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Original Article

Dentistry Section

Comparative Evaluation of Apical Extrusion of Debris using Hand and Rotary Assisted Instrumentation in Primary Single Rooted Teeth: An In-vitro Study

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ABSTRACT

Introduction: Extrusion of periapical debris is one of the common problem encountered during root canal treatment. As the endodontic instruments differ in terms of design and use, apical extrusion of debris may vary.

Aim: To determine the quantity of debris extruded apically during various hand and rotary assisted instrumentation in extracted primary single rooted teeth.

Materials and Methods: This in-vitro study was conducted in Department of Paediatric and Preventive Dentistry at Kannur Dental College, Anjarakandy, Kannur, Kerala, India, from December 2020 to May 2021. Four file systems were compared i.e, two hand files (Kedo SH and Protaper hand) and two rotary files (Kedo SG blue and Pro AF baby gold) among 60 therapeutically extracted single rooted primary teeth. The tooth was inserted into Eppendorf tube till cementoenamel junction, access opening was done, pulp extirpated, working length determined with 10 size k-file. After instrumentation, the tooth was washed with 10 mL of distilled water for debris collection. Tube was incubated at 70°c for drying and weighed to measure the collected debris. Data collected was analysed statistically using Independent t-test, One-way Analysis of Variance (ANOVA) and Least Significant Difference (LSD) Posthoc test for multiple comparison to compare between the groups were done. Level of statistical significance was set at p-value <0.05.

Results: There was significant difference in the amount of debris collected between the hand file and rotary files (p-value <0.001), between Kedo SG blue and Pro AF baby gold (p-value <0.001), and Kedo SH hand file and Protaper hand file (p-value <0.05).

Conclusion: Rotary files shows lesser amount of debris extrusion than the hand files. Comparing the four file system Kedo SG Blue file shows least periapical debris extrusion, the second least is Pro AF Baby Gold (rotary), then Kedo SH hand file and last Protaper hand file.

Keywords: Kedo SG blue rotary file, Kedo SH hand file, Protaper hand file, Pro AF baby gold rotary file

INTRODUCTION

Periapical pathology is treated with endodontic treatment by preserving and restoring periapical tissue health. It is considered as a mix of root canal mechanical instrumentation, bactericidal irrigation, and inert material obturation. Instrumentation and irrigation are used to debride and totally remove infectious tissue debris from the root canal system, as well as to create a constant conical shape canal that allows for medication, distribution and optimum obturation [1].

During root canal preparation, the periapical region may be irritated in an unpredictable way, resulting in postoperative pain. Flare up is a rapid exacerbation of periradicular pathosis after beginning or continuing root canal therapy. The occurrence of discomfort and flare-up during or following endodontic therapy is a common and ongoing problem in endodontics. During root canal preparation, necrotic material, dentinal chips, or pulpal remnants may be extruded into the apical region, causing postoperative pain. The extruded material can trigger an inflammatory response right away, resulting in increased periapical tissue pressure and intense pain [2].

Traditionally, hand files were used to mechanically prepare the root canals of primary teeth. Since hand preparations are time consuming and can lead to iatrogenic errors, they are being replaced with rotary instruments [3]. Barr ES et al., introduced the use of Nickel-Titanium (Ni-Ti) rotary instruments in primary teeth, since then there has been a rise in research [1-4] into the use of NiTi instruments in paediatric endodontics [5].

According to studies, apical debris is produced by almost all instrumentation procedures [2,5]. The amount of debris extruded apically was first measured by Vande Visse JE and Brilliant JD [6]. There may be variances in apically extruded debris because endodontic instruments differ in terms of design and use [1-6].

Literature review shows that there are only few studies [1-3,5] which compare the apically extruded debris in primary teeth. Moreover, new file systems with varied features are available in the market. Therefore, this study was conducted to check for the apical extrusion of debris by using newer paediatric rotary and hand instruments in extracted anterior primary tooth.

MATERIALS AND METHODS

This in-vitro study was conducted in Department of Paediatric and Preventive Dentistry at Kannur Dental College, Anjarakandy, Kannur, Kerala, India, from December 2020 to May 2021. This study was approved by the Review Board and Institutional Ethical Committee (KDC/ETH/17/PED11/1).

Sample size calculation: The sample size for the study was 60 therapeutically extracted deciduous single rooted tooth, it was calculated using software G star power version 3.1 at 5% level of significance, 80% power and effect size 0.45, minimum sample size calculated was 14 per group which was rounded off to 15 samples per group.

Inclusion criteria: Primary single rooted teeth with straight canal, extracted due to various therapeutic reasons such as serial extraction and due to pulpal infections were included in the study.

Exclusion criteria: Any teeth with visible root caries, teeth with more than one-third root resorption, fracture or cracks were excluded from the study.

Preparation of sample: The collected tooth was cleaned and stored in distilled water at room temperature. Access opening was done using a No.6 (Mani Inc. Japan) round bur and de-roofing of pulp chamber was completed using high speed hand piece under water cooling. After the extirpation of pulpal tissue, canal patency was established using a 10 size K-file. Working length determination was done by placing the file 1 mm short of apex.

The tooth was inserted in Eppendorf tube in Myers and Montgomery model for quantification of debris till Cementoenamel Junction (CEJ) [Table/Fig-1] [6]. The tube was covered with aluminum foil to prevent the operator from viewing the debris extrusion during instrumentation procedure. The Eppendorf tubes was preweighed with microbalance before the procedure started. A 27 gauge needle was inserted into the tube as drainage cannula to equalise the pressure inside and outside of Eppendorf tubes.

[Table/Fig-1]: Myers and Montgomery Model.

The tooth samples in the Eppendorf tube were randomly allotted to four different groups of 15 teeth each [Table/Fig-2,5]

- Group A: To be instrumented with Protaper hand files (Dentsply).
- Group B: To be instrumented with Kedo SH files (Reeganz dental care).
- Group C: To be instrumented with Kedo SG Blue rotary files (Reeganz dental care).
- Group D: To be instrumented with Pro AF Baby Gold (Kids-e-Dental).

Procedure

The instrumentation of all the teeth was done by a single examiner to eliminate operator bias. The irrigant used was standardised to 10 mL of distilled water for all samples. The external root surface was washed with 1 mL of the distilled water for the collection of the adhered debris into the Eppendorf tube. For the evaporation of the distilled water and to measure only the weight of the dry debris, the tubes were taken and stored at a temperature of 70° celsius in an incubator for 5 days. A second examiner who was completely blinded to the study evaluated the amount of apical debris collected [6].

Three measurements of Eppendorf tube with debris after incubation were taken for each tube using analytical balance and their mean was calculated. The initial preweighed value of the empty Eppendorf tube was subtracted from the final measured gross weight value to arrive at the total net weight of the extruded dry debris.

STATISTICAL ANALYSIS

Statistical analysis was performed using the Statistical Package for the Social Sciences version 22.0 (SPSS Inc., Chicago. IL, USA). Data collected was analysed statistically to compare between the groups by using Independent t-test, One-way Analysis of Variance (ANOVA) and Least Significant Difference (LSD) Posthoc test for multiple comparison. Level of statistical significance was set at p-value <0.05.

RESULTS

[Table/Fig-6] shows comparison of debris collected between the four file systems. ANOVA test was used for comparison of debris collected between the four different file systems. Statistically significant difference (p-value <0.001) was noted between the these groups with regards to the apical extrusion of debris.

[Table/Fig-7] shows comparison of debris collected between hand file and rotary file system. Independent t-test was used to compare between the hand file and rotary file. The mean value of debris extruded was 0.00457±0.001223 µg for hand files and was 0.00263±0.000999 µg for rotary files. There was a statistically significant difference in amount of debris collected at p-value <0.001.

[Table/Fig-8] shows the comparison of two rotary files. Independent t-test was used to compare between the Kedo SG Blue rotary file and Pro AF Baby Gold rotary file. The amount of debris extruded between the two rotary file system was highly significant (p-value <0.001).

[Table/Fig-9] shows the comparison of debris collected between two hand files. The debris extruded by Kedo SH Hand file (0.00413±0.000990 µg) was significantly less than the Protaper hand file (0.005±0.001309 µg) with a p-value=0.014.

[Table/Fig-10] shows the multiple comparison of debris collected between all four file systems. LSD's Posthoc test for multiple comparisons was used for comparison of debris collected between the four different file systems. Statistically significant difference (p-value <0.05) was noted between the these groups with regards to the apical extrusion of debris.

[Table/Fig-2]: Kedo Sg Blue File. **[Table/Fig-3]:** Pro Af Baby Gold File. **[Table/Fig-4]:** Kedo SH File. **[Table/Fig-5]:** Protaper File. (Images from left to right)

Groups	N	Debris collected (µg)		p-value (ANOVA)
		Mean	Standard deviation	
Protaper hand (Group A)	15	0.00500	0.001309	<0.001
Kedo SH hand (Group B)	15	0.00413	0.000990	
Kedo SG Blue rotary (Group C)	15	0.00187	0.000640	
Pro AF Baby Gold (Group D)	15	0.00340	0.000632	

[Table/Fig-6]: Comparison of debris collected between the four different files. p-value <0.05 was considered as statistically significant

After incubation	N	Debris collected (µg)		p-value (Independent t-test)
		Mean	Std. Deviation	
Hand file	30	0.00457	0.001223	<0.001
Rotary file	30	0.00263	0.000999	

[Table/Fig-7]: Comparison of debris collected between hand file and rotary file.
p-value <0.05 was considered as statistically significant

After incubation within group	N	Debris collected (µg)		p-value (Independent t-test)
		Mean	Std. Deviation	
Kedo SG Blue (Group C)	15	0.00187	0.000640	<0.001
Pro AF Baby Gold (Group D)	15	0.00340	0.000632	

[Table/Fig-8]: Comparison of debris collected between Kedo SG blue and Pro AF Baby Gold.
p-value <0.05 was considered as statistically significant

After incubation within group	N	Debris collected (µg)		p-value (Independent t-test)
		Mean	Std. Deviation	
Kedo SH hand (Group B)	15	0.00413	0.000990	0.014
Protaper hand (Group A)	15	0.00500	0.001309	

[Table/Fig-9]: Comparison of debris collected between Kedo SH Hand and Protaper hand.
p-value <0.05 was considered as statistically significant

(I) G1	(J) G1	Mean difference (I-J)	Standard error	p-value
Protaper hand (Group A)	Kedo SG Blue rotary (Group C)	0.003133	0.000342	<0.001
	Kedo SH Hand (Group B)	0.000867	0.000342	0.014
	Pro AF Baby Gold (Group D)	0.001600	0.000342	<0.001
Kedo SH Hand (Group B)	Kedo SG Blue rotary (Group C)	0.002267	0.000342	<0.001
	Pro AF Baby Gold (Group D)	0.000733	0.000342	0.036
	Protaper hand (Group A)	-0.000867	0.000342	0.014
Kedo SG Blue rotary (Group C)	Kedo SH hand (Group B)	-0.002267	0.000342	<0.001
	Pro AF Baby Gold (Group D)	-0.001533	0.000342	<0.001
	Protaper hand (Group A)	-0.003133	0.000342	<0.001
Pro AF Baby Gold (Group D)	Kedo SG Blue rotary (Group C)	0.001533	0.000342	<0.001
	Kedo SH Hand (Group B)	-0.000733	0.000342	0.036
	Protaper hand (Group A)	-0.001600	0.000342	<0.001

[Table/Fig-10]: LSD's Posthoc test for multiple comparisons.
p-value<0.05 was considered as statistically significant

DISCUSSION

The present study showed that the rotary instruments produced less periapical debris extrusion when compared to hand instrumentation. By comparing the files individually Kedo SG Blue rotary file showed least apical extrusion of debris than other three file system.

Periapical extrusion occurs with all canal instrumentation procedures regardless of technique [7]. The high amount of material extruded is most likely due to the filing action conducted during the instrumentation of the apical third. The filing motion of the tool could act like piston, forcing irrigation solution and debris into the apex [8]. Mangalam S et al., and Reddy SA and Hicks ML, have shown that variations in apical extrusion of debris by different instrumentation techniques are due to differences in root canal preparation procedures and instrument design [9,10]. The factors affecting periapical extrusion also includes method of instrumentation, the end point of the preparation, the length size and type of instrument. Hence, the goal of instrumentation should be directed towards reducing the risk of debris extrusion [11].

As a part of this present study only deciduous single rooted teeth with straight canal were included. Distilled water was selected as an irrigant in this study to prevent possible alteration on weight due to crystallisation of sodium hypochlorite to sodium crystals which was in accordance with the study done by Preethy NA et al., [6]. The Myers and Montgomery method was used for quantification of debris collected. The collection of debris from tooth is done in the tube with distilled water irrigation. The collected apically extruded debris and the irrigated distilled water in Eppendorf tube was incubated at 70° C for 7 days in incubator as per the study by Preethy NA et al., [6].

Present study results are in concurrence with previous studies by Reddy SA and Hicks ML, [10], Ferraz CC et al., [12] and Preethy NA et al., [6] which shows that rotary instrument produced less amount of debris than hand instruments.

Among the file systems tested in this study, Kedo SG blue files showed minimal extrusion of debris. It is a third generation Kedo-S file system which consists of three heat-treated and titanium oxide-coated Ni-Ti rotary files with a tip diameter of 0.40 mm. This is the first study which compares the apical extrusion by Kedo SG blue file. These files have a triangular cross section and non cutting tip negative rake angle and has got the superior flexibility and is shown to have greater resistance to cyclic fatigue. Its variably varying taper of 4-8% may be reason for blocking the apical extrusion to certain extend. These files with their bulky core which fill the apical part of the canal and leave little space for the suspension of debris compared to the loose space may be the reason for minimal apical debris [13]. Naidu DV et al., found that when compared to the Pro AF baby gold files, the Kedo SG Blue group had ideal endodontic obturation [14]. In various studies by Priyadarshini P et al., and Sruthi S et al., it was concluded that Kedo SG blue paediatric rotary file showed a marked reduction in instrumentation time which can also be a reason for less apical extrusion [15,16]. Jeevanandan G et al., found that Kedo SG blue resulted in less postoperative pain when compared to Kedo SH and hand K-files [17]. Postoperative pain is a feature of apical extrusion of debris [6,11,18].

In this study, Pro AF Baby Gold rotary files showed lesser apical debris than Kedo SH and Protaper hand files. The Pro AF Baby Gold file is a flexible paediatric rotary file with Ni-Ti CM-Wire technology. A recent study by Rathi N et al., showed that Pro AF Baby Gold paediatric rotary files have significantly less periapical extrusion of debris when compared to Kedo SH and Protaper hand file [18]. Albrecht LJ et al., showed that reducing the number of files will help in reducing the canal aberrations along with reduced apical extrusion [19]. Shah HS et al., showed superior quality of obturation in lesser time using Pro AF files [20]. The results of the present study support the "taper lock effect" [18]. Waly A et al., showed that Pro AF Baby gold systems were efficient and faster, therefore reducing the time of instrumentation may be the reason for less apical extrusion [21].

Among the hand files used in this study Kedo SH files showed lesser apical debris collection than Protaper files. Kedo SH files are six colour-coded files with standard 16 mm length and 12 mm flutes. These files result in better obturation quality due to its efficient preparation of primary root canals. These second generation files have modified active cutting edges and require fewer instruments for the completion of the root canal preparation [22]. They also have enhanced shaping ability and cleaning efficacy with diminished preparation time and instrument distortion in primary molars than manual K files [23]. Study by Sruthi S et al., showed that Kedo SH paediatric hand files needed only lesser time than reciprocating hand K-files [16]. Priyadarshini P et al., in a study inferred that Kedo SG files showed less instrumentation time when compared to hand K files [15]. Jeevanandan G et al., found that Kedo-SH resulted in less postoperative pain when compared to other hand K-files which may indicate less apical extrusion [24].

The flutes of the Protaper file lightly engage and shave the dentin by rotating the handle clockwise while simultaneously with drawing the file [25]. Tanalp J and Güngör T and Buldur B et al., concluded that the Protaper hand caused a significantly higher amount of debris extrusion compared to the ProFile system [5,11]. Asif A et al., found that Protaper files produced more apical debris than Kedo-S files

Author's name and year of study	Place of study	Sample size	Files compared	Parameters assessed	Conclusion
Uzunoglu E and Turker SA, [26] (2016)	Turkey	36 single-rooted prepared mandibular premolar teeth	Reciproc R40 (VDW, Munich, Germany) EdgeFile XR retreatment rotary files (EdgeEndo, Albuquerque, NM, USA) and D-RaCe retreatment systems (FKG, Dentaire, La Chaux-de-Fonds, Switzerland).	Amount of apically extruded debris	The findings revealed that during endodontic retreatment, number, and taper of files might have an influence on the amount of apically extruded debris during endodontic retreatment.
Azar NG and Ebrahimi G, [27] (2005)	Turkey	45 extracted mandibular premolar teeth with single canals with similar lengths	• ProTaper Next • ProTaper Gold Sx • TruNatomyTM files	Apically extruded debris	All the instrumentation systems caused apical extrusion of debris. However, the TRN system resulted in significantly less debris extrusion than the other systems.
Guelzow A et al., [28] (2005)	Universitä̈tsmedizin Berlin, Germany	147 extracted mandibular molars	• FlexMaster • System GT • Hero 642	Root canal preparation	Under the conditions of this ex-vivo study all Nickle-Titanium systems maintained the canal curvature, were associated with few instrument fractures and were more rapid than a standardised manual technique. ProTaper instruments created more regular canal diameters.
Asif A et al., [3] (2019)	Chennai, India	45 freshly extracted primary canine with mature apices and a single canal	• K-files • Kedo-S • ProTaper rotary	Apical debris extrusion during root canal preparation	All instrumentation systems cause apical debris extrusion. Kedo S produced less apical debris extrusion when compared to the hand files and ProTaper files.
Rathi N et al., [18] (2021)	Maharashtra, India	20 extracted primary molar teeth	• Kedo SG blue rotary file • Pro AF Baby Gold rotary file • Kedo SH hand file • Protaper hand file	Apical extrusion of debris and cleaning efficacy	All instruments caused apically extruded debris in primary teeth. Pro AF Baby Gold files can be used with less apical extrusion of debris. Cleaning efficacy was shown to be better with the Pro AF Baby Gold paediatric rotary endodontic file.
Present study	Kannur dental college	60 therapeutically extracted single rooted primary teeth	• Kedo SG blue rotary file • Pro AF Baby Gold rotary file • Kedo SH hand file • Protaper hand file	Quantity of debris extruded apically during various hand and rotary assisted instrumentation, and to compare the quantity of debris extruded with all files	The amount of debris is collected with rotary files is less compared to hand files. Kedo SH file shows less debris extrusion compared to Protaper hand file and Kedo SG blue file shows less than Pro AF Baby gold file. Kedo SG blue file shows good result compared to all other files.

[Table/Fig-11]: Comparison with other similar studies [3,18,26-28].

which is in agreement with this study [3]. The reasons for more apical extrusion with Protaper hand instruments may be that the instrumentation is in filing motion which pushes the debris apically and also it has a taper of 0.02 which creates less space for the debris to get flushed coronally [3]. Comparative evaluation of similar studies have been done in [Table/Fig-11] [3,18,26-28]. Thus, in this study, it was found that rotary instruments are better than hand filing systems as they reduce the apical extrusion of debris while canal preparation.

Limitation(s)

This study was conducted in in-vitro condition, the clinical scenario contributing to the apical extrusion of debris could not be taken into account, and also the primary teeth samples taken in this study were in various stages of resorption therefore the size of the apical foramen differs according to the resorption therefore the extrusion of debris may vary. The type of irrigants and force of canal irrigation, which can have an effect on apical extrusion of debris were not taken into consideration in this study was also a limitation of this study.

CONCLUSION(S)

Within the limitations of this study it can be concluded that all four file systems produce apical extrusion of debris. When hand and rotary files are compared, hand file shows more apical extrusion of debris than rotary files. Among the four file systems Kedo SG Blue rotary file showed the least apical extrusion of debris followed by Pro AF Baby Gold file, Kedo SH hand files and Protaper hand files. The majority of studies are conducted in-vitro conditions on extracted teeth, therefore, more in-vivo studies are needed to evaluate the effect of apical debris extrusion.

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