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Comparative In-Vitro Evaluation of Remaining Dentinal Thickness at Peri-Cervical Region Using Cone Beam Computed Tomography with Four Different Rotary Ni-Ti File Systems

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Abstract

Aim and objective: This study aims to evaluate and compare the effect of instrumentation with Protaper Gold, Neoendo Flex, Hyflex CM and Protaper Next rotary files systems on Peri-cervical dentin thickness using cone-beam computed tomography (CBCT).

Material & Methods: A total of 60 freshly extracted human mandibular premolars were collected and divided into four groups (n=15), namely, Group 1: Protaper Gold, Group 2: Neoendo flex, Group 3: Hyflex CM, & Group 4: Protaper Next. Pre-Instrumentation CBCT scans were taken after conservative access cavity preparation and working length determination with a size of 10-k file in all four sample groups.

Instrumentation of the canals was done according to the manufacturer recommendations & enlarged up-to tip diameter of #30 to maintain standardization and post-instrumentation CBCT scans of teeth were obtained. Pre & Post instrumentation CBCT Cross Sections were taken in each sample at an interval of 1 mm & the peri-cervical dentine thickness measured 4 mm apical and coronal to the cementoenamel junction. The peri-cervical dentin thickness was calculated as the shortest distance from the canal outline to the closest adjacent external root surface, which was measured in four surfaces, i.e., facial, lingual, mesial, and distal, in the pre & post CBCT scans.

Results: From this study, it was found that Protaper Next file system group preserves maximum amount of peri-cervical dentin followed by Hyflex CM, followed by Protaper Gold and finally the Neoendo flex File system group which was associated with maximum removal of dentin at peri-cervical region when considering all the four surfaces.

Conclusion: Neoendo Flex file system removes maximum peri-cervical dentin as compared to other experimental groups, whereas Protaper Next file system had the least effect on peri-cervical dentin.

Keywords: Peri-cervical dentin, Cone-beam computed tomography, Neoendo flex, Protaper Gold, Protaper Next, Hyflex CM, Rotary Ni-Ti file.

Introduction

Successful endodontic treatment depends on the accuracy of diagnosis and adequate mechanical preparation of the pulp space for three-dimensional filling. The introduction of NiTi rotary instrumentation has revolutionized the art and science of endodontic practice in the past decade with predictable success. The rotary files have been subjected to constant evaluation in the form of metallurgy, design features, the number of instruments, and the manner in which these instruments are driven (rotary/reciprocation).[1] Neoendo Flex file is a 3rd Generation rotary file with a maximum 2 to 3 files shaping system that have undergone gold thermal treatment rendering its extreme flexibility. These files have undergone a specialized heat treatment process which gives them unique flexibility characteristics. Their flutes do not open up when stress levels are reached, yet the file does not present shape memory. The golden color of the file is a result of a very sophisticated and technologically advanced surface treatment to achieve a far superior cutting efficiency.[2]

A more recent and advanced metallurgy process allowed the manufacturer to introduce ProTaper Gold (Dentsply Sirona) rotary files. This 3rd generation file system features identical geometric characteristics as Protaper Universal (Dentsply Maillefer) but presents more flexibility, a shorter handle (11mm) that allows improved accessibility to teeth, and more cyclic fatigue resistance, as it is claimed by the manufacturer. This file system features a patented, progressively tapered design that significantly improves cutting efficiency and safety. The Shaping & Finishing files each have a variably tapered design which respects the concept of minimally invasive endodontics.[3]

A new 3rd generation nitinol rotary instrument (HyFlex CM) has recently been marketed that is machined from a wire (termed CM-wire) previously subjected to a proprietary, novel, thermomechanical processing procedure. Hyflex Controlled Memory NiTi Files (Coltene-Whaledent) are extremely flexible but without the shape memory of other NiTi files. This gives the file the ability to follow the anatomy of the canal very closely, reducing the risk of ledging, transportation or perforation.[4]

The ProTaper NEXT file System is a 5th generation rotary file system that provides shaping advantages through the convergence of a variable tapered design on a given file (ProTaper Universal), innovative M-Wire technology, and a unique offset mass of rotation (as developed by Dr. Michael J. Scianamblo and the Dentsply International team).[5]

Previously it was believed that endodontically treated teeth are more prone to fracture due to loss of moister [6]. But later multiple well-designed studies showed minimal dehydration effects from pulpal removal with similar strength test results between vital and nonvital dentin (Tzyy-Jou G. Huang, Herbert Schilder, Dan Nathanson, 1992. Papa, Cain, and Messer, 1994.)[7-8]. Nowadays It has been concluded that endodontically treated teeth are more prone to fracture largely due to the structural loss during the shaping phase of endodontic treatment and not due to dehydration.

Moreover, it is also apparent that remaining structural integrity and the preservation of especially peri-cervical dentin are key factors that determine the long-term prognosis (relating to fracture resistance) in these teeth (Tang, Wu, and Smales, 2010). The term peri-cervical dentin was first described by Clark and Khademi (2010) [9] and refers to an area roughly 4 mm coronal to the crestal bone and 4 mm apical to the crestal bone which is often destructed with access burs, Gates Glidden burs, and orifice shapers used for coronal enlargement of root canal systems. Root canal therapy requires effective shaping in order to facilitate irrigation and disinfection of the canals. This should be done in such a conservative manner that the structural integrity of the tooth is respected, and dentin is preserved where possible.[10]

To the best of our knowledge, there are only very limited literature [1] available which evaluated the preservation of dentin at peri cervical region with rotary single-file systems and reciprocating single-file systems and there are still no study has been conducted in the past which explored the amount of preservation of remaining dentinal thickness at peri-cervical region before and after instrumentation among two constant (Hy Flex CM, Neo-endo Flex) and two variable tapers (Protaper Gold, Protaper Next) heat-treated rotary multiple file systems. Therefore, this study was conducted to compare and evaluate the amount of preservation of peri-cervical dentin after instrumentation with these file systems using cone-beam computed tomography.

Materials & Methods

The sixty freshly extracted human mandibular second premolar teeth free of caries, cracks, anatomic variations (more than one canal), immature apex, calcifications, resorption, restoration and curved root canal with the angle of curvature less than 20 degrees selected by Schneider's method were used in the study. Before using for the study, the teeth were decontaminated by immersion in 5.25% sodium hypochlorite for 30 min. Then the teeth were cleaned free of debris and calculus with ultrasonic device (Woodpecker UDS P Ultrasonic Scaler, China) and they were stored in normal saline solution until use in order to maintain the physiological characteristics of the teeth. To determine the degrees of curvature and ensure the exclusion criteria (e.g., absence of calcified canal, more than one canal, any internal resorption) a preoperative CBCT was taken of all samples and canal curvatures (both buccolingually and mesiodistally) were measured which ranging between 50 to 20º as described by Schneider were selected. Conservative access preparations were made for all the sample teeth.

The orifice exploration was done with a DG 16 (Dentsply Maillefer) explorer followed by removal of

pulp with the help of a barbed broach (Intello). The sixty specimens were randomly divided using online True Random Number Generator software (www.random.org) into four experimental groups using containing 15 teeth each. All the teeth in each group were mounted in a modeling wax sheet in order to scan using Cone Beam Computed Tomography (Myray, Skyview. 90Kvp, 10mA, 0.33mmVoxel, and Exposure time-20 sec, Effective dose- 37microseivert) to determine the peri-cervical dentin thickness before instrumentation. After initial scanning, each root canal was negotiated by a no 10 K stainless steel file.

The working length (WL) was determined with a No. #10 K (Mani, Japan) file, which was placed in the root canal so that its tip was visible at the apical foramen, the working length was set 1 mm short of the file length. The root canals of each Sample were enlarged up to #15K file (Mani, Japan) followed by shaping of teeth in each group was done with their respective rotary file systems. Each file system was discarded after single use in one canal to standardize the cutting efficiency and the root canals of all teeth (in each group) were enlarged up to size 0.30 mm tip diameter with each file system to standardize the apical enlargement.

During each instrumentation, the instruments were coated with a lubricating paste (RC Help, Prime dental products) to lubricate the canal. After each instrumentation, root canals were irrigated with 3 ml of 5% sodium hypochlorite solution (Steptodont, India). Final irrigation was done with 5 ml of saline (Claris Life sciences, Ahmadabad, India). Then, the samples were subjected to the CBCT imaging keeping the parameter the same as for pre instrumentation scans.

The remaining dentinal thickness during the pre and post instrumentation CBCT scans were evaluated using special software (Irys Viewer, Myray) simultaneously in two different laptops in order to minimize the chances of error while measuring dentinal thickness in each cross-section. As the peri-cervical dentin (PCD) extends 4 mm above and 4 mm below the crest of the alveolar bone, Cross-sections of 1 mm from the buccal Cementoenamel junction were obtained, and the PCD thickness in each section was analyzed for all four rotary file systems i.e., Protaper Gold, Neoendo Flex, Hyflex CM and Protaper Next. The PCD thickness was calculated as the shortest distance from the canal outline to the closest adjacent external root surface, which was measured in four surfaces, i.e., facial, lingual, mesial, and distal for all the groups in the two obtained scans. The Pre & Post-instrumentation thickness of dentine at peri-cervical region were measured and data were sent to the statistician for statistical analysis using Microsoft Excel 2016. One-way Analysis of Variance (ANOVA) with a post hoc Tukey's HSD test was carried out to compare the mean difference(preop-postop) between the four groups at various levels of cross-sections for all the four surfaces (Buccal, Lingual, Mesial and Distal). The P-value of 0.05 was considered as the level of significance.

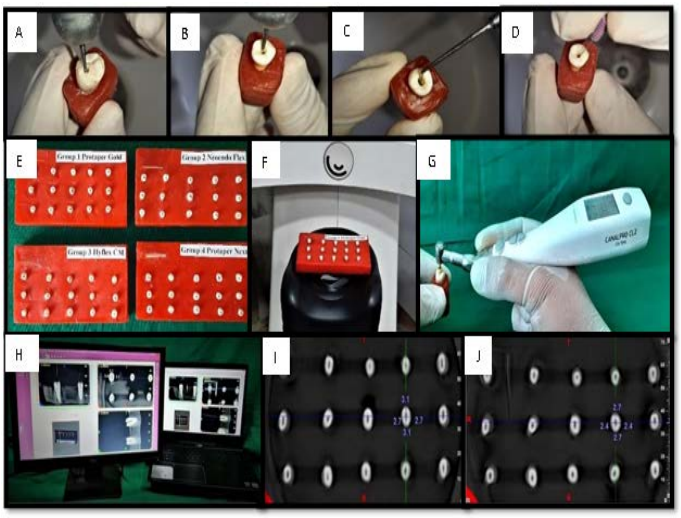


Figure 1: A) The conservative access cavity preparation was started initially with no.2 round carbide bur for penetration through the roof of pulp chamber. B) After

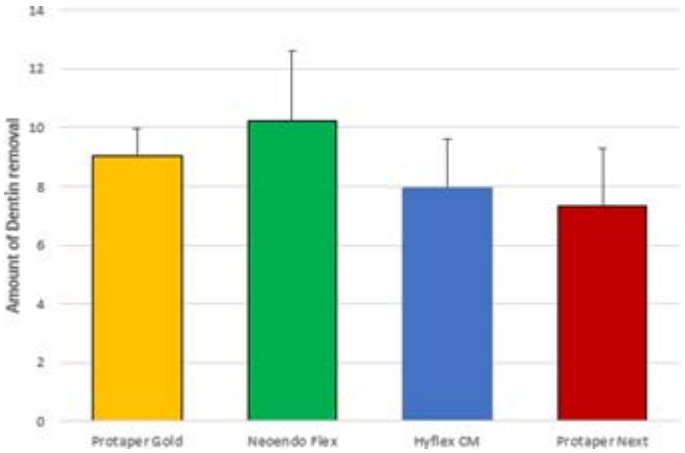
the initial drop, Endo Z bur is used to extent the access cavity as minimum as possible to explore the orifices. C) The exploration of orifice was made with DG-16 instrument. D) Pulp extirpation was made with the help of barbed broach. E) All the teeth in each group were mounted in modeling wax sheet in order to scan using CBCT. F) Pre-instrumentation CBCT was done in each group to determine the peri-cervical dentin thickness before instrumentation. G) Instrumentation of samples were performed with respective file systems. H)

The remaining dentinal thickness during the pre and post instrumentation CBCT scans were evaluated simultaneously in two different electronic appliances. I)& J) Pre & Post instrumentation CBCT measurement of remaining tooth structure on four surfaces i.e., Buccal, Lingual, Mesial, and Distal at different level of cross sections for all the groups in the two obtained CBCT scans.

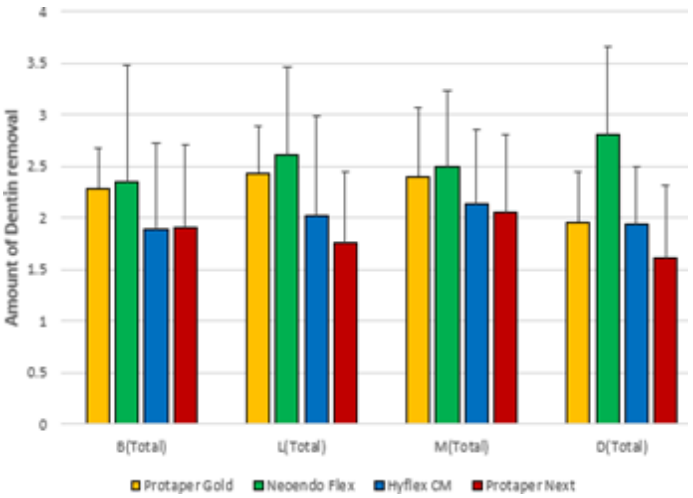
Results

From this study, it was found that Protaper Next file system group preserves maximum amount of peri-cervical dentin followed by Hyflex CM, followed by Protaper Gold and finally the Neoendo flex File system group which was associated with maximum removal of dentin at peri-cervical region when considering all the four surfaces.When compared between Protaper Next with Hyflex CM, Hyflex CM with Protaper Gold, and Protaper Gold with Neoendo Flex, the preservation of peri cervical dentin differed insignificantly when all four surfaces were considered. (P>0.05). When compared between Protaper Next with Protaper Gold and Neoendo Flex, Hyflex CM with Neoendo Flex file system group, the preservation of peri cervical dentin differed significantly when all four surfaces were considered.(P<0.05)

Neoendo flex file system group removes significantly more dentin in the lingual surface, when compared with Protaper Next and in the distal surface, when compared with Protaper Gold, Hyflex CM and Protaper Next (P<0.05).



Graph 1: Average of the mean differences and standard deviation at different levels for all four surfaces for four groups.



Graph 2: Mean differences and standard deviation for allgroups for all four surfaces for four groups.

(I) Groups	(J) Groups	Mean Difference (I-J)	Sig.
ProtaperGold	Protaper Next	1.74	.051*
NeoendoFlex	Hyflex Cm	2.29	.005*
	Protaper Next	2.94	.000**

Table 1: Mean differences and standard deviation for all groups for different surfaces.

*Lowest amount of dentin removal. (Preop-Postop)

		Mean	Std. Deviation
B(Total)	Protaper Gold	2.28	0.40
	Neoendo Flex	2.34	1.14
	Hyflex CM*	1.89	0.84
	Protaper Next	1.91	0.80
L(Total)	Protaper Gold	2.43	0.46
	Neoendo Flex	2.61	0.85
	Hyflex CM	2.01	0.98
	Protaper Next*	1.75	0.69
M(Total)	Protaper Gold	2.39	0.68
	Neoendo Flex	2.49	0.75
	Hyflex CM	2.13	0.73
	Protaper Next*	2.05	0.76
D(Total)	Protaper Gold	1.95	0.50
	Neoendo Flex	2.81	0.85
	Hyflex CM	1.94	0.56
	Protaper Next*	1.60	0.71

Table 2: Results of Tukey's HSD showing the exact difference between the groups

*Values are significantly different when compared to other groups ($P<0.05$).

Discussion

Mechanical instrumentation of the root canal system is considered as one of the most important step of root canal preparation. Although the major goals of root canal preparation are removal of vital and necrotic tissue from the root canals and the creation of sufficient space within the canal for optimal function of irrigation and medicaments.

It is also important that we prevent too much tooth structure loss during shaping as it is the most important cause that decreases the fracture resistance of endodontically treated teeth.[11-12]

The advancements in rotary root canal instruments over the last few years have led to greater root canal enlargements and increased taper. This leads to significant weakening of teeth due to excessive loss of Peri- cervical dentin with variable taper instruments especially in the cervical region of the tooth which is more prone to fracture.[13] Improved prognosis of root canal treated teeth is evident with conservative endodontic cavity where teeth are accessed at central fossa and extended only as necessary to detect canal orifices.

This incomplete deroofing attempts to preserve the soffit and thus preserves the peri cervical dentin which improve the fracture resistance of endodontically treated teeth.[14] Therefore, in this study conservative access cavity was prepared to evaluate the remaining dentinal thickness at peri cervical region after instrumentation. The Peri-cervical dentin extends 4 mm above and below the alveolar crest (Clark & Khademi 2010)9. Since it was an in-vitro study where the crest of the alveolar bone is absent, therefore the nearest substitution of the crest of alveolar bone was considered as cementoenamel junction and as the buccal Cementoenamel junction is more apically positioned than other surfaces[15],therefore in this study the apical most point of buccal cementoenamel junction was standardized for each sample from which all the nine cross sections (Sections of 1millimeter from 4 millimeters above and below the buccal cementoenamel junction) were examined on all four surfaces (Buccal, Lingual, Mesial, Distal).

A study done by Min-Kai Wu16 reported that the median canal diameter of mandibular premolar was 0.28mm (In Mesiodistal dimension) & 0.35 mm (In Buccolingual dimension), as the dimensions of the

mandibular premolar root canal system are wider buccolingually than mesiodistally[17].

Also, a study done by A Morfis18 reported that the mean diameter of apical foramina of mandibular premolars is 0.26 mm. Thus, the minimum canal enlargement to create the apical seat with the master rotary file in this study was considered up to 0.30 millimeters of tip diameter, which was standardized for all the four rotary file systems.

A recently introduced non-destructive & comparatively easier procedure method to evaluate changes of root canal geometry after endodontic preparation in more detail is the use of cone beam computed tomography. Cone beam computed tomography offers reproducible data in all three dimensions and also offers comparison between data on each tooth before and after root canal instrumentation. Furthermore, the Cone beam computed tomography is an economical procedure that offers the opportunity to scan many teeth simultaneously in compared to micro-CT 19-20.

Also, there are various successful well-designed previously published studies available which evaluated canal shape before and after instrumentation using cone beam computed tomography.[21-25] In this era of rotary endodontics several rotary nickel-titanium (Ni-Ti) systems with multiple designs and configurations have been developed. These are more commonly preferred and used by clinicians26, improves augering debris out of a canal thereby associated with less extrusion of debris, required less inward pressure after canal preparation as compared to reciprocation file system.[27-28]

Therefore the remaining dentinal thickness at peri-cervical region before and after canal instrumentation was assessed using four different file systems (Protaper Next, Proteper Gold, Neoendo Flex & Hyflex CM) in order to evaluate the ability of the instruments in the preservation of the peri-cervical dentin. According to this study the maximum preservation of peri-cervical dentin with protaper next file system may be associated with its “M” Wire alloy technology that increases flexibility, its variable taper design with decrease percentage of taper and file diameter than pro-taper gold. The rectangular cross section with off centered mass of rotation which features a swaggering motion of the file into the canal also serves to minimize the contact between a file and dentin (Two point contact)5 and absence of orifice shaper which may also contribute to the peri-cervical dentin preservation.

More preservation of peri-cervical dentin with Hyflex CM file system may be due to its novel CM wire alloy technology that composed of lower nickel content (52% by weight) 29 of the file along with post machining heat treatment 30 both of which increases the proportion of the martensitic component of the alloy at intracanal temperature thereby increasing the flexibility which helps to preserve more amount of peri-cervical dentin.

In this study it was found that Protaper Gold file system group removes more amount of peri-cervical dentin as compared to Hyflex CM and this may be due to its Increased stiffness (less shape memory effect due to post machining heat treatment) as compared to Hyflex CM (no shape memory effect as it is made up of novel CM Wire technology[4] along with post machining heat treatment[30]), increased cross sectional diameter (Convex triangular) with active cutting edges, multiple increasing taper design (variable taper) of the shaping files (SX,S1,S2) over the length within the shaft with maximum taper present at the region of peri-cervical dentin of the tooth.[31]

Neoendo flex file system group removes maximum amount of peri-cervical dentin as compared to other three groups and this may be due to its increased

diameter of orifice shaper file at the region of peri cervical dentin(D14) 2 (the taper and tip diameter of Neoendo flex file is 8% #30-fixed taper, as compared with Hyflex CM: 8%,#25-Fixed taper & Protaper Gold: 0.4% ,#19-variable taper),its triangular cross section with active cutting edges which enhances the cutting efficiency of the file system.[2], more stiffness as compared to other three file system groups and as more number of files were used to reach the standardized apical enlargement as compared to other groups. Although the main goal of those studies[21-25]

Which evaluated the canal centering ability after shaping with different file systems was to compare and evaluate the probability of iatrogenic mishaps like canal transportation, ledge, elbow, perforation, strip perforation among each of the examined file systems. The main aim of this study was to compare the preservation of peri-cervical dentine after using different rotary instrument which increases the fracture resistance of the endodontically treated teeth. It is also expected that when an instrument remains centered in the canal, it preserves more amount of dentin.[32]

Any kind of deviation from original root canal curvature can lead to excessive and inappropriate dentin removal. [33] Studies which evaluated the canal centering ability with different file systems also measured the pre and post instrumentation dentinal thickness at different cross sections along the entire length of the root canal (coronal third, middle third, apical third) similar to this study which also measured the remaining dentinal thickness at the coronal third of root canals only.

Therefore, it can be said that, the file system with the best canal centering ability specially at the coronal third of root canal has the ability of maximum preservation of residual dentin on that region. Similar findings also found by Krisha Doshi [34], who compared the canals centering ability of Three different rotary file systems (Protaper Gold, Hyflex CM, Profile S3) using Cone-beam Computed Tomography and concluded that Hyflex CM has a better centering ability than protaper gold in cervical third (9mm from root apex) as well as middle and apical third (6 and 3 mm from root apex) of root canals. Shenoi et al,[35] also evaluate the shaping ability of V-Taper 2H, ProTaper Next, and HyFlex CM in Curved Canals Using Cone-beam Computed Tomography and found that the mean canal centering ability values at 9mm from root apex of Hyflex CM and Protaper Next varies insignificantly rather than Vtaper 2H which significantly higher than other two groups (Hyflex CM and Protaper Next). Though Neoendo Flex file system was recently introduced in the field of endodontics, its effectiveness should be evaluated further in terms of its efficiency in preservation of peri-cervical dentin thickness.

Conclusion

Within the limitation of the study we can conclude that Neoendo Flex file system removes maximum amount of peri-cervical dentin than that of protaper gold, Hyflex CM & Protaper Next. There was no significant alteration in preservation of peri-cervical dentin when root canals were prepared with Protaper Next and Hyflex CM.

Reference

1. Zinge PR, Patil J. Comparative evaluation of effect of rotary and reciprocating single-file systems on peri- cervical dentin: A cone-beam computed tomography study. J Conserv Dent. 2017 Nov-Dec;20(6):424-428.

2. Neoendo Flex Files - Endodontic NiTi Rotary Files India. Orikam Health care. URL: https://orikamhealthcare.com/product/neoendo.
3. Protaper Gold Brochure by DentsplySirona. URL :https://www.dentsply.com/content/dam/dentsply/pim/manufacturer/Endodontics/Glide_Path Shaping/RotaryReciprocating_Files/Shaping/ProTaper_Gold_Rotary_Files/ProTaper-Gold-Brochure-p7btcwy- en-1502.pdf.
4. Caicedo, Ricardo & Clark, S.J.. (2012). HyFlex CM rotary files: An excellent innovation for endodontic treatment. Endod Pract. 2012;4(6):10-17.
5. Ruddle CJ, Machtou P, West JD. The shaping movement: fifth-generation technology. Dent Today. 2013Apr;32(4):94, 96-9. PMID: 23659098.
6. Helfer AR, Melnick S, Schilder H. Determination of the moisture content of vital and pulpless teeth. Oral SurgOral Med Oral Pathol. 1972 Oct;34(4):661-70.
7. Huang TJ, Schilder H, Nathanson D. Effects of moisture content and endodontic treatment on some mechanical properties of human dentin. J Endod. 1992 May;18(5):209-15.
8. Papa J, Cain C, Messer HH. Moisture content of vital vs endodontically treated teeth. Endod Dent Traumatol. 1994 Apr;10(2):91-3.
9. Clark D, Khademi J. Modern molar endodontic access and directed dentin conservation. Dent Clin North Am. 2010 Apr;54(2):249-73.
10. Vorster, M. (2019). Minimally invasive endodontics using a new single-file rotary system. 2019;(4)6-20.
11. Hülsmann, Michael & Peters, Ove & Dummer, Paul. (2005). Mechanical preparation of root canals: Shaping goals, techniques and means. Endodontic Topics. 2005;10:30-76.
12. Van der Vyver PJ, Vorster M, Peters OA. Minimally invasive endodontics using a new single-file rotary system. Int Dent Afr Ed. 2019;9(4):6-20.
13. V. Arora and M. Yadav and Sing S. Peri-Cervical Dentin (PCD): A New Paradigm for Endodontic Success. Global journal for research analysis. July 2015.4;(7):490-93.
14. Vats S. Mishra P. Nikhil V. Modern Access Cavity Concept: A Review. International Journal of Research and Review 450 Vol.8; Issue: 2; February 2021.450-53.
15. Scheid RC, Gabriela W. Morphology of premolars. Part1. Chapter 4. 8th ed. Philadelphia: Lippincott Williams and Wilkins; 2012. Woelfel's Dental Anatomy: Its Relevance to Dentistry:85-119.
16. Wu MK. R'oris M.Barkis D, Paul R. Wesselink, Prevalence and extent of long oval canals in the apical third. Oral Surgery, Oral Medicine, Oral

Pathology, Oral Radiology, and Endodontology. June 2000;89(6):739-743.

17. Baroudi K, Kazkaz M, Sakka S, Tarakji B. Morphology of root canals in lower human premolars. Niger Med J. 2012 Oct;53(4):206-9.
18. Morfis A. Sylaras SN. Georgopoulou M. Kernani M. Prountzos F. Study of the apices of human permanent teeth with the use of a scanning electron microscope, Oral Surgery, Oral Medicine, Oral Pathology. 1994;77(2):172-176.
19. Haupt F. fitzner J. Hulsmann M. A comparative in vitro study of different techniques for removal of fibre posts from root canals. Aust Endod J 2017:1-6.
20. Patel S, Kanagasingam S, Mannocci F. Cone beam computed tomography (CBCT) in endodontics. Dent Update. 2010 Jul-Aug;37(6):373-9.
21. Noon AK et al. Comparative Evaluation Of Remaining Dentinal Thickness After Protaper Next, Neoendo Flex, Mtwo Rotary Files Preparation Using CBCT -An In Vitro Study. Journal Of Critical Reviews.2020;7(1):1379:90.
22. Issac C. Valli K. Pasha S. CBCT evaluation of peri-cervical dentin thickness after completion of biomechanical preparation with fifth generation rotary files. International Journal of Medical Science and Diagnosis Research.2020;4(8):44-9.
23. Kulkarni NR, Kamat SB, Hugar SI, Nanjannawar GS, Patil PD. Evaluation of remaining dentin thickness following use of three different rotary nickel-titanium retreatment files: A cone-beam computed tomography study. J Conserv Dent. 2019;22(6):588-592.
24. Singh S, Abdul MSM, Sharma U, Sainudeen S, Jain C, Kalliath JT. An in vitro Comparative Evaluation of Volume of Removed Dentin, Canal Transportation, and Centering Ratio of 2Shape, WaveOne Gold, and ProTaper Gold Files Using Cone-Beam Computed Tomography. J Int Soc Prev Community Dent. 2019;9(5):481-485.
25. Hadhoud FM. Cone beam computed tomography assessment of canal transportation, centering ability, and radius change of two single file systems in curved root canal.2019:65(3):2739-47.
26. Christensen GJ. Rotary vs Reciprocal Endodontics. Clinician Reports. 2012;5(9):1-6.
27. Shau Gk et al. Rotary Endodontics or Reciprocating Endodontics: Which is New and Which is True? Journal of Health Sciences & Research, July-December 2016;7(2):51-57.
28. Ruddle CJ. Single-File Shaping Technique Achieving A Gold Medal Result. Advance Endodontics. Dentistry Today. January 2016:1-7.

29. Saber SE, Nagy MM, Schäfer E. Comparative evaluation of the shaping ability of ProTaper Next, iRaCe and Hyflex CM rotary NiTi files in severely curved root canals. Int Endod J. 2015 Feb;48(2):131-6.
30. Gavini G e al. Nickel–titanium instruments in endodontics: a concise review of the state of the art. Braz. Oral Res. 2018;32(e67):44-65.
31. Ruddle.CJ. The Protaper Advantage:Shaping The Future Endodontics.Advance Endodontics. Dentistry Today. 2001:1-9.
32. Gagliardi J, Versiani MA, de Sousa-Neto MD, Plazas-Garzon A, Basrani B. Evaluation of the Shaping Characteristics of ProTaper Gold, ProTaper NEXT, and ProTaper Universal in Curved Canals. J Endod. 2015 Oct;41(10):1718-24.
33. Kandaswamy D, Venkateshbabu N, Porkodi I, Pradeep G. Canal-centering ability: An endodontic challenge. J Conserv Dent. 2009 Jan;12(1):3-9.
34. Doshi K. Antony SDP. Nivedhitha MS. A Comparative Evaluation Of The Canal Centering Ability Of Three Rotary File Systems: An In Vitro Study. Int J Dentistry Oral Sci. 2021;8(6):2870-2874.
35. Shenoi PR, Luniya DA, Badole GP, Makade CS, Kubde R, Khode RT. Comparative evaluation of shaping ability of V-Taper 2H, ProTaper Next, and HyFlex CM in curved canals using cone-beam computed tomography: An in vitro Study. Indian J Dent Res. 2017 Mar-Apr;28(2):181-186.