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A Comparative Evaluation Of Pericervical Dentin Thickness Following The Use Of Three Different Rotary Systems: A Cbct In-Vitro Study

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Abstract:
Background*: It Is Apparent That Remaining Structural Integrity And Peri-Cervical Dentin(PCD) Are Key Factors That Determine The Long-Term Prognosis Of These Teeth. PCD Extends 4 Mm Above And 4 Mm Below The Crestal Bone. Root Fractures In Endodontically Treated Teeth Is Strongly Correlated To Remaining Dentin Thickness(RDT) Following Intra-Radicular Procedures. The Type Of Instrument Used Plays An Important Role In The Amount Of Dentin Removed. The Advent Of Single File Rotary Systems, With Smaller Initial Wire Blank, Fluting Design And Thermal Treatments Have Simplified Cleaning And Shaping And Aids In Minimally Invasive Endodontics(MIE). Revo-S(RVS), Trunatomy (TNT) And Hyflex EDM(HEDM) Are Three Fifth Generation[3] File Systems Where Manufacturers Claimed To Remove Lesser Amount Of Dentin Than Previous Files.*
Materials And Methods*: Dentin Thickness In The Pericervical Area Of Each 30 Freshly Extracted Single-Rooted Human Mandibular Premolars With Single Canal Were Determined By CBCT Scanning Before And After Instrumentation With Revo-S(RVS), Trunatomy (TNT) And Hyflex EDM(HEDM) File Systems. The PCD Thickness Was Measured In Axial Sections At Two Levels Within A 4mm Distance From The CEJ, One 2 Mm Below The CEJ And The Second 2 Mm Above The CEJ.*
Results: *PCD Measurements Obtained In This Study Shows That The TRN File System Had The Lowest Amount Of Dentin Removal With Statistically Significant Result At Most Of The Levels Under Study, But Not All The Levels.*
Conclusion: *All Three Groups Under Study Showed Statistically Significant Differences In Dentin Thickness Post-Instrumentation. However, The Trunatomy File System Showed Better Conservation Of Tooth Structure Compared To Revo-S And Hyflex EDM.*
Key Word: *Intrathecal; Bupivacaine; Buprenorphine; Nalbuphine; Postoperative Analgesia.*

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I. Introduction

The success of endodontic treatment ca[i]n be influenced by factors such as a thorough knowledge of root canal morphology, access cavity design, and chemomechanical preparation techniques. An ideal access cavity should help in locating canal orifices, permit direct access to the initial canal curvature, and also conserve tooth structure. The traditional preparations lead to additional loss of tooth structure and can weaken the remaining tooth. This lead to advocating conservative acees cavity designs. Newer access cavity designs are aimed at reducing the loss of tooth structure and to strengthen the remaining tooth structure. But later studies revealed that not only the preservation of the coronal tooth structure by conservative access cavity preparation methods are essential but the instruments and the techniques used also plays an important role in maintaining the

structural integrity because the circumferential residual dentin thickness along the length of the tooth should be maintained for long occlusal force withstanding and fracture resistance under the load.

Remaining dentin thickness along the entire length of the canal can influence the long term prognosis of the tooth, which varies along the length of the tooth. Recently studies have done to quantify this values and their influence on the fracture resistance. Peri-cervical dentin extends 4 mm above and 4 mm below the crestal bone. It plays a pivotal role in toth fracture by acting as the neck of the tooth. It is important to maintain the pericervical dentin for feerrule and to improve fracture resistance of the tooth.

This study was aimed to evaluate the pericervical dentin (PCD) thickness on using three different rotary file systems, namely Revo-S, Trunatomy and Hyflex EDM.

II. Material And Methods

This in-vitro comparative study was carried out on 30 extracted human mandibular premolar teeth in Department of Conservative Dentistry and Endodontics, PSM College of Dental Science and Resesarch, Thrissur and e Dent Imaging X-ray lab, Thrissur during 2nd to 23rd of December 2022.

Inclusion criteria:

1. Intact single rooted teeth with single canal
2. Teeth with completely formed root and mature apices
3. Teeth which were extracted due to periodontal reasons or for orthodontic treatment.
4. Teeth with less than 10˚ curvature

Exclusion criteria:

1. Teeth with pre-existing fractures, caries, craze lines, resorption and restoration were excluded
2. Teeth with calcified canals
3. Teeth with root curvature more than 10˚ are excluded.

Procedure methodology

After receiving approval from ethical committee, a total of 30 freshly extracted single-rooted human mandibular premolars having similar dimensions with single root and single canal were collected and stored in sterile normal saline at room temperature. Teeth were cleared of any debris or deposits using an ultra sonic scaler and decontaminated by immersing in 5.25% NaOCl for 30 minutes. Then the samples were stored in sterile normal saline 0.9% at room temperature until use. All the teeth were examined under a stereomicroscope at 10× magnification to ensure the absence of pre-existing fractures. To standardize the measurement, teeth with similar dimension ie length, and diameter were used.

The specimens were then randomly divided into 3 groups of 10 each. The three experimental groups were;

Group 1- Instrumented using Revo-S file system

Group 2- Instrumented using TruNatomy file system

Group 3- Instrumented using HyFlex EDM file system

A customised template was made to arrange teeth in an arch form with size equivalent to the bite plane of CBCT machine, to standardize the position and angulation of the specimens for the CBCT scanning, with cold cure acrylic base mimicking bone and modeling wax as the periodontium. This template also allowed for the repositioning of the teeth in same position after instrumentation.

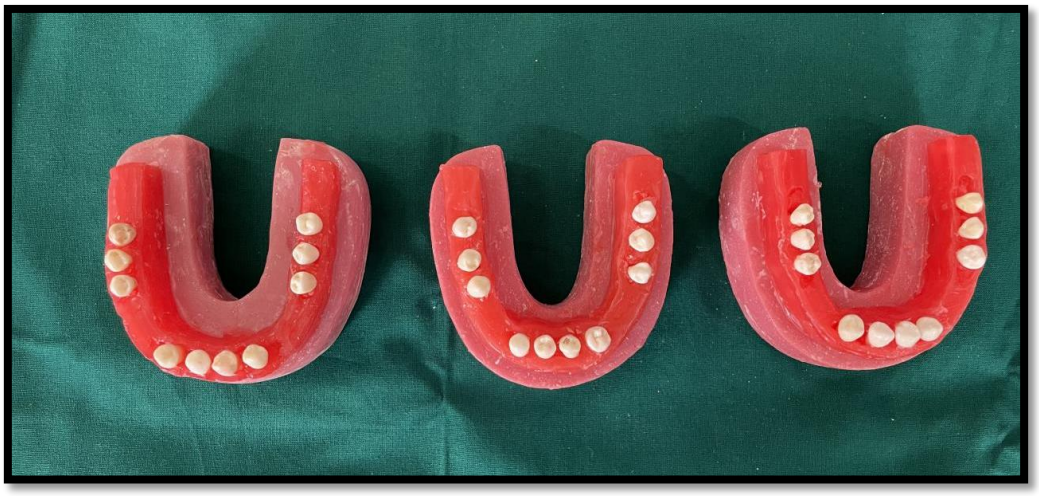


Figure1: Customised Template

Pre-operative scans: A customized template(figure 1) with a size equivalent to the bite plane of the CBCT machine was made using cold cure acrylic resin and modeling wax for each group to standardize the position and angulation of the specimens for the CBCT scanning and also to allow for the repositioning of the teeth in the same position after instrumentation.

The preoperative CBCT scans were made for each sample with exposure parameters 80 kVp, 7mA using HDX WILL DENTRI (HDX WILL North America) CBCT machine. The images were analyzed using InVivo 6 software (Anatomage, USA). The PCD thickness was measured in axial sections at two levels within a 4mm distance from the CEJ, one 2 mm below the CEJ and the second 2 mm above the CEJ. The dentin thickness was calculated as the shortest distance from the canal outline to the closest adjacent root surface 1, which was measured in four surfaces i.e.; facial, lingual, mesial, and distal for all teeth samples using InVivo 6 software (Anatomage, USA).

Instrumentation: Conservative access cavity were prepared using size 1 Endo access bur. Canal patency was determined by passing 10 K file passively and the working length was established 1 mm short of the file length at which the file become visible through the apical foramen(1). 17% EDTA, normal saline, and 5.25% sodium hypochlorite were used to irrigate the canal while instrumenting the samples by no. 15 K file upto the working length to produce a reproducible glide path.

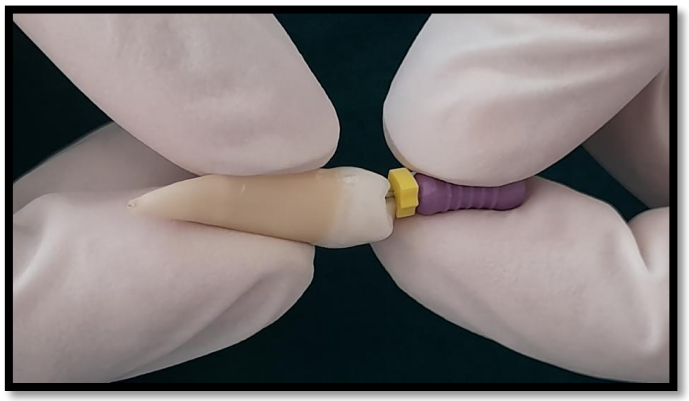


Figure 2: Working length determination

The samples were then instrumented with the corresponding rotary file system according to the manufacturer's instructions.

Group 1: Revo-S Group

All the 10 samples were instrumented sequentially by using SC1, SC2, and SU files with a speed of 350rpm and torque of 0.8 Ncm. The SC1 was taken upto two third of the working length, followed by SC2 upto full working length, and final shaping was done with SU upto full working length. Intermittent irrigation and recapitulation was done between the instrumentation.

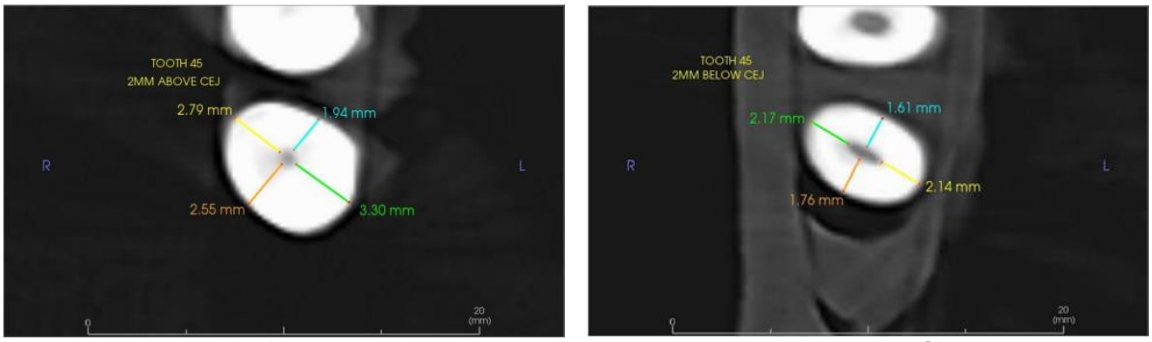
Group 2: TruNatomy Group

All 10 samples were instrumented sequentially by using TruNatomy orifice modifier, Glider, and TruNatomy prime shaping files at a speed of 500 rpm and torque of 1.5Ncm. TruNatomy orifice modifier was used up to coronal 5 mm of the canal in 2-3 gentle amplitude motions. The TruNatomy Glider file was used in 2-3 gentle amplitude upto the full working length of the canal followed by the TruNatomy Prime file upto full working length. Intermittent irrigation and recapitulation was done in between each file.

Group 3: HyFlex EDMGroup

All 10 samples were instrumented sequentially by using a HyFlex EDM orifice opener up to coronal one third of the canal, followed by a Glidepath file upto full working length in 2-3 amplitudes, and finally by using HyFlex One file upto full working length. Intermittent irrigation and recapitulation was done in between each file. After instrumentation, manual dynamic agitation was done with NaOCl and then a final rinse of saline irrigation was done.

Post-Operative Scans: Post-operative CBCT scans were taken after repositioning tooth samples in customized template in the same position as that of the pre-operative scan maintaining the angulation. The PCD values were recorded in the same manner as before.



a) b)

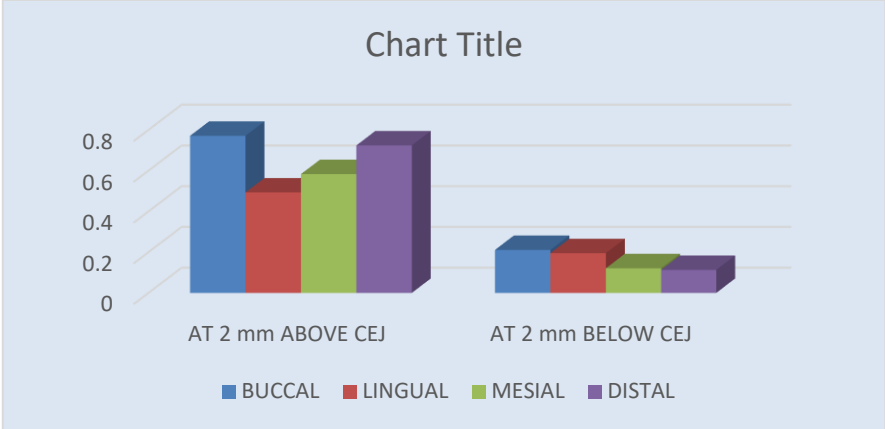
Figure 3: CBCT image showing axial sections; a) At 2 mm above CEJ, b) At 2 mm below CEJ. Markings show linear measurement.

Statistical analysis

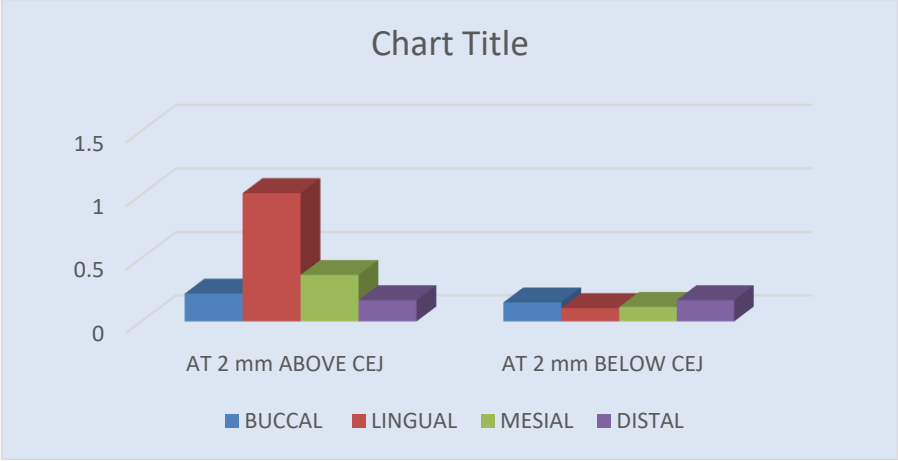
The paired t-Test was used to assess PCD changes for each group at different levels. The intergroup comparison was carried out with One-Way ANOVA for 2 different levels under study.

III. Result

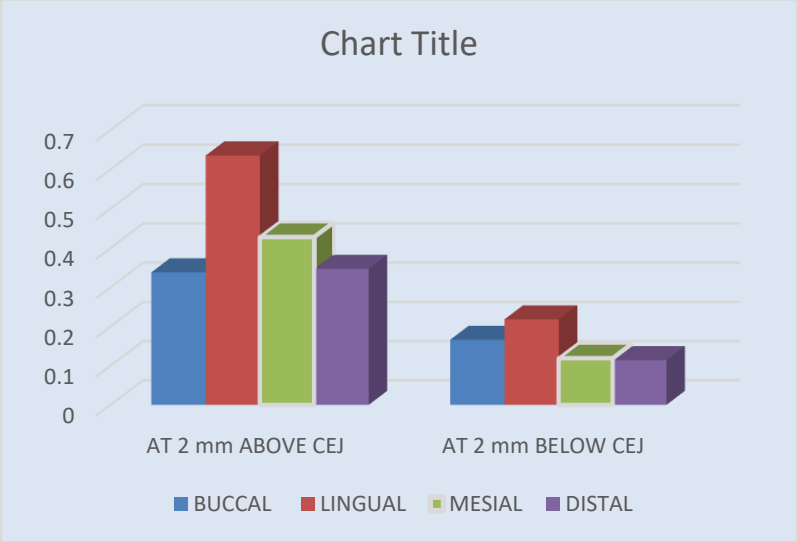
PCD measurements obtained in this study shows that the TRN file system had the lowest amount of dentin removal with statistically significant result at most of the levels under study, but not all the levels. Comparatively higher amount of dentin removal was seen on the lingual aspect at 2 mm above CEJ, and distal aspect at 2 mm below CEJ.



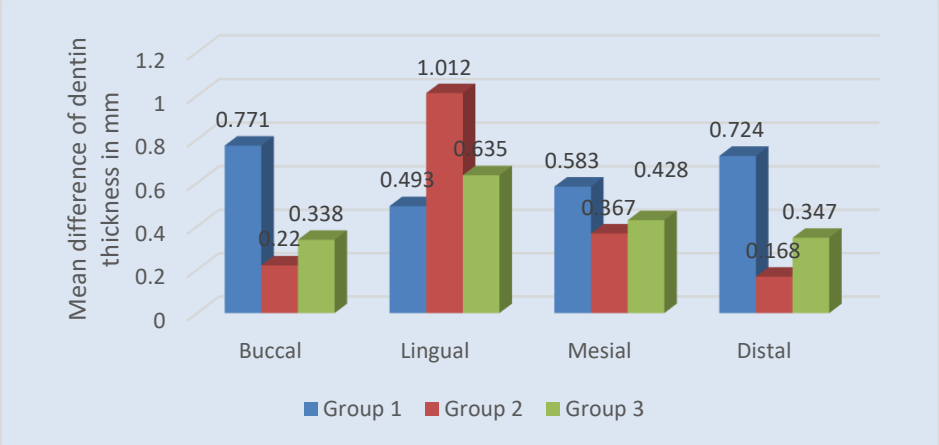
Graph 1: Change in dentin thickness for group 1 at different levels



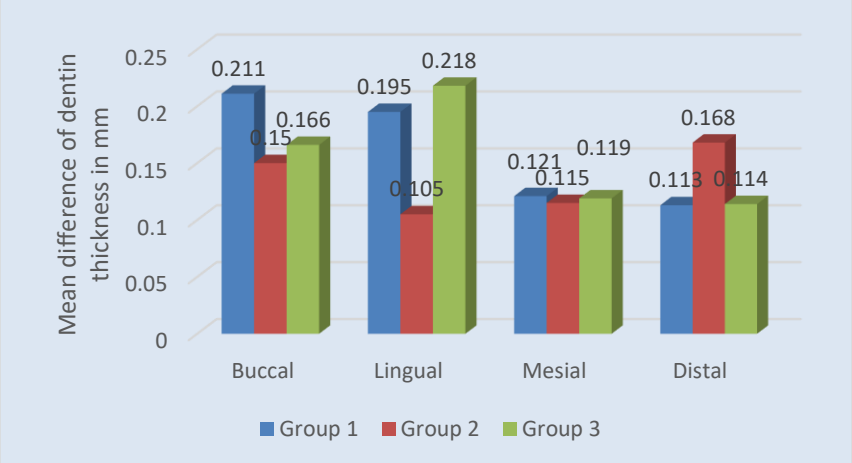
Graph 2: Change in dentin thickness for group 2 at different levels



Graph 3: Change in dentin thickness for group 3 at different levels



Graph 4: Intergroup comparison of change in dentin thickness at 2 mm above CEJ



Graph 5: Intergroup comparison of change in dentin thickness at 2 mm below CEJ

IV. Discussion

Root canal therapy requires effective shaping 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 dentine is preserved whenever possible[1]. Remaining dentin thickness (RDT), also known as residual dentin thickness is a key factor for establishing conservative as well as endodontic treatment and is first suggested by Stanley in 1984[2]. After the shaping of the root canal wall, RDT plays a major role in the structural and functional integrity of the tooth with a directly proportional relationship. According to Katz et al[3](2006), approximately 1mm of dentin should be present circumferentially in the entire length of the root after root canal instrumentation otherwise it may lead to strip perforation and vertical root fracture. Therefore, thorough knowledge of the anatomy and thickness of dentin in different regions of the root is essential.

PCD is the dentin near the alveolar crest, roughly 4 mm above the crestal bone and extending 4 mm apical to the crestal bone, acting as the neck of the teeth. Peri-cervical dentin (PCD) preservation has been reported as critical in the long–term survival especially in molars with optimum function (Clark and Khademi et al, 2010)[4]. This critical zone is important for 3 reasons: ferrule, providing fracture resistance, and dentin tubule orifice proximity from inside to out.

More advanced treatment options in endodontics (for example magnification and more flexible NiTi instrumentation) has therefore shifted paradigms to a minimal invasive approach in both access cavity preparation as well as shaping of root canals in order to preserve dentine[5]. Numerous variables influence the cutting efficiency of NiTi files, including rake and helical angle, depth and number of flutes, cross-sectional area and design – which seems to be a crucial parameter– tip design, chip removal capacity, hardness, instrument motion, and manufacturing processes including heat treatment[6].

In the present study, Cone Beam Computed tomography(CBCT) was used to analyze cervical dentin thickness and radicular dentin thickness. CBCT is a diagnostic imaging modality that provides high quality three-dimensional representation of bony structures of the maxillofacial region with small field of view and smaller doses than conventional CT. This method ology permits calculations of the amount of removed dentin during cleaning and shaping of the tooth without complicated procedures, destructive sectioning of the specimens or loss of the root material during sectioning.

Revo-S NiTi instrument system (Micro-Mega, Besanc¸on, France) includes three shaping instruments; the shaping and cleaning instrument number 1 (SC1) with #25/.06 taper rotary used to enlarge the coronal two-thirds of the canal. SC2 with #25/.04 taper, and universal shaper (SU) with #25/.06 taper used along the entire length of the canal, which may result in high stresses on the instrument[7]. There are finishing file options available with 6% taper and sizes #30, #35, and #40.

Revo-S has an offset center of rotation, improving the efficiency of canal shaping with continuous clockwise rotation of the instruments inside the root canal system. This offset design reduces the taper lock or the screwing effect which causes instrument separation[8]. This file system containing only three files simplifies and optimizes the cleaning and shaping of the root canals and the asymmetric cross-section of the Revo-S facilitates penetration by a snake-like movement inside the canal. In a study conducted by Tomer A K et al[9], in which he compared the remaining dentin thickness at apical middle and cervical thirds of teeth on instrumenting with ProTaper Gold, NeoEndo, and Revo-S systems using cone beam computed tomography, Revo-S showed less dentin removal than ProTaper and NeoEndo at different levels under study.

Recently, TruNatomy instruments (TRN) (Dentsply Sirona) has been developed as a novel type of heat-treated NiTi instrument with a special design. The TRN shaping instruments are provided in three different sizes which are small (size 20/.04 taper), prime (size 26/.04 taper), and medium (size 36/.03 taper). It has been claimed by the manufacturer that the three shaping instruments of TRN provide a slim shaping which enhances the debridement due to more space that is available by this unique design of the instrument. The slim NiTi wire design is 0.8 mm instead of up to 1.2 mm diameter of most other variable tapered instruments. The TRN instruments have off-centered parallelogram cross-section design[1].

TruNatomy instruments are manufactured using a post-manufacturing thermal process that produce a file with super-elastic NiTi metal properties. Another advantage of this reduced memory of the files are that in cases with difficult straight-line access, it is possible to slightly pre-curve the files to allow easy placement into the canal orifices[10]. File geometry includes variable taper, off-center design with a square cross-section[11]. All the instruments in the system have a shortened handle of 9.5mm to further improve the straight-line access and placement of the instruments into the root canal systems[1]

HyFlex EDM are the first endodontic instruments manufactured with EDM technology. According to the manufacturer, this will result in an increase in cutting efficiency, and flexibility and reduces the risk of instrument fracture[12]. The presence of the Ni_4Ti_3 intermetallic compound in the EDM files is of particular interest in relation to the existence of the R-phase and may shed some light on the processing of these instruments.

In the present study TruNatomy file system showed a lesser amount of dentin removal at all levels of the tooth under study, 2 mm above and 2 mm below the CEJ compared to Revo- S and Hyflex EDM. This is in accordance with the reports of Morales et al and Van der Vyver et al. In the study conducted by Morales et al[13], they compared the shaping ability of WaveOne Gold (Dentsply Tulsa Dental Specialties, Tulsa, OK), Reciproc Blue (VDW, Munich, Germany), TRUShape (Dentsply Tulsa Dental Specialties), XP-endo Shaper (FKG, La Chaux-de-Fonds, Switzerland), iRace (FKG), and TruNatomy (Dentsply Sirona, Ballaigues, Switzerland) for preparation of moderately curved canals using micro–computed tomographic technology. He concluded that TruNatomy and XP-endo Shaper were the files that kept the anatomy better and the structure of the canal walls in all the longitude of the roots. According to him similarities and differences regarding the shaping ability between the files could be more related to their characteristics in alloy, taper, and design than with their kinematic characteristics.

TruNatomy touched the lowest percentage of canal surface (50%)[13]. This may affect the biomechanical preparation of the root canal as all the canal surfaces are not touched by the file. It could be explained by the off-centered parallelogram cross-section and slim NiTi wire design of 0.8 mm [13].

Van der Vyver et al[1], in his case report, concluded that the TruNatomy system preserved original canal anatomy, dentine thickness and maintained the structural integrity of teeth which is an integral part of root canal shaping and preparation. The case report also stated that focusing on the benefits like dentine preservation, improved performance, and efficacy the TruNatomy instruments offer the clinician superior debridement while respecting original canal anatomy[1].

Alarfaj B[14], compared the canal transportation in mesiodistal and buccolingual directions, using TRN, HEDM, and ProTaper Gold. According to the results, TRN showed the least transportation in both directions in addition to the best centralization with a significant difference from other file systems used. These findings could be attributed to the small and regressive taper (0.04) of TRN compared to the larger apical taper (0.08) of both ProTaper Gold and HFEDM, and the off-centered parallelogram cross-section, non-cutting tip, and the slim NiTi wire design of 0.8 mm making it more conservative during root canal preparation.

PCD measurements obtained in this study shows that the TRN file system had the lowest amount of dentin removal with statistically significant result at different levels under study, especially 2 mm below the CEJ. This is in accordance with the study results by Massad N et al (2021)[15]. This could be due to the difference in geometry of the file systems used. In the case of the TruNatomy Glider and TruNatomy preparation instruments, the largest taper is at the apical extent of the shaping instruments. The instruments are designed to provide approximately the same apical sizing as the most commonly used instruments. However, they have a reduction or regressive taper as the instrument progresses coronally allowing each instrument to maintain the 0.8mm maximum flute diameter[1]. Gruia C et al[12], in her study, assessed the quality of the root canal shaping using rotary endodontic instruments ProTaper Next X1-X2 (Dentsply Sirona) with ProGlider (Dentsply Sirona) and HyFlex EDM(Coltene/Whaledent). They concluded that the coronal enlargement can be due to the unique design of these instruments which allows their contact with the root canal circumference in only two cutting points, and because of their swaggering motion[12]. This is in agreement with the results obtained in this study.

PCD 2mm above CEJ is also affected by the access cavity preparation. Varghese et al and Makati et al, in their studies, concluded that the amount of coronal peri-cervical dentin was significantly greater in the conservative access groups[16],[17]. In the present study, the mean of the difference between pre-operative and post-operative values in PCD coronal to the floor of the pulp chamber was significantly higher TruNatomy group and compared to 2 mm below CEJ. It is likely that the RDT in this area is simply a function of the access cavity size[18] and the type of instrument used. On contrary to this, in the present study, for group 2 measurements obtained on the lingual aspect at the level of 2 mm above CEJ for much higher than that of other aspects, this could be due to lateral forces and the larger orifice modifier of TruNatomy with #20, 8% taper.

Tomer A K et al[9] in his case report stated that the Hyflex EDM system is an efficient file system to shape the root canal completely to a continuously tapering funnel shape. He also added that it has extreme fracture resistance due to the innovative manufacturing process, controlled memory which allow to follow the anatomy of the canal, significantly reducing the risk of ledging, transportation, and perforation. It has increased flexibility, at the same time reduces the number of instruments needed for effective cleaning and shaping.

Minimally invasive Endodontics(MIE) is getting popular. The advantages of MIE are faster shaping with fewer files, lower risk of fracture of the files, greater preservation of root dentin, and good cleansing if irrigant activation is used. Recent research has shown that conservative shaping can achieve excellent results when performed in conjunction with active cleaning[18].

Further clinical researches are required with more sample size, more operators, and evaluators to produce more conclusive results. Within the limitations of this study, it can be concluded that the TruNatomy filesystem preserves more tooth structure compared to the other two fifth-generation file systems HyFlex EDM and Revo-S.

V. Conclusion

Respecting original canal anatomy, preserving dentine, and therefore maintaining the structural integrity of teeth should form an integral part of root canal shaping and preparation. Similarities and differences regarding the shaping ability between the files could be more related to their characteristics in alloy, taper, and design than with their kinematic characteristics.

Within the limitations of this study, it can be concluded that conservative tooth preparation with a conservative access cavity and single file systems with less taper can improve the preservation of tooth structure.

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