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Comparative Evaluation of Efficiency and Efficacy of Various Files System Used in Endodontics: And in Vitro Study

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Abstract

Dental caries remains a prevalent ailment impacting human populations globally. Despite advancements in prevention and management strategies, children continue to shoulder a significant portion of the burden associated with this condition. The field of endodontics has undergone significant evolution and revolution over time. Modern endodontic practices bear little resemblance to traditional methods, which primarily rely on manual instrumentation.

Originally, carbon steel was used to make endodontic files, but this material was prone to corrosion, breakage, and discolouration. After that, stainless steel files were released, and subsequently, NiTi files were quite popular because of their better qualities. While traditional stainless-steel files usually had a 2% taper, NiTi files now offer a 12% taper. However, manual handling of these files was laborious and frequently resulted in operator and patient fatigue3 While manual root canal instrumentation is commonly used to treat primary teeth, there are several disadvantages to this approach, Thus, the goal of this research is to evaluate and analyse the efficacy and productivity of various file management system

Aim & Objectives: Compare & evaluate the efficiency and efficacy of file systems in terms of cleaning efficiency and remaining dentine thickness tems

Materials & Methods: The current research took place in the Department of Pediatric and Preventive Dentistry in Modinagar, Ghaziabad in association with the Department of Oral Pathology and Microbiology and Department of Oral Medicine and Radiology at D. J. College of Dental Sciences & Research. The fifty-six teeth that satisfied the requirements for inclusion were split into two major groups: Group A (Cleaning efficacy) (n= 28) Group B (Remaining/Residual dentin thickness) (n=28)).

Conclusion: Among experimental materials the Kedo S plus file system had demonstrated the highest but comparable cleaning effectiveness to Kedo S Square system while manual Hand ProTapers demonstrated the least efficacy. The Kedo S plus file system demonstrated the least but comparable reduction in dentin thickness after biomechanical preparation. Among experimental materials Hand ProTaper showed maximum reduction in remaining dentin thickness after biomechanical preparation.

Keywords: Laborious, Discolouration, Root fracture, Protracted operations

Introduction

Dental caries remains a prevalent ailment impacting human populations globally. Despite advancements in prevention and management strategies, children continue to shoulder a significant portion of the burden associated with this condition. The field of endodontics has undergone significant evolution and revolution over time. Modern endodontic practices bear little resemblance to traditional methods, which primarily rely on manual instrumentation. Originally, carbon steel was used to make endodontic files, but this material was prone to corrosion, breakage, and discolouration[1]. After that, stainless steel files were released, and subsequently, NiTi files were quite popular because of their better qualities. While traditional stainless-steel files usually had a 2% taper, NiTi files now offer a 12% taper.

However, manual handling of these files was laborious and frequently resulted in operator and patient fatigue3 Treatment failure may result from root perforation caused by excessive flaring of the root canal. Additionally, if the root canal is too widely opened to accept bigger instrumentation files, dentin thickness may be reduced, which increases the possibility of vertical root fracture.[2] There is a higher risk of fracture during instrumentation because more dentin is removed. Therefore, the thickness of the residual dentin (RDT) is important for improving the resistance of endodontically treated teeth to fracture. To increase effectiveness and lower these dangers, the most recent advancements in instrument design have included non-cutting tips, radial lands, diverse cross-sections, and adjustable tapers. While manual root canal instrumentation is commonly used to treat primary teeth, there are several disadvantages to this approach, including challenging patient participation, protracted operations, and a variety of clinical problems including perforation, ledge development, canal transportation, dentinal fissures, and broken files. Hand ProTaper instruments are considered a significant advancement in the mechanical treatment of root canals. Their unique convex triangular cross-sectional shape, guided tip design, and variable helical angle and slope offer distinct advantages over traditional steel or nickel-titanium instruments [3]. Ongoing research in rotary endodontics continually introduces newer systems with improved efficiencies. Currently, there are five generations of rotary shaping files available.

Aim & Objectives

Compare & evaluate the efficiency and efficacy of file systems in terms of cleaning efficiency and remaining dentine thickness using stereomicroscope and CBCT.

Materials & Methods

An in vitro study Primary clinical research (experimental) took place in the Department of Pediatric and Preventive Dentistry in Modinagar, Ghaziabad in association with the Department of Oral Pathology and Microbiology and Department of Oral Medicine and Radiology at D. J. College of Dental Sciences & Research. The fifty-six teeth that satisfied the requirements for inclusion were split into two major groups: (fig 1)

(1) Group A (Cleaning efficacy) (n= 28)

1. A1 - Kedo S Square (n=7)
2. A2- Kedo S Plus (n=7)
3. A3- Manual Protaper (n=7)
4. A4- No file system used (n=7)

(2) Group B (Remaining/Residual dentin thickness) (n=28)

1. B1 - Kedo S Square (n=7)
2. B2 - Kedo S Plus (n=7)
3. B3 - Manual Protaper (n=7)
4. B4 - No file system used (n=7)

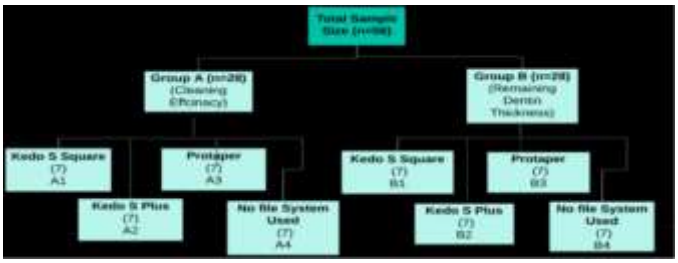


Figure 1: Study Sample

According to OSHA (Occupational Safety and Health Administration) regulations, all teeth underwent scaling with an ultrasonic scaler to remove debris, and they were all utilised within three months. After that, the samples were kept at room temperature in distilled water. After access opening and biomechanical preparation with respective file systems, cleaning efficacy was evaluated by using stereomicroscope and remaining dentin thickness was evaluated using CBCT.

Inclusion Criteria

- Teeth removed without any abnormal root resorption, either internal or exterior.
- Existence of apical closure
- Lack of perforation in the furcation region.

Exclusion Criteria

- Immature tooth
- Presence of perforation in the furcation area
- Presence of pathological root resorption
- Considerable root angulation

Discontinuation Criteria

- If there is any visible fracture of root while doing biomechanical preparation.
- If India ink is extruded from the apical end.

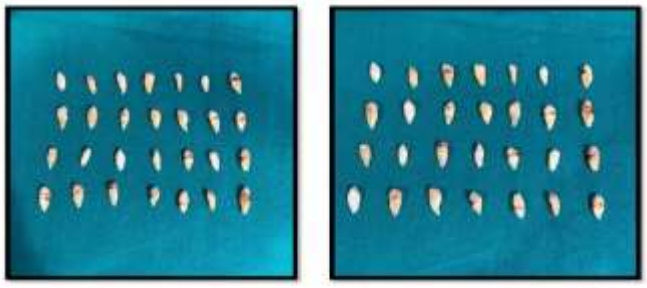


Figure 2: Samples comprising of single rooted teeth

Methodology

Preparation of the Samples

A total of 56 anterior teeth were collected and evenly distributed based on the file systems utilised. (Fig: 1)

The procedures conducted in all four groups were as follows:

1) Access Cavity Preparation

2) Measurement of the working length.

3) Pulp Extirpation

Procedure

Group A (Cleaning efficacy)

All samples in Group A underwent the same preparation procedure until pulp removal. Subsequently, Indian ink was used to fill the root canals using a 30-gauge needle syringe until a drop was visible at the apex. To enable ink penetration, the teeth were immersed in distilled water at room temperature for 48 hours following the application of the dye. Afterwards, 28 allotted teeth were divided into four subgroups according to three files systems used and one control group where no files system was used. Several file systems were used for the biomechanical preparation according to the designated categories

Biomechanical Preparation

1. Group A1 (Kedo S Square)

The Kedo-S Square rotary files comprised two distinct files: one intended for use on anterior primary teeth (A1) and another designed for posterior primary teeth. (fig :3)

Figure 3: Biomechanical preparation with Kedo S Square

2. Group A2 (Kedo S Plus)

There is just one file in the Kedo S Plus system, and it has a teardrop-shaped coronal cross-section and a triangular apical cross-section. This single-file system includes P1+ files for molars and A1 for incisors. Similar to group A2, the Kedo S Plus method was employed for biomechanical preparation. (fig: 4)

Figure 4: Biomechanical preparation with Kedo S Plus

3. Group A3 (Protaper)

The innovative ProTaper nickel-titanium rotary files have sophisticated flute configurations that taper progressively, offering maximum flexibility and efficiency for reliable cleaning and shaping result (fig:5)

Figure 5: Biomechanical preparation with Protapers

4. Group A4

No Biomechanical preparation was done

Decalcification of the samples

Following their biomechanical preparation, the teeth in each group were put individually in breakers with labels that contained 10% nitric acid to undergo decalcification Until the tooth was completely decalcified, the acidic solution was replaced every day. The teeth were hung with thread in a breaker to ensure complete decalcification of all the surfaces. It took almost twenty-four hours for teeth samples to decalcify completely. The complete decalcification of the teeth was ensured by the sponginess of the tooth which was checked with the help of the blunt probe. (fig : 6)

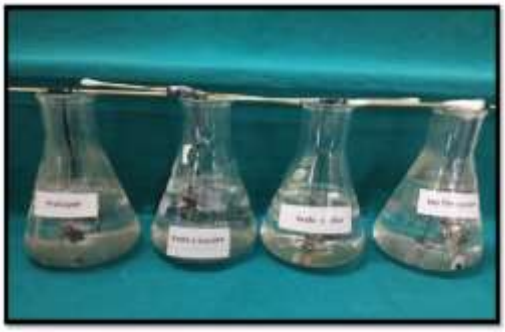


Figure 6: Samples hung in 10% Nitric acid for decalcification

Dehydration of the samples

Running tap water for approximately an hour to ensure complete removal of any remaining decalcifying agents. After that, the teeth were immersed in an assortment of ethyl alcohol solutions for eight hours each to dry them:

70%, 95%, and finally 100% pure alcohol for eight hours. (fig: 7)

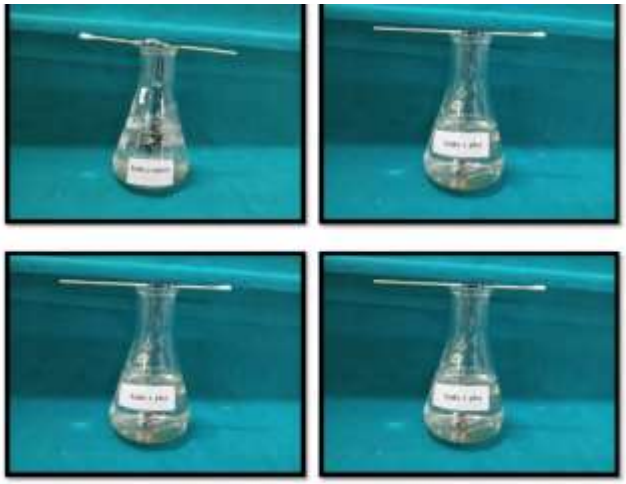


Figure 7: Dehydration of the samples

Clearing of the sample

Following dehydration, the teeth were immersed in methyl salicylate solution (oil of the apple green) for 6 hours to ensure the complete removal of any remaining calcific components, rendering the samples fully translucent.

Microscopic evaluation

Using a stereomicroscope with a 10x magnification, the amount of Indian ink remaining in the canal's apical, middle, and coronal thirds was assessed. The results were reported on a scale from 0 to 3. (Fig: 8)

Figure 8: Stereomicroscope

Scoring Criteria for the ink removal

Grade 0: Indicated complete clearance, where the entire canal was thoroughly cleaned. (Fig: 9)

Grade 1: Represented the nearly complete removal of the ink. (Fig :10)

Grade 2: Indicated partial removal of the ink. (Fig: 11)

Grade 3: Indicated no removal of ink. (Fig: 12)

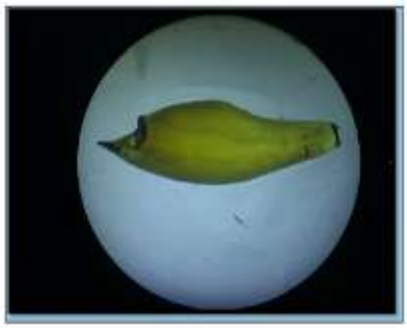


Figure 9: No Ink Remaining in the root canal after biomechanical preparation was done. (Grade 0)

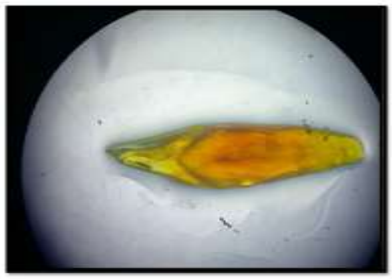


Figure 10: Almost all Ink was removed from the root canal after biomechanical preparation was done. (Grade 1)

Figure 11: Partial Ink remaining in the root canal after biomechanical preparation was done. (Grade 2)

Figure 12: No Ink was removed. (Grade 3)

Group B (Amount of Remaining Dentin)

The twenty-eight removed anterior single-rooted teeth were selected and organized based on the file system in use: Group B1 for Kedo S Square, Group B2 for Kedo S Plus, Group B3 for ProTaper, and Group B4 as a control group with no file system. This categorization was aimed at assessing the remaining dentin thickness.

Pre-Instrumentation CBCT

CBCT scans were conducted before instrumentation for all samples. After biomechanical preparation using different file systems, the dentin thickness that remained after the twenty-eight removed teeth in each group was evaluated thanks to these first Cone-beam computed tomography (CBCT) scans that served as a baseline (Fig:13)

Figure 13: CBCT Cone Beam Computed Tomography

Procedure

The biomechanical preparation was conducted using the allocated file systems in their respective groups.

Biochemical Preparation

Group B1 (Kedo S Square)

Similar to group A1, Kedo S Square was utilized for the biochemical preparation.

Group B2 (Kedo S Plus)

The biomechanical preparation was conducted using Kedo S Plus in a manner consistent with that of group A2.

Group B3 (ProTaper)

Protaper was used for the biochemical preparation in the same way as group A3.

Group B4 (No File System Utilized)

The biochemical preparation was not done

Post Instrumentation CBCT

Using the designated file systems, a post-instrumentation CBCT scan was conducted to assess dentin thickness following biomechanical preparation. The images before and after instrumentation were juxtaposed to ascertain the remaining dentin thickness. (Fig:17,18)

Equipment

1. Endomotor
2. Stereomicroscope
3. CBCT (Cone Beam Computer Tomography)

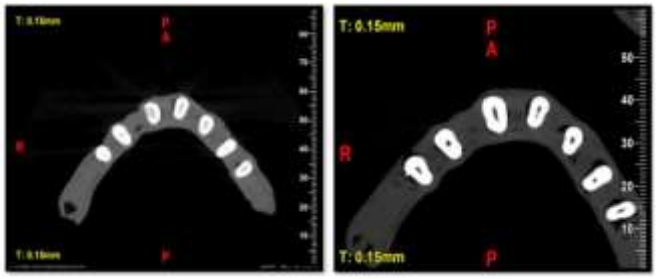


Figure 14: Pre and Post Instrumentation CBCT view of Group B1 ((Kedo S Square)

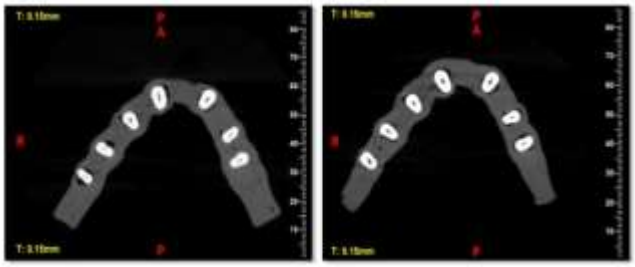


Figure 15: Pre and Post Instrumentation CBCT view of Group B2 (Kedo S Plus)

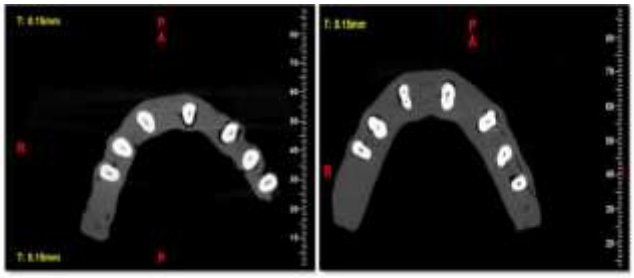


Figure 16: Pre and Post Instrumentation CBCT view of Group B3 (ProTaper)

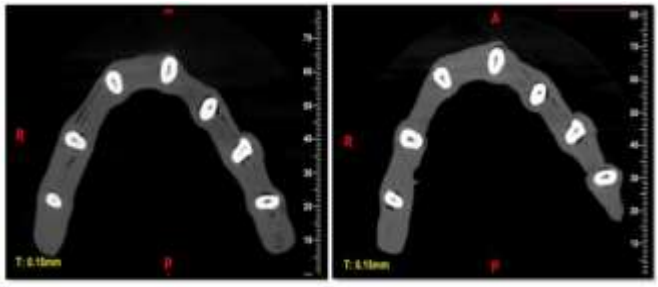


Figure 17: Pre and Post Instrumentation CBCT view of Group B4 (No File System Utilized)

Result & Observations

Statistical Analysis

The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23 Version. The descriptive statistics included mean, standard deviation. The level of the significance for the present study was fixed at 5%. The intergroup comparison for the difference of mean scores between independent groups was done using the One Way ANOVA The Shapiro–Wilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables. The data were found to be homogeneous and normally distributed. Mean and standard deviation (SD) were computed for each variable

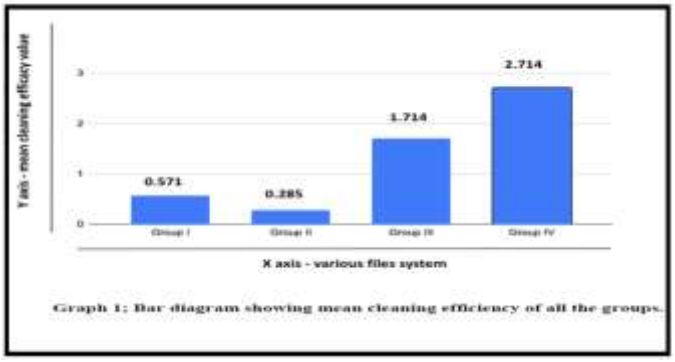
The mean Value of the cleaning efficiency in Group I (Kedo S Square), Group II (Kedo S Plus), Group III (Hand Protaper) and Group IV(Control Group) were 0.571 (sd=0.534), 0.285 (sd=0.487),1.714 (sd=0.755) and 2.714 (sd=0.487) respectively. It was found that the cleaning efficiency was best in the Group II followed by Group I and least in the Group IV.(Table 1 and graph 1)

Table 1:

Groups	Mean	SD	Std Error	Minimum	Maximum
Group I (Kedo S Square)	0.571	0.534	0.202	.00	1.00
Group II (Kedo S Plus)	0.285	0.487	0.184	.00	1.00
Group III (Protaper)	1.714	0.755	0.285	1.00	3.00
Group IV (Control Group)	2.714	0.487	0.184	2.00	3.00

Table 1: Mean values of cleaning efficiency in different groups

Graph 1:



Graph 1: Bar diagram showing mean cleaning efficiency of all the groups.

Distribution of variance between and within the group using ANOVA test

Description: Sum of squares on between groups were 26.107 & within groups were 8.00. Degrees of freedom for between the groups were 3 & and within groups were 24. The difference between the three groups was statistically significant when analyzed using the One Way ANOVA (p=0.001) (F value 6597.159

Table 2:

Groups	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	26.107	3	8.702	26.107	0.001 (Sig)
Within Groups	8.00	24	0.333		
Total	34.107	27			

Table: 2 Distribution of variance between and within the groups using ANOVA test

Graph 2:

Graph 2: Bar diagram showing mean change in remaining dentin thickness of all the groups

Distribution of variance between and within the groups using ANOVA test

Sum of square on between groups were 205.462 & within groups were 400.255 . Degrees of freedom for between the groups were 3 & within groups were 24 .

The difference between the three groups was statistically significant when analyzed using the One Way ANOVA (p=0.017) (F value-4.107).

Groups	Sum of Squares	df	Mean Square	F	Sig
Between Groups	205.462	3	68.487	4.107	0.017 (Sig)
Within Groups	400.255	24	16.677		
Total	605.717	27			

Table 3: Distribution of variance between and within the groups using ANOVA test

Discussion

Children are frequently affected by dental caries, sometimes referred to as cavities or tooth decay, as an oral health issue. It involves the progressive demineralization of tooth enamel and dentin. Untreated dental caries can lead to discomfort, infection, and the risk of tooth loss, emphasising the importance of timely and efficient intervention. One of the most important techniques for removing bacteria and their by products from diseased root canals is biomechanical preparation with endodontic tools. In the past, traditional instruments like K-files, H-files, and reamers were commonly employed for primary root canal cleaning. While these manual tools were capable of removing debris effectively, research has revealed certain limitations such as the risk of creating ledges, causing perforations, compacting dentin, and encountering instrument fractures, alongside being time-intensive. Conversely, rotary instrumentation with nickel-titanium, not only leads to superior preparation quality with a decreased likelihood of complications but also notably reduces the overall working time**5** Motor-activated Ni-Ti files enable rapid root canal preparation without the need for pre-curvature, thanks to their elastic memory. The samples were subjected to decalcification, dehydration, and clearing (demineralization) to determine whether any dye remained in the root canal walls after cleaning. This elastic memory feature reduces the risk of root canal deformation, while the radial land and inactive tips of NiTi files help keep them centred within the root canal. **Moghaddam KN, Mehran M, Zadeh HF et al. (2009)[4]**

In pediatric endodontics, rotary instrumentation has been used since 1993. The first research on the use of NiTi rotary files in primary tooth root canals was published in 2000 by **Barr et al. (2020)[5]**. Since then, pediatric dentistry has made use of a variety of NiTi rotary devices that use modified procedures. Rotary Files Kedo-S (First Generation): There is just one NiTi rotary file in the Kedo-S rotary file system. It is specifically made for the first permanent molars' palatal and distal canals. D1 files serve the mesiobuccal and mesiolingual canal[6]

Kedo-SG Rotary (Second-Generation): A second-generation improvement over the Kedo-S files is the Kedo-SG rotary files. These are NiTi rotary files with M-Wire technology that have been heat-treated Kedo SG blue (Third Generation): It consists of three files in order. There is the entire 16 mm length[7]. The files are designated as D1, E1, and U1 in that order is appropriate for primary tooth applications because of its variable taper, which is achieved through heat treatment and controlled memory. Greater flexibility and resistance to cycle fatigue of around 75% are among the features. An optimal rotating speed is between 250 and 300 rpm, and the required torque is between 2.2 and 2.4 N. The disadvantage of these files is that it causes more dentin removal while preparation [8].

A member of the fourth generation of rotary files, the Kedo-S Square file is identified by its triangle cross-section at the apex and its teardrop cross-section at the crown. It was developed to minimise the removal of root

dentin, thereby mitigating the risk of primary root resorption. Using a variety of taper sizes, this method carefully removes a small layer of dentin from the entire circle of the root canal [9]. Using a variety of techniques, this procedure includes delicately abrading a thin layer of dentin off the whole root canal's circumference. While single rotary file systems offer advantages, such as streamlined preparation, they can be costly, which may present a barrier to adoption for some dental practitioners or clinics [10]. **Salgotra P. et al.2007** Kedo-S plus (Fifth-Generation) rotary pedo files: Kedo S plus has a uniform cross-section with the dual-core material, the dual-core material is heat-treated titanium oxide coated at the apical and middle region and only heat-treated at the coronal region Another aspect addressed in the research was the preservation of root canal structure, assessed by measuring the remaining dentin thickness using CBCT (Cone Beam Computed Tomography) [11]. Pre- and post-instrumentation scans were conducted to establish baseline measurements and ensure result accuracy while minimising discrepancies

This study aims to comparatively assess the cleaning performance and efficacy of recently installed file systems. A set of fifty-six permanent, single-rooted teeth were selected after ensuring statistical validity. A comparable study conducted by **Seema T et al. (2020)** [12] also utilized fifty-six permanent, single-rooted teeth to assess the cleaning effectiveness of different file syste Saline served as the storage medium for the entire study, chosen for its non-altering effect on the tooth's chemical nature and topographic structure. Other storage media, such as 10% thymol, formalin, etc, were excluded due to reported effects on mineral content and tooth hardness. Protaper has shown the least cleaning efficacy when compared to Kedo S Square and Kedo S Plus because Protaper is a manual file system with reduced flexural stresses, increased tip stiffness causing cyclic fatigue, and progressive taper which makes the protaper more susceptible to canal straightening and it is time-consuming. It prepares the apical area for a prolonged period, and the operator controls the variable factor of the file's rotating motion [13]. Excessive pressure or attempts to withdraw the file with strong counterclockwise rotation can establish a prominent threshold on the canal wall surface, resulting in more dentin removal and consequently, a greater number of debris, irrigant, and bacteria extrusion compared to rotary files [14]. In contrast, the apical area is engaged by rotary files for a shorter period, and their torque and rotating speed are fixed **Kandari S, et.al (2016)3** In this study a control group was also taken where no biomechanical preparation was done with any file system to provide a baseline against which the experimental group (the group that receives the intervention or treatment). It minimises bias in the interpretation of results and also contribute to the validity and reliability of the research findings[16]. Hence, based on the findings outlined above, it is recommended to consider the Kedo S Plus and Kedo S Square rotary file systems as choices compared to traditionally utilized hand and rotary file systems, given their demonstrated cleaning efficacy and efficiency. To validate these findings, nevertheless, more research with bigger sample numbers is necessary.

Conclusion

Among experimental materials the Kedo S plus file system had demonstrated the highest but comparable cleaning effectiveness to Kedo S Square system while manual Hand ProTapers demonstrated the least efficacy. The Kedo S plus file system demonstrated the least but comparable reduction in dentin thickness after biomechanical preparation. Among experimental

materials Hand ProTaper showed maximum reduction in remaining dentin thickness after biomechanical preparation. The group where no biomechanical preparation was done, least cleaning efficacy and maximum reduction in remaining dentin thickness was seen.

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