITI K FILE AND WAVEONE USING CBCT.

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Abstract

Introduction: Continuously tapered form of root canal and to maintain the original shape and position of the apical foramen is the key element in root canal treatment. However, canal curvature may cause difficulty in instrumentation.

Aim: The aim of this study was to evaluate the shaping efficacy and centering ability of reciprocating handpiece with stainless steel (SS) K files and Nickel Titanium (NiTi) K files in 90 degree and WaveOne gold file system in 150 counterclockwise and 30 clockwise reciprocation using cone beam computer tomography.

Materials and methods: Thirty freshly extracted human mandibular molars with fully formed apices were taken for the study and 11 mm of distal roots were used for the study. They were divided into three groups (n=10). All the three groups were instrumented using reciprocating handpiece. The file system used for Group 1, 2 and 3 are SS k file, NiTi K files, and WaveOne gold file respectively.

Statistical analysis: Data was tabulated and One-way analysis of variance (ANOVA) followed by Tukey's post hoc honestly significant difference (HSD) test were conducted at p=0.05 significance.

Results: The results revealed significant variations in shaping efficacy and centering ability at various level by all the three file system. A good canal taper and improved shaping efficacy was significantly reported in favor of WaveOne gold reciprocating file.

Conclusion: The WaveOne Gold showed better shaping ability whereas the canal centering ability at the coronal, middle and the apical third were not found uniform for the three tested instrument.

Keywords: Shaping efficacy, Canal centering, reciprocating handpiece, NiTi files, WaveOne Gold, CBCT

Introduction

Root canal treatment aims to manage endodontic disease by eradicating bacterial 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 space.¹

A good cleaning and shaping should preserve the integrity, location of the canal and apical anatomy to facilitate adequate filling. These objectives were difficult to achieve using stainless steel (SS) files, especially in curved canals.

Management of curved canals has always posed a challenge, as it requires to enlarge curved canals and at the same time preserves dental anatomy by selecting appropriate endodontic instruments. The mechanical use of stainless steel files with conventional designs pose the threat of file breakage as well as canal transportation. Thus the nickel-titanium (NiTi) files were a huge breakthrough, because of their unique ability to negotiate curvatures during continuous rotation without undergoing the permanent plastic deformation or failure that traditional stainless steel files would produce.² After the introduction of NiTi instruments 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.³ In spite of all these advantages, over instrumentation of canal was a clinical concern. Hence, the newer file system (one file systems) were aimed to increase reliability, effectiveness and fracture resistance.^{4,5} WaveOne gold file, the single-file reciprocating system (Dentsply Sirona, USA) was developed based on dedicated motor mechanism. WaveOne gold files are made of a M-wire technology designed to have increased flexibility of the instruments and resistance to cyclic fatigue.⁶ In this file system, the flutes engages dentin as it advances into the canal in its counter-clockwise motion allowing the cutting action, while the clockwise motion allows the file to immediately disengage and safely progress along the canal path, thus reducing the screwing effect and file separation with ease.⁷

Apart from advancement in newer files systems, the rotation of file within the canal also influence the clinical outcomes. The principles of rotary motion have been in clinical usage for close to 25 years. However, the physics behind reciprocating motion is based on balanced force during canal instrumentation. The reciprocating movement minimizes torsional and flexural stresses thereby reducing the taper lock of the instruments within the canal and in turn increases the canal centering ability.⁸ Centering ability is influenced by the instrument taper, flexibility, type of the alloy and the root canal anatomy. Reciprocating handpiece can also be used with conventional files which will lessen the operational cost when compared to continuous rotary instrumentation systems. They offer greater clinical advantages like easy operation and accessibility to all operators.

On thorough review of literature there are no studies that compare the shaping efficacy and canal centering ability of reciprocating NiTi file systems and that of reciprocating handpiece used with hand files. Hence the aim of this study was to evaluate and compare canal centering ability and shaping efficacy in mandibular molars with various reciprocation techniques using cone beam computer tomography.

Materials and methods:

Specimen selection:

30 freshly extracted human mandibular molars with fully formed apices having curvature of up to 10 degrees (Schneider's method) that were extracted for periodontal or prosthetic reasons were selected for the study. Teeth was stored in 0.1% thymol until use. All the samples were decoronated at the level of CEJ and the distal root was separated using a diamond disk (D345-190 NTI Flex, Kerr USA). A 10 K size file (Mani, Japan) was passively introduced into the root canal to determine the patency.

Working length was determined such that it is 1mm short of anatomical apex and the root lengths was standardized to 11mm.

The roots were arranged in a wax rim simulating arch form and pre-operative CBCT (*Planmeca ProMax® 3D Max*, Helsinki, Finland) was taken in 3 dimensions to measure the remaining dentin thickness at 3 mm, 6 mm and 9 mm from apex. The samples were divided into 3 groups, each containing ten samples. Coronal enlargement was done by gates glidden drills (Mani, Japan) upto size 3 in groups 1 and 2, and Proglider (Dentsply Maillefer, Ballégues, Switzerland) was used in group 3. (Fig 1)

Figure 1: Decoronated distal root of the mandibular molar

Specimen preparation:

Group 1- Reciprocating Handpiece (NSK TEP - ER 10 with gear ratio 10:1 reduction for hand files / 60° twist max speed 4,000 min⁻¹) with stainless steel K files (Mani, Japan) was used in a standardized step back manner. The files were operated at about 2500 rpm. Apical preparation was done up to size 25 K file and step back technique was used with reduction of 1 mm in working length for an increase in each file size until size 40.

Group 2- Reciprocating Handpiece (NSK TEP - ER 10 with gear ratio 10:1 reduction for hand files / 60° twist max speed 4,000 min⁻¹) with NiTi K files (Mani, Japan) were used at about 2500 rpm. Same procedure was followed as that of group 1.

Group 3- Reciprocating file system instrumentation was performed with WaveOne gold file (primary file 25/ 0.07, 150 degrees CCW and 30 degrees CW) with X-Smart plus endomotor (Dentsply Sirona, USA) that was adjusted according to manufacturer's instruction

All instruments in Group 1, 2 and 3 was discarded after use in 5 canals. A 30 gauge needle (Dispovan, Faridabad, India) was used for irrigation. For every change of file 3 ml of 2.5% sodium hypochlorite (NaOCl) (Prime dental, Thane, Maharashtra) was used as irrigant. Ethylenediamine tetraacetic acid paste (EDTA) (RC help, Prime dental, Thane, Maharashtra) was used as a lubricant through-out the procedure. After root canal instrumentation was

completed, 1 ml of 17% EDTA (Prime dental, Thane, Maharashtra) was used for 1 min followed by final flush of 3 ml of 2.5% NaOCl. The canals were finally dried with absorbent paper points (Meta Biomed, Korea) Post instrumentation CBCT was taken in order to evaluate the shaping efficacy and canal centering ability of the different file systems.

Evaluation of shaping efficacy:

Remaining dentin thickness was checked after cleaning and shaping at varying levels like 3 mm, 6 mm and 9 mm from apical foramen. Mesial, distal, buccal and lingual dimensions post instrumentation was recorded. Gradual decrease in canal width from coronal to apical third of canal was counted as good taper, where as other than that described above was recorded as poor taper using the formula.⁹

$$(x1-x2/y1-y2) \text{ or } (y1-y2/x1-x2)$$

Evaluation of centering ability:

After post-operative CBCT the measurements of mesial and distal cross sections was calculated. The mean centering ratio indicates the ability of instrument to stay centered in the canal, this is described based on the formula. (Fig 2) If both numerator and denominator has the same number then the value will be 1 which indicates perfect centering. If not, the lower figure is considered as numerator.¹⁰

$$(a1-a2/ b1-b2) \text{ or } (b1-b2/a1-a2)$$

Figure 2: Schematic representation of before and after instrumentation

Statistical analysis:

Data was tabulated and One-way analysis of variance (ANOVA) followed by Tukey post hoc honestly significant difference (HSD) test were conducted to explore canal centering ability and shaping efficacy at various levels. The level of significance was set at $p=0.05$.

Results:

In table 1, WaveOne gold reciprocating file showed good shaping efficacy compared to the other two groups. It was observed that there was a progressive taper from coronal to apical end. (Fig 3)

Figure 3: Pre and Post CBCT images

On centering evaluation, reciprocating handpiece with SS hand files at 3 mm from apex showed significant difference. At mid root level, reciprocating handpiece with NiTi hand files showed better centering ability compared to group 1 and 3. At coronal level WaveOne gold reciprocating file showed better centering ability than group 1 and 2. (Table 2)

Table 1: Results of shaping efficacy at three levels

SHAPING EFFICACY	3 mm from Apical	6 mm from Apical	9 mm from Apical
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD
Reciprocating handpiece with SS hand files	0.57 $\pm$ 0.47	0.47 $\pm$ 0.32	0.51 $\pm$ 0.31
Reciprocating handpiece with NiTi hand files	0.49 $\pm$ 0.14	0.52 $\pm$ 0.12	0.51 $\pm$ 0.28

WaveOne gold reciprocating file	0.39 ± 0.29	0.47 ± 0.25	0.51 ± 0.25
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Table 2: Results of canal centering ability at three levels

CANAL CENTERING ABILITY	3 mm from Apical	6 mm from Apical	9 mm from Apical
	Mean ± SD	Mean ± SD	Mean ± SD
Reciprocating handpiece with SS hand files	0.53 ± 0.41	0.37 ± 0.32	0.49 ± 0.31
Reciprocating handpiece with NiTi hand files	0.45 ± 0.24	0.42 ± 0.19	0.48 ± 0.23
WaveOne gold reciprocating file	0.32 ± 0.35	0.39 ± 0.35	0.52 ± 0.15

Discussion:

Complete disinfection of root canal space is primary objective in endodontic treatment. This comes with considerable amount of dentin removal. At the same time the preservation of natural root canal anatomy after instrumentation is of great concern. Hence it is essential that, we strike a balance between controlled instrumentation and removal of infected dentin.^{11,12} The aim of this study was to evaluate the shaping efficacy and centering ability of three different file systems, which are

1. reciprocating handpiece with SS K files,
2. reciprocating handpiece with NiTi K files and
3. WaveOne gold file system.

Numerous investigations have shown that SS instruments results in undesirable aberrations such as elbows, zips and danger zones in curved root canals.¹³ Even with humongous advancements in the field of rotary and hand instruments and despite the introduction of NiTi files, the usage of SS K file is never obsolete.¹⁴ NiTi instruments are

superelastic and flexible compared to stainless steel instruments.¹⁵ NiTi instruments were developed to overcome the drawbacks of SS files and to facilitate management of curved canals. Owing to the lack of shape memory of SS files the amount of force exerted by the file during instrumentation will result in excessive cutting of canal walls. On contrary, the shape memory of NiTi files helps in exerting negligible force on the canal wall during instrumentation. WaveOne gold file system has a huge advantage of being a single-file system to shape the root canal completely. The specially designed NiTi files are manufactured using M-wire technology thus improving strength and resistance to cyclic fatigue to approximately four times in comparison with other brands of rotary NiTi files.^{16,17}

In this study, CBCT is considered for the assessment of root canal instrumentation techniques due to its accuracy. Canal transportation and centering ability have been studied with various methodologies, but CBCT is considered to provide detailed information of the root canal before, during and after biomechanical preparation.^{18,19} Although a numerous methods are present to evaluate canal shape before and after instrumentation, cone beam computer tomography (CBCT) imaging was employed for this study as it provides detailed three-dimensional observation as evidenced by the previous studies.^{8,20,21} The fact that CBCT provides images in orthogonal planes as well as in oblique planes is an added advantage for measuring dentin thickness, canal curvature, apical transportation, and canal centering.^{8,22}

In this study, the CBCT showed higher frequency of good canal taper with WaveOne gold file system than manual K files which are in line with few studies which compared rotary files.²³⁻²⁵ The reason behind poor taper obtained by K file than engine driven instrumentation achieved with WaveOne gold, is the number of continuous or reciprocating motions per unit of time that NiTi instruments make to shape the canal. Additionally, cutting efficacy of blades might be postulated as another factor. The S-shaped cross-section of WaveOne gold file increases engagement of the cutting side of file to tooth dentin, possibly enhancing tapering toward apex.²⁶ The results of our study was in accordance to Dhingra *et al* (2014) who evaluated the canal curvature modification after instrumentation with One Shape rotary file and WaveOne gold primary reciprocating file. It was observed that WaveOne gold file preserved canal shape, respected the anatomical J-shape and produced a continuously tapered funnel.²⁷

Canal centering ability is inversely proportional to canal transportation.²⁷ If the canal preparation in apical third is not centered it may cause blockages, ledges and perforations. Better the centering ability in apical third,

lesser the chances of apical transportation. In this study, reciprocating handpiece with SS files had superior centering ability compared to NiTi K files and WaveOne gold. This is due to lesser taper of SS files when compared to WaveOne gold reciprocating file. This is in contradiction to the study done by Hülsmann *et al* (2001) and Arora *et al* (2014), who stated that centering ability is better within NiTi instruments with noncutting tips.^{13,28} Canal centering ability varies at each third for the 3 groups in our study which is in accordance to a study done by Tambe *et al* in 2014.¹⁰ The results obtained suggested that all the three systems used in this study for shaping efficacy and centering ability showed significant variations.

Within the limitations of the study, the canal centering ability differs at each level depending on instrumentation technique used. The centering ability at the most significant apical part was found superior for SS K files followed by NiTi K files and WaveOne gold reciprocating file. However, the overall result of improved shaping efficacy and good canal taper was significantly reported in favor of WaveOne gold compared to SS K files and NiTi K files.

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