ISSN (O) : 2582-3271
PubMed-National Library of Medicine - ID: 101766917

International Journal of Dental Science and Clinical Research (IJDSCR)

Dr. Angel Vaidic Publication

Available Online at: http://www.ijdscr.org

Volume - 8, Issue – 3, June - 2026, Page No. : 09 – 23

An In-Vitro Comparative Evaluation of Canal Centering Ability of Three Different Niti File Systems Using Cone Beam Computed Tomography with or Without Ultrasonic Activation

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Citation of this Article: Dr. Krishna Mondal, Dr. Asim Bikash Maity, Dr. Anirban Bhattacharyya, Dr. Dipanjan Das, Dr. Gayatri Majumder, "An In-Vitro Comparative Evaluation of Canal Centering Ability of Three Different Niti File Systems Using Cone Beam Computed Tomography with or Without Ultrasonic Activation'' IJDSCR – June – 2026, Vol. – 8, Issue - 3, Page No. 09-23.

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Type of Publication: Original Research Article

Conflicts of Interest: Nil

ABSTRACT

Aim

The prime aim of this study was to compare anal centering ability of different rotary endodontic files with and without Ultrasonic Activation.

Materials and Methods

Sixty extracted single-rooted mandibular premolars with less than 30° of curvature were selected and divided into three groups. In Group 1, the canals were prepared with Wave-One Gold files, in group 2 with Hyflex-CM and in Group 3 with Protaper gold files. Each group were subdivided into A and B subgroups. Subgroup A irrigated with ultrasonic activation, while subgroup B with traditional method. Pre and post-

instrumentation CBCT were performed using to evaluate the centering ability at 3mm, 6mm, 9mm from apex.

Results

Group II demonstrates superior centering at the middle third (6 mm) in the Mesiodistal direction and the coronal third (9 mm) in the buccolingual direction when ultrasonic activation is applied.

Conclusion

Hyflex CM NiTi file system showed better canal centering trend specially at the middle third (6 mm) of the canal, followed by WaveOne gold group while Protaper gold group showed comparative lower canal centering ability at all 3 level of root. In groups where ultrasonic irrigation activation of irrigating solution was done, they have showed improved canal centering trend, particularly in the group IIA where shaping done with Hyflex CM files.

Keywords

Canal centering ability, Ultrasonic activation, Cone Beam Computed Tomography, NiTi Rotary Files.

INTRODUCTION

Preparation of the root canal system is recognized as being one of the most important stages in root canal treatment. It involves removing the infected root dentine as well as vital and necrotic tissues from the root canal system. (1)

The main objectives of root canal therapy are to completely disinfect the root canal space and create a three-dimensional apical and coronal seal. Through appropriate biomechanical root canal preparation this can be achieved. The ideal root canal preparation must be constantly tapered without deviating from the original canal curvature and maintaining the foramen as small as possible in order to maintain a centered preparation.(2)

While performing an endodontic treatment, it is crucial that the final root canal preparation presents a shape and direction similar to the initial canal anatomy. This is important in order to accomplish a correct irrigation, removing all debris and microorganisms. At the same time, it is also important to avoid excessive dentinal removal, which can compromise the success of the treatment. However, it is known that maintaining initial canal shape and direction becomes a challenge as root canal curvature increases, especially in the apical regions. To overcome these difficulties in root canal preparation, to simplify the procedures and to reduce its preparation time, several rotary systems have been developed and improved in the last few years, with the development of new rotary file designs, techniques and manufacturing methods. (3)

It was in late 1988 that Walia et al. [4] introduced the magic properties of a corrosion resistant alloy to the manufacturers for making the nickel–titanium (NiTi) rotary instruments. Nickel-titanium (NiTi) alloys have continued to revolutionize the field of endodontics. It has been shown that root canal preparation with engine-driven NiTi endodontic instruments results in significantly less canal transportation and fewer preparation errors compared with stainless steel hand instruments. The super-elasticity and shape memory of these instruments reduce the possibility of the canal transportation along with saving the time for both the patients and the clinicians. (5)

Wave-One Gold (Dentsply Sirona, Tulsa) is an innovative single-file system that advocates the principle of reciprocation. These files undergo gold thermal treatment to the original primary Waveone M-wire, which alters the molecular structure of the nickel

titanium alloy, enhancing its mechanical properties. The file incorporates a reverse helix, an offset parallelogram cross-section, and a semi-active guiding tip, contributing to its advanced functionality. [6,7]

Hyflex CM (Coltene Whaledent) is a NiTi rotary file system made using the novel "controlled memory" technology with convex triangular cross section. Controlled memory wire (CM wire) is manufactured by a unique process that controls the material's memory, making the files extremely flexible. [8]

A more recent and advanced metallurgy process allowed the manufacturer to introduce Protaper gold (Dentsply Sirona) rotary files. The protaper files were specifically designed to provide superior flexibility, unmatched efficiency and greater safety. The unique design features of the protaper files enables clinicians to more consistently create uniformly tapered shapes in anatomically difficult or significantly curved canals. [9]

The canal curvature is viewed to be a difficult risk factor susceptible to procedural errors such as ledge creation, canal straightening, zipping, and canal transportation (CT). The greater the degree of curvature and the smaller the radius of curvature, the greater the risk of canal transportation.

Centering ability (CA) of an instrument is the ability to keep the instrument centered in the root canal to provide appropriate preparation, without excessive weakening of the root structure. The configuration of the instrument (taper, flexibility, and type of alloy) and the root canal anatomy influence the centering ability of a given instrument. The straighter the root canal is, the lower the instrument receives constraint and the more centered it is. [8]

Despite the constant development of endodontic instruments, their association with auxiliary irrigation solution is still fundamental. Richman first introduced ultrasonic instrumentation to endodontics in 1957 for root canal therapy and obtained good results. [10]

Ultrasound waves produced by the vibrating instrument reduce the demineralizing effect of the chelator by reducing the working time, as EDTA only develops its full effectiveness after a certain working time. In contrast, a superior root canal cleanliness is achieved following ultrasonically agitated irrigation with NaOCl. [11]

The rotary files have been subjected to constant evolution in the form of metallurgy, design features, and the manner in which these instruments are driven (rotary/reciprocation), etc., resulting in revolution, both within the canal and in the area of contemporary endodontics.

AIM AND OBJECTIVE OF THE STUDY

The prime aim of this study was to compare canal centering ability of different rotary endodontic files with and without ultrasonic activation. The objective of the study was to find proper shaping of root canal without deviating from the original root canal anatomy, reducing occurrence of perforation and canal transportation.

MATERIALS AND METHODS

Sixty extracted human single rooted mandibular premolars were selected which were free of caries, cracks, restorations, curvature less than 30^0 determined by Schneider's method, without any signs of resorption. Teeth with calcified canals, more than one root and one root canals, any anatomic variation or any signs of resorption were excluded.

Before use the teeth were decontaminated by immersion in 10% freshly prepared formalin for two weeks. The teeth were cleaned free of debris and calculus with Ultrasonic scaler (Woodpecker UDS P, China) and stored in normal saline (0.9% Axaline-NS, India) solution until use in order to maintain the physiological characteristics of the teeth.

To determine the degrees of curvature and ensure the exclusion criteria a preoperative radiovisiography (VATECH USA) was taken for all samples and samples with canal curvatures less than 30º as determined by Schneider's method were selected.

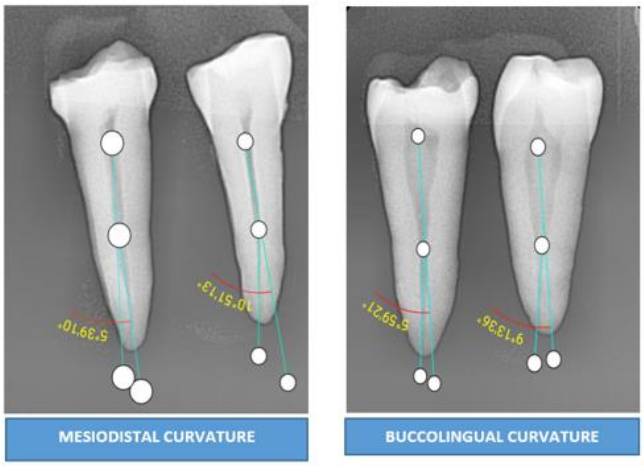


Figure-i: Pre-operative radiovisiography was performed to assess the mesiodistal and buccolingual curvature of the samples which were determined by Schneider's method.

The sixty experimental samples were randomly divided using online True random number generator software (www.random.org) into six experimental groups containing 10 teeth each namely:

Name of the groups	Files used
IA	Waveone gold with ultrasonic activation (n=10).
IB	Waveone gold with traditional irrigation without ultrasonic activation (n=10).
IIA	Hyflex CM file with ultrasonic activation (n=10).
IIB	Hyflex CM file with traditional irrigation without ultrasonic activation (n=10).
IIIA	Protaper gold file with ultrasonic activation (n=10).
IIIB	Protaper gold file with traditional irrigation without ultrasonic activation (n=10).

Table 1: Distribution of Samples

Figure-ii: Teeth in each group were mounted in modelling wax sheet in order to pre-instrumentation scan using Cone Beam Computed Tomography

Pre-instrumentation radiographic analysis of the samples:

All the teeth in each group were mounted in modelling wax sheet in order to scan using Cone Beam Computed Tomography (VATECH, USA. 90Kvp, 10mA, 0.33mmVoxel, and Exposure time-20 sec, Effective dose- 37microseivert) to determine the dentin thickness before instrumentation at 3 levels- (a)3mm from root apex, (b) 6mm from root apex and (c) 9 mm from the root apex. Mesio-distal bucco-lingual diameter of dentin of each tooth were measured at the three levels(3mm,6mm,9mm) and recorded for further reference.

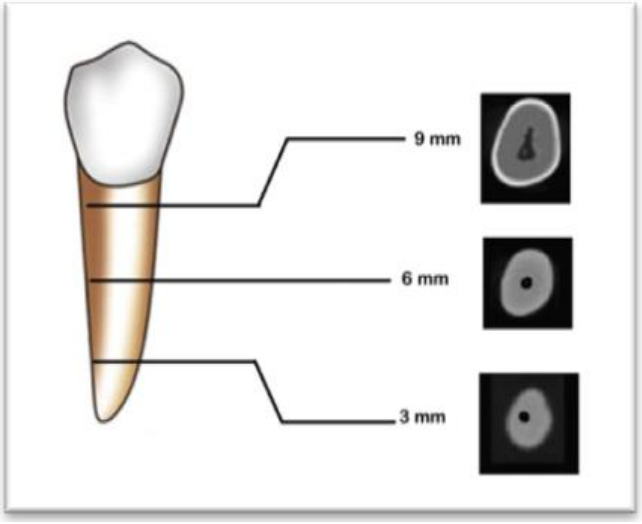


Figure-iii: Measurement of the dentin thickness was done at 3 levels of root-(a) 3mm from root apex, (b) 6mm from root apex and (c) 9 mm from the root apex.

Preparation of the specimens:

Conservative access cavity preparations were started initially with a no. 2 round carbide bur (Mani, Japan) for penetration through the roof of the pulp chamber followed by endo Z bur (Dentsply Maillefer, Switzerland), orifice exploration was done with a DG 16 explorer (Dentsply Maillefer). After detection of the canal orifice, a

no. 15 size barbed broach (Micromega, France) was inserted into the canal to remove the pulp. Each root canal was negotiated by a no. 10 K stainless steel file. The working length (WL) was determined with a size 10 K file (Mani, Japan) that was set 0.5 mm short of the file length. The root canal of each sample was enlarged up to size 15K file (Mani, Japan) with the help of EDTA gel (RC Help, Prime Dental Pvt. Ltd, India) followed by shaping of teeth in each group were done with their respective rotary file systems i.e., WaveOne Gold for group –I, Hyflex CM for group-II and Protaper Gold for group-III. Each file system was discarded after single use in one root canal to standardize the cutting efficiency and the root canals of all teeth (in each group) were enlarged up to size 0.25 mm tip diameter of each file system to standardize the apical enlargement.

Irrigation protocol maintained during Instrumentation:

Root canal of all samples were irrigated with 3 ml of 5.25% sodium hypochlorite solution for 1 minute (CanalPro, Coltene, Whaldent, Switzerland) after changing of each instrument. The irrigating solution was placed using a closed ended side vented needle tip (Superendo, China) coupled with luer lock plastic syringe (Unolok, Hindustan Syringes Ltd, India) inserted at 1 mm short of working length in the root canals of all samples. In all subgroup-A samples, that is group IA (Waveone gold), IIA (Hyflex-CM), IIIA (Protaper gold), ultrasonic activation of 5.25% sodium hypochlorite was done after each instrument change with an ultrasonic activator for one minute placing the tip at 1 mm short of working length (Woodpecker, UDS P Ultrasonic Scaler, China) by activating passively with filing motion. This process was executed out in three cycles of twenty seconds each (frequency 40 kHz/cycle), resulting in sixty seconds activation time. The subgroup -B samples, that is group IB (WaveOne gold), IIB (Hyflex-CM), IIIB (Protaper gold) root canals were irrigated with 3 ml of 5.25% sodium hypochlorite solution using closed ended side vented needle tip (Super endo, China) coupled with luer lock plastic syringe. No ultrasonic activation of 5.25% sodium hypochlorite was done. After each rinse, an ISO 10 K-file (Mani, japan) was inserted inside the canal to check apical patency. Final irrigation was done using 1 ml of 17% EDTA solution (CanalPro, Coltene Whaldent, Switzerland) for 1 minute followed by final flushing with 3 ml of normal saline for 1 minute in each canal (0.9% Axaline-NS, India). Ultrasonic agitation of 17% EDTA solution was done in all subgroup-A samples tip inserted at 1 mm short of working length (Woodpecker, UDS P Ultrasonic Scaler, China) by activating passively filing motion for one minute. Final irrigation of subgroup -B samples were done using 1 ml of 17% EDTA solution (Canal Pro, Coltene Whaldent, Switzerland) for 1 minute followed by final flushing with 3 ml of normal saline for 1 minute in each canal (0.9% Axaline-NS, India) without using ultrasonic activation.

Post-instrumentation radiographic analysis of samples:

After instrumentation and final irrigation, the samples were subjected to the CBCT imaging (90Kvp, 10mA, 0.33mmVoxel, and exposure time-20 sec, Effective dose- 37microseivert, VATECH, USA.), to determine the post instrumentation dentin thickness at-3mm,6mm and 9mm from the root apex. The CBCT images of pre and post instrumentation dentin

thickness were evaluated using special software (EZ 3D PLUS) in order to minimize the chances of error at four surfaces of root, i.e., facial, lingual, mesial, and distal at 3mm,6mm and 9 mm from the root apex for all groups.

The configuration of the instrument (taper, flexibility, and metallurgical characteristics of alloy) and the root canal anatomy influence the centering ability of a given instrument. In other word, it is the difference between instrumented and un-instrumented canals, which measures the ability of an instrument to stay centered, inside the canal. The formula given by Gambill et al. was used in this study to measure the canal centering ability and canal transportation (deviation from the original canal shape) during root canal preparation. The formula was applied to measurements taken from cross-sectional images of a root canal before and after instrumentation. Canal transportation was calculated as the difference between the change in width on one side of the canal and the change on the other side. A result of zero indicates no canal transportation. The canal centering ability was calculated as a ratio. A result of one indicates perfect centering ability, while values closer to zero indicate poorer centering ability. The formula uses the smaller of the two possible results as the numerator to ensure the ratio remains between 0 and 1. In this study the measurements are typically performed at different levels of the root canal (e.g., 3mm, 6mm, and 9mm from the apex) using three-dimensional imaging techniques like cone-beam computed tomography (CBCT).

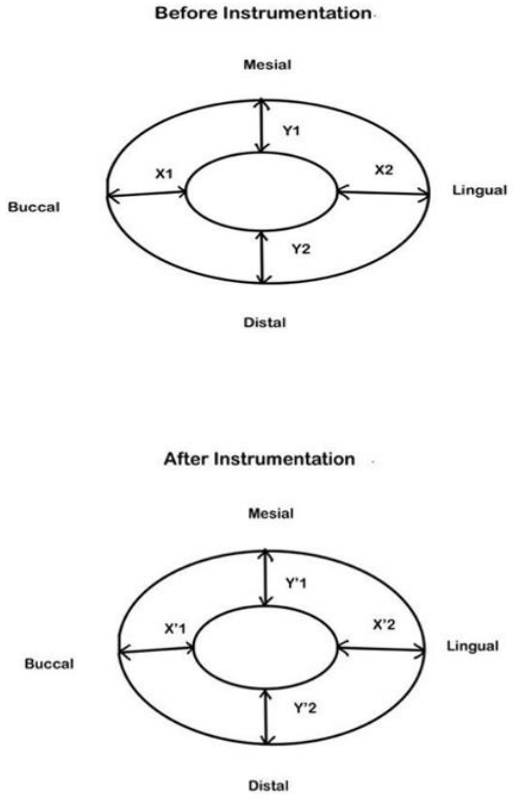


Figure-iv: Schematic diagram of Post instrumentation measurement of dentin in mesial, distal, buccal, lingual surface.

Canal centering ratio can be obtained by following formula given by Gambill et al.:

$$D1 = \frac{(X1-X'1)}{(X2-X'2)} \qquad D2 = \frac{(Y1-Y'1)}{(Y2-Y'2)}$$

- X1 is the shortest distance from the buccal aspect of the root to the periphery of the un instrumented canal. X'1 is the same distance in prepared canal.
- X2 is the shortest distance from the lingual aspect of the root to the periphery of the un instrumented canal.X'2 is the same distance of the prepared canal.
- Y1 is the shortest distance from the mesial aspect of the root to the periphery of the un instrumented canal.
- Y'1 is the same distance of the prepared canal. Y2 is the shortest distance from the distal aspect of the root to the periphery of the un instrumented canal. Y'2 is the same distance of the prepared canal.

STATISTICAL ANALYSIS

The collected data was tabulated in a spreadsheet using Microsoft Excel 2024 and then statistical analysis was carried out using the Graph Pad Prism for Windows, Version 10.1.2 (Graph Pad Software, La Jolla California USA). A Normality of the collected data was assessed using the Shapiro-Wilk test alongside visual inspection of histograms, Q-Q plots, and box plots. The data were approximately normally distributed across the sample. A two-way ANOVA was employed to test the effect of multiple factors on the Canal Centering ability. Pair t-test was employed to test the Canal Centering ability between the directions. The P value of ≤ 0.05 was considered as the level of significance.

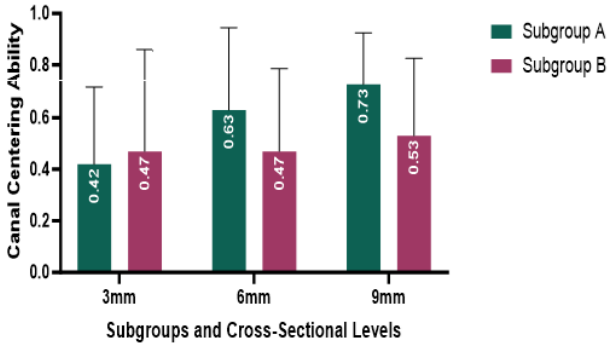
The bucco–lingual canal centering ability varied across the study groups and cross-sectional levels.

In Group IA, the mean centering ratio increased progressively from 3 mm level (0.42 ± 0.30) to 6 mm level (0.63 ± 0.32), reaching its highest value at the 9 mm level (0.73 ± 0.20). In Group IB, the mean values were similar at the 3 mm level (0.47 ± 0.39) and the 6 mm level (0.47 ± 0.32), followed by a slight increase at the 9 mm level (0.53 ± 0.30).

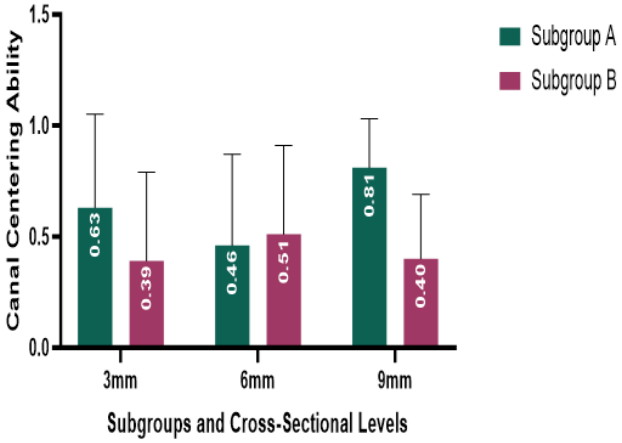
In Group IIA, the mean centering ability was 0.63 ± 0.42 at the 3 mm level, decreased to 0.46 ± 0.41 at the 6 mm level, and then increased markedly to 0.81 ± 0.22 at the 9 mm level. In contrast, Group IIB recorded mean values of 0.39 ± 0.40 at the 3 mm level, 0.51 ± 0.40 at the 6 mm level, and 0.40 ± 0.29 at the 9 mm level, indicating relatively minor fluctuations across levels.

For Group IIIA, the mean centering ratios were 0.34 ± 0.28 at the 3 mm level, rising to 0.55 ± 0.36 at the 6 mm level, followed by a slight reduction to 0.47 ± 0.36 at the 9 mm level. Finally, Group IIIB showed a decreasing pattern from the 3 mm level (0.62 ± 0.37) to the 6 mm level (0.56 ± 0.39) and further to the 9 mm level (0.42 ± 0.29).

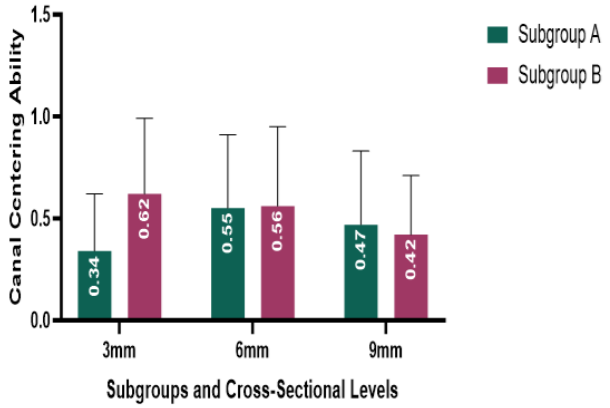
Bar Graph 1: Mean (and standard deviation) Canal Centering ability on the Bucco-Lingual direction in Group I evaluating the effect of Ultrasonic activation (Subgroups) and Cross-sectional Levels



Bar Graph 2: Mean (and standard deviation) Canal Centering ability on the Bucco-Lingual direction in Group II evaluating the effect of Ultrasonic activation (Subgroups) and Cross-sectional Levels



Bar Graph 3: Mean (and standard deviation) Canal Centering ability on the Bucco-Lingual direction in Group III evaluating the effect of Ultrasonic activation (Subgroups) and Cross-sectional Levels



Overall Analysis Summary

Across all comparisons, HyFlex CM generally showed a more favorable centering trend, followed by WaveOne Gold, while ProTaper Gold tended to show comparatively lower centering performance. Ultrasonic activation showed a tendency to improve centering, particularly in combination with HyFlex CM, although this effect was not universal across all levels and directions.

Statistically significant differences were not widespread and were mainly limited to selected levels and directions, particularly around the middle third (6 mm) and coronal third (9mm). Significant activation-related differences were observed primarily within HyFlex CM, whereas WaveOne Gold showed occasional differences and ProTaper Gold showed few significant changes. Directional differences between bucco–lingual and mesio–distal measurements were also significant only at isolated root levels.

RESULT

The results indicate that while all systems provide adequate centering, Group II (HyFlex CM) demonstrates superior centering at the middle third (6 mm) in the Mesiodistal direction and the coronal third (9 mm) in the buccolingual direction when ultrasonic activation is applied. The middle third (6 mm) appears to be the most sensitive level for observing statistical differences between file systems and directions.

DISCUSSION

Root canal anatomy and morphology is an important factor for successful endodontic treatment as it deals with the management of the tooth's internal anatomy. Mandibular premolars usually present with a single root and single canal that is wider buccolingually and narrower mesiodistally. [12]

Rotary NiTi instruments mainly functions in two motions, namely continuous rotation and reciprocation. Continuous rotary motion is continuous 360^0 motion. In this current study two continuous rotary files that are Hyflex CM, Protaper gold has been used.

Reciprocation motion can be defined as a repetitive backward-and-forward (clockwise (CW)/counter-clockwise (CCW)) movement which can be applied to endodontic instruments, or as an oscillating motion in which an instrument rotates in one direction, reverses direction, and then completes a full rotary cycle. [13.14] In this current study one reciprocation motion file that is Waveone gold has been used to find their efficacy in maintaining canal centering trend.

The key advantage of reciprocal motion is the reduced incidence of endodontic mishaps through file separation, which can be attributed to avoiding constant dentinal over engagement. This movement minimises flexural and torsional stresses, decreased risk of fracture and a reduction in the number of cycles during preparation of the root canal. It also improves canal-centring ability and decreases the taper lock of the file in the canal. [15]

WaveOne gold, an improved system has emerged that provides excellent safety, effortless efficiency, and super simplicity. It is a unique instrument system with variable taper introduced by Dentsply Maillefer in the year 2015 with offset parallelogram cross section. It is composed of four single-use files: Small (ISO 20 tip and 7% taper) for fine root canals; primary (ISO 25 tip and 7% taper) for most of the canals; and large (ISO 35 and 6% taper-ISO 45 and 5% taper) for large root canals. In this study small (ISO 20 tip and 7% taper) and primary (ISO 25 tip and 7% taper) files of wave one gold file system were used.[7]

The Hyflex-CM system represents a new generation of Nickel Titanium (NiTi) instruments that are machined from a wire (termed CM-wire) previously subjected to a proprietary, novel, thermomechanical processing. This allows the file to closely follow the anatomy of the canal, minimizing the danger of ledging, transportation, or perforation compared to other instruments with rebound. In the present study we have used 08/25 that is Orifice Opener (19mm), 04/20 and 04/25 that are both apical enlargement files. [8]

Protaper Gold (Dentsply Tulsa) is a NiTi file system with advanced metallurgy, increased flexibility and greater resistance to cyclic fatigue with a convex triangular cross section and progressive taper. [16] It was introduced in the year 2014. Protaper Gold consist of three shaping (Sx, S1 & S2) and five finishing files (F1, F2, F3, F4 & F5). It is available in various sizes and variable tapers of about 19 / .04 (Sx), 18 / .02 (S1), 20 / .04 (S2), 20 / .07 (F1), 25 / .08 (F2), 30 / .09 (F3), 40 / .06 (F4), 50 / .05(F5). [17] In this present study file size until F1 has been used.

In the present study, all apical portions of each root canals of experimental samples were uniformly prepared to size 25; this was to maintain the uniformity in apical preparation size of 25 for all the three rotary systems. The amount of canal transportation increases with apical preparation larger than size 25 hence apical preparation was restricted to size 25 file in the present study.

Root canal irrigation is one of the most crucial step for elimination of bacteria and their by-product and to remove smear layer. The mechanism of action of NaOCL follows three steps namely, saponification, amino acid neutralization and chloramination. NaOCl has been used in concentrations ranging from 0.5% to 5.25%. The most effective concentration recommended is 5.25% sodium hypochlorite. [18] The additional properties of sodium hypochlorite include the ability to denature toxins but more importantly, it can dissolve organic tissues of dentin. The organic tissue dissolving capacity of this higher concentration of NaOCL may lead to better shaping of root canal walls while instrumentation with the NiTi files, without removing excessive amount of dentin.

EDTA is generally used after biomechanical preparation as final irrigation solution for their chelating action by which it removes the smear layer.

[19]. The most popular concentration for endodontic therapy is 17% EDTA. [20]

EDTA acts by forming a chelating calcium solution with dentinal calcium ion so that dentin can become softer and easily instrumented. EDTA chelator with sodium hypochlorite alternatively act as irrigating solution that has the potential to clean smear layer and inorganic debris effectively. [19] So, in our study, we have used 17% EDTA solution as final irrigation solution followed by final flush with normal saline.

There are a very few study in the literature examining and comparing the effect of traditional irrigation and ultrasonic activation irrigation on root canal shaping, in terms of apical transportation and centering ability during root canal shaping. So, in this study we subdivided each instrument groups in two subgroups one, irrigation along with ultrasonic activator and two, irrigation in traditional method that is without ultrasonic activator to evaluate the effect of these two types of irrigation technique on canal centering ability of the used file systems.

In the present study, the subgroups IA, IIA and IIIA where ultrasonic activation of irrigating solutions was done for 60 seconds, showed a tendency of improved canal centering trend compared to subgroups IB, IIB, IIIB where ultrasonic activation was not done, particularly when root canal shaping done with Hyflex CM files at middle (3mm) and coronal third(9mm), although this effect was not universal across all levels and directions.

This result is may be due to, the action of sodium hypochlorite to dissolve organic material was increased when passive ultrasonic activation of irrigation was performed. Ultrasonic activation of irrigation also provides a continuous flow of the irrigating solution, improving debris and smear layer removal, and adequate cleaning of the root canal system.

It is known that the removal of debris during root canal shaping procedure reduces the risk of apical transportation and subsequently better centering ability into the canal, facilitating the extrusion of debris coronally, and thus creating a lubricating effect. Based on these findings, the fact that this study produced a significant result at 6 mm and 9mm can be attributed to the facts that the flow of the solution is greater in the coronal region and that root canal curvature begins in the coronal region. [21]

In this study the results showed that while all the file systems maintain centering, Group II (HyFlex CM) demonstrates superior centering at the middle third (6 mm) in the mesiodistal direction and the coronal third (9 mm) in the buccolingual direction followed by Waveone Gold and followed by protaper gold. At Apical third (3 mm) no significance difference in canal centering was noted between Waveone gold, hyflex CM and protaper gold.

Hyflex CM demonstrated less canal transportation and was more centered in the canal than Wave One Gold and Protaper Gold. Hyflex CM showed superior performance in this study particularly at middle third (6mm) and coronal third(9mm) can be attributed to a variable tapers and triangular cross-sectional design.

Hyflex CM' NiTi rotary files retain their shape in curved canals and do not possess the 'Spring back action', thereby avoiding any perforation. The file maintains the shape of the canal even after its removal. Accelerated Flute Design (Variable pitch) of the file system improves its flexibility and its increasingly wider flutes provide for efficient debris

removal and prevents the file from "screwing" into the canal. [8]

In this present study, WaveOne Gold Reciprocating file system group showed significantly better centering trend after Hyflex CM group at the middle third (6 mm) and coronal third (9 mm) of the canal and also maintained more original root canal curvature when compared with Protaper Gold group.

This may be associated to the high austenite finish temperature value and two-stage transformation behaviour of the WaveOne Gold file system. The cross section of the file has been changed to a parallelogram with two 85-degree cutting edges in contact with the canal wall, alternating with an off-centred cross-section where only one cutting edge is in contact with the canal wall. Decreasing the contact area between the file and the canal wall reduces binding (taper lock) and, in conjunction with a constant helical angle of 24 degrees along the active length of the instrument, ensures little or no screwing in. This reciprocal movement minimises flexural and torsional stresses, causing reduction in the number of cycles during preparation of the root canal. [22]

The most notable point is that Waveone gold is manufactured with gold alloy technology, which involves heating and then slowly cooling the file. This new heat treatment procedure, according to the manufacturer, improves the flexibility of files. [23]

In this study, Protaper Gold file system group showed comparatively lower canal centering ability than other two groups that is WaveOne Gold and Hyflex CM at all level(3mm,6mm,9mm) which may be due to-

● Its increased stiffness and less shape memory effect due to post machining heat treatment as compared to Hyflex CM file system which are extremely flexible and have a higher fracture resistance than traditional NiTi files, and also WaveOne Gold file system, may be due to high austenite finish temperature value and two-stage transformation behaviour. [24]

● Multiple increasing taper design (variable taper) of the shaping files (SX, S1, S2) over the length within the shaft with maximum taper (For Sx it is 19% at D9, For S1 it is 11% at D14 and for S2 it is 11.5% At D14). Due to protaper gold's multiple changing tapers over the cutting part, progressively changing helical angle and pitch and no radial lands it removes higher amount of dentin.

CONCLUSION

Hyflex CM NiTi file system showed better canal centering trend specially at the middle third (6 mm) of the canal, followed by WaveOne gold group while Protaper gold group showed comparative lower canal centering ability at all 3 level of root. In groups where ultrasonic irrigation activation of irrigating solution was done, they have showed improved canal centering trend, particularly in the group IIA where shaping done with Hyflex CM NiTi files.

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