ORIGINAL RESEARCH

Volumetric Analysis of Various Pediatric Rotary Files in the Preparation of Primary Root Canals Using Cone-beam Computed Tomography

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Abstract

Aim: This study was planned to evaluate and compare the cleaning efficacy of three pediatric rotary files with the standard Protaper adult file system in primary teeth using cone-beam computed tomography (CBCT).

Materials and methods: A total of 40 extracted deciduous second molars, with palatal/mesial roots having at least two-thirds of root length and an intact furcation area, were distributed randomly among four groups, with each group containing 10 teeth. Canal preparation of group I (Pro AF Baby Gold), group II (Kedo SG Blue), group III (Prime Pedo), and group IV (Protaper) was done. Pre- and postoperative CBCT images were taken. The volumetric changes of the root canals were assessed and subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS) version 16 and R Studio 3.1.1. Volumetric changes within the groups were analyzed using paired *t*-tests and between the groups using analysis of variance (ANOVA).

Results: The comparison of mean volume difference between groups using ANOVA was statistically significant with $F = 4.467$, $p = 0.002$. A Tukey *post hoc* test revealed that group IV was statistically significant compared with groups I ($p = 0.033$) and III ($p = 0.008$) but was not statistically significant with group II ($p = 0.170$). There was no statistically significant difference in volumetric changes within the three pediatric rotary file systems.

Conclusion: Protaper removed more dentin than all the pediatric rotary files, but it was not statistically significant over Kedo SG Blue. Among the pediatric rotary files, Kedo SG Blue removed more dentin than Pro AF Baby Gold and Prime Pedo, but they were not statistically significant.

Keywords: Cone-beam computed tomography, Deciduous, Endodontics, Pediatric rotary files, Pulpectomy, Teeth.

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Introduction

Dental caries is one of the prevalent chronic diseases affecting children. Caries progresses rapidly in children to involve the pulp, resulting in pulpitis/necrosis, thereby affecting their routine day-to-day activities. Extraction of these infected primary molars and delay in space management or maintenance may result in space loss, which is a disquietude in pediatric dentistry.[1] Endodontic treatment of deciduous teeth helps to maintain these teeth until they exfoliate physiologically, thus contributing to esthetics, mastication, and phonation and preventing the development of deleterious oral habits in children.[2] The main objective of the endodontic procedure is the cleaning and shaping in permanent dentition, whereas debridement and disinfection of the root canals in the primary tooth. When the debridement protocol is planned for primary teeth, morphological characteristics such as thinner dentin walls, shorter and more curved roots, ectopic surface resorption, and a ribbon-shaped root morphology must be considered.[3]

Debridement and disinfection of primary teeth are carried out by chemomechanical preparation using hand files, ultrasonic instruments, nickel–titanium (NiTi) rotary file systems, reamers, and irrigants.[4] Although manual instrumentation with hand files is commonly done in primary teeth, there are limitations regarding its effective debridement of root canals, dentine compaction, ledge formation, possible perforations, and instrument separation. The introduction of NiTi in endodontics kindled my interest in using the same in pediatric endodontics. It drew a lot of attention towards canal preparation with NiTi rotary instruments in primary teeth. NiTi was used to replace stainless steel due to its better flexibility and fracture resistance. NiTi files have shape memory; hence, the precurvature of files is not necessary for negotiating curved canals. The chances of canal deformation are decreased due to its elasticity, radial lands, and inactive tips. Manufacturers feature their cleaning efficacy concerning root canal preparations, simple technique, and reduced instrumentation time, which is important in children.

Rotary preparation in deciduous teeth was first reported by Barr et al. with ProFile 0.04 taper, and they stated that it was economical and more efficient, resulting in a uniform and predictable obturation.[5] Kuo et al. introduced the Protaper rotary files sequence for the mechanical preparation of primary teeth.[6]

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Musale et al. compared the effectiveness of Protaper with hand K-files, Profile, and Hero shaper rotary file systems, while Vieyra et al. did a study comparing hand K-file, Rotary light speed LSX, and Protaper file system in primary teeth.[7,8] Similarly, numerous studies have been done comparing various hand files and different rotary file systems for pulpectomy of primary teeth.[9–21] All of these rotary file systems were manufactured for the biomechanical preparation of permanent teeth. The drawbacks of these rotary files were increased length and larger taper when used for pulpectomy of primary teeth.

Various file systems designed specifically for primary teeth preparation with shorter lengths and smaller tapers have been made available. The literature search revealed numerous studies and case series on Kedo S rotary files and their variations in comparing the quality of obturation postoperative pain between the manual K-files and manual files in the reciprocating handpiece.[22–31] Two studies on Prime Pedo files compare the cleaning efficacy and the quality of obturation with DXL-Pro, Protaper, and manual H files.[32,33] Due to the lack of sufficient data comparing the efficacy of various primary rotary files, this study was drafted to evaluate the efficacy of the newly available pediatric rotary files with the Protaper file system using cone-beam computed tomography (CBCT).

Materials and Methods

This *in vitro* study was planned and carried out in the Department of Pedodontics, and ethical clearance was obtained from the Institutional Ethical Committee (SBDCH/IEC/10/2018/15).

Sample Selection

The samples collected for this study were extracted due to extensive caries, pathologic mobility, orthodontic requirement, or retained molars. A total of 56 freshly extracted maxillary and mandibular deciduous second molars were collected from institutions and private clinics. They were rinsed under running water, and all soft tissues were removed from the root surface using a handscaler. Teeth were then stored in normal saline with 1% thymol crystals at room temperature until they were subjected to the experimental procedure. Preoperative intraoral periapical radiographs (cone shift technique) were taken to rule out the presence of internal pathological root resorption (12 nos.) and pulpally treated teeth (4 nos.), which were excluded. The sample size of 40 primary molar root canals was calculated from previous literature with a 95% confidence interval and 86% power of the study. A total of 40 deciduous maxillary (20 nos.) and mandibular (20 nos.) second molars with the following inclusion criteria were selected:

- The palatal/mesial root has at least two-thirds of the root length.
- An intact furcation area.

Samples were immersed in 1% sodium hypochlorite for 15 minutes for disinfection. The samples were then randomly allocated into four groups: group I—Pro AF Baby Gold (Dentobizz, India), group II—Kedo SG Blue (Reeganz Dental Care Pvt. Ltd. India), group III—Prime Pedo (Sky International Enterprises, India), and group IV—Protaper (Dentsply, Maillefer, Switzerland) with each group containing 10 teeth (maxillary molars: 5, mandibular molars: 5). Preoperative CBCT (Kodak 9500, Carestream Inc., Rochester) images were taken by mounting the samples in modeling wax with the following exposure of 80 kV and 4 mA for 12 seconds (Fig. 1).

Working Length Determination

All preparations were done by a single operator on different days. Access opening was done with a round bur. The patency of the palatal and mesiobuccal root canals was checked by inserting a #size 10 K-file (Dentsply, Maillefer, Switzerland). The working length was determined with an apex locator (Root ZX, J. Morita Inc., United States of America) for all the samples individually. The samples of each group were mounted in a plastic container (Fig. 2). The container was filled with tap water to a level where the roots were immersed up to the cementoenamel junction to simulate the intraoral/clinical environment. To complete the circuit, the labial hook electrode was inserted through an opening created in the container and was made to come in contact with the filled tap water, and the other electrode was attached to a #size 10 K-file. The file was introduced into the root canals till the light signal indicated that the file tip was 0.5 mm from the apex. The reference point was marked for each tooth, and the rubber stopper on the file was adjusted to rest on the reference point before taking the file out.

Fig. 1: Cone-beam computed tomography (CBCT) imaging of the samples

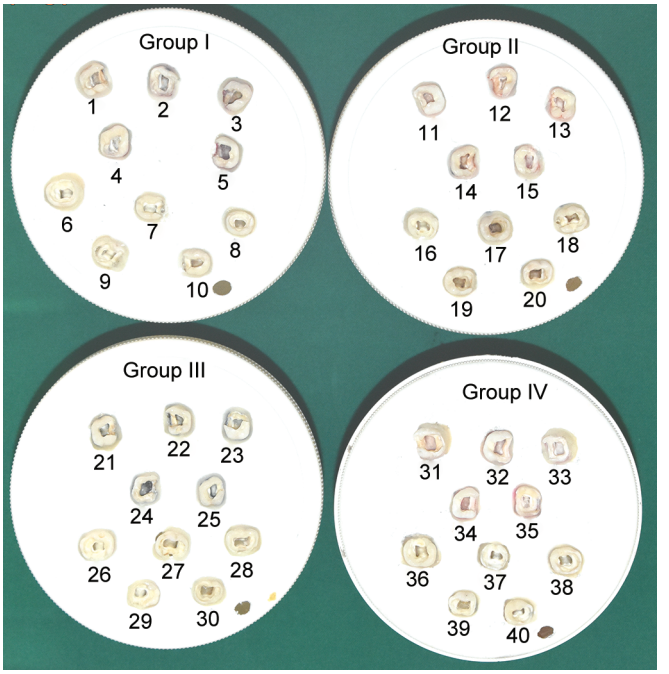

Fig. 2: Access opening done in all the samples

The working length for each sample was measured using an endo gauge (Dentsply, Maillefer, Switzerland) and noted (Fig. 3).

Canal Preparation

The rotary files of the various groups were used at the specific torque and rpm as recommended by the file manufacturer using X-Smart (Dentsply, Maillefer, Switzerland). The file was coated with Endoprep-RC (Anabond Stedman, India) and introduced while rotating into the canal up to the estimated working length as per the motion (pecking/brushing) recommended by the manufacturer. Normal saline was used for irrigation of the canals after preparation.

The root canals of group I samples were prepared with rotary Pro AF Baby Gold files (300 rpm, 2 N/cm). The B2 (25/04) and B4 (30/04) files were used for the palatal canal, and the B2 (25/04) and B3 (25/06) files were used for the mesiobuccal canal. The root canals of group II samples were instrumented with rotary Kedo SG Blue files (300 rpm, 2 N/cm). The E1 (16 mm/03) file was used for the palatal canal, and the D1 (16 mm/02) file was used for the mesiobuccal canal. The root canals of group III samples were instrumented using Prime Pedo rotary files (350 rpm,3 N/cm). The orifices were enlarged with an orifice opener (16 mm/08), followed by a P2 (25/06) file for the palatal canal and a P1 (15/06) file for the mesiobuccal canal. Group IV was the control group, and the root canals of the samples were instrumented with #size 10 K-file, followed by rotary SX and S2 Protaper files (Dentsply, Maillefer, Switzerland) and #size 25 H-file.[6]

Postoperative CBCT images were taken by mounting the samples in modeling wax (Fig. 1).

Volumetric Analysis

Analysis of the images was done using CS 3D Imaging Software 3.2.9 (Carestream Health Inc.) by a blinded single examiner. The pulp chamber floor was marked on the CBCT image. The diameter of the canal orifice (CS) was measured 2 mm apically from the floor of the pulp chamber. The length of the root canal was measured from the center point in the diameter up to a point placed 0.5 mm short of the apex (Fig. 4). With the measurements obtained; the volume was calculated using the formula,

Volume of a cone = $1/3\pi r^2 h$,

Where r is the radius of the canal (r = ½ diameter of CS)

h is the height of the canal, $\pi = 22/7$

Pre- and postoperative volumes of the palatal and mesiobuccal root canals were calculated. The values of volumetric changes between the preoperative and postoperative images were tabulated and subjected to statistical analysis.

Data Analysis

All the data presented were analyzed using Statistical Package for the Social Sciences (SPSS) version 16 and R Studio 3.1.1. Volumetric changes within the groups were analyzed using paired *t*-tests, and analysis of variance (ANOVA) was performed to compare volumetric changes between the groups.

Results

Table 1 shows the descriptive analysis of the pre- and postoperative volume of all the groups. Even though the postoperative volume was higher in all the groups, the comparison of the pre- and postoperative volume within groups using paired *t*-test with a 95% confidence interval was not statistically significant (Table 2). The amount of volume removed was comparatively more in the case of Protaper (1.085 mm^3), followed by Kedo SG Blue (0.592 mm^3) when compared to Prime Pedo (0.289 mm^3) and Pro AF Baby Gold (0.195 mm^3).

Table 3 shows the comparison of the mean difference in the volume using ANOVA between groups, which was statistically significant with $F = 4.467$, $p = 0.002$. A Tukey *post hoc* test revealed that group IV was statistically significant compared with groups I ($p = 0.033$) and III ($p = 0.008$) but was not statistically significant with group II ($p = 0.170$). There was no statistically significant difference in volumetric changes within the three pediatric rotary file systems (Table 4).

Discussion

Primary teeth with severe pulpal inflammation should be considered for pulpectomy with the prime objective of eliminating microorganisms from the root canal. Routinely or traditionally endodontic treatment in primary teeth is usually done using hand instruments, increasing chairside working time. This is an important aspect of treating children as it can affect their cooperation.

In a study, the palatal and the mesiobuccal canals of the maxillary and mandibular second molars were the longest and with maximum angulation.[34] Another study stated that the mesiobuccal canal of mandibular second molars almost has an equal distribution of straighter and curved appearance in the outline form.[35] Hence, these canals were chosen in our study to assess the cleaning efficacy in both canal outline forms. The adult Protaper system has a particular sequence for the preparation of primary teeth; hence,

Fig. 3: Working length determination done

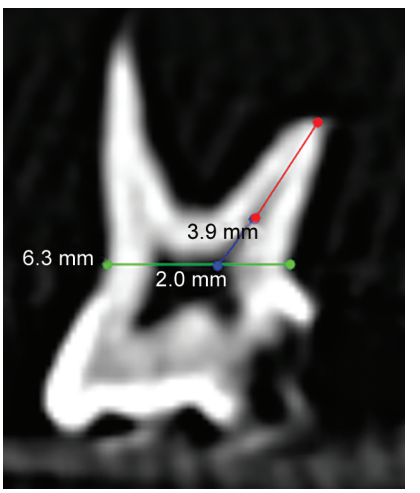

Fig. 4: Volumetric analysis done in the CBCT image

Table 1: Descriptive analysis of the pre- and postoperative volume of all the groups

Rotary files		*N*	*Mean*	*Standard deviation*
Pro AF Baby Gold	Before	10	1.091	0.548
	After	10	1.286	0.598
Kedo SG Blue	Before	10	1.947	0.871
	After	10	2.539	1.156
Prime Pedo	Before	10	1.938	1.278
	After	10	2.226	1.366
Protaper	Before	10	2.578	2.051
	After	10	3.663	2.833

Table 2: Comparison of mean volume difference within groups using paired *t*-test

				95% confidence interval of the difference	
Groups	*t*	*p-value*	*Mean difference*	*Lower*	*Upper*
Pro AF Baby Gold	–0.758	0.458	–0.195	–0.733	0.344
Kedo SG Blue	–1.294	0.212	–0.592	–1.554	0.369
Prime Pedo	–0.488	0.632	–0.288	–1.531	0.954
Protaper	–0.981	0.339	–1.085	–3.409	1.238

Table 3: Comparison of mean volume difference between groups using ANOVA

Groups	*Mean*	*SD*	*F*	*p-value*
Pro AF Baby Gold	0.193	0.187	5.884	0.002*
Kedo SG Blue	0.592	0.446		
Prime Pedo	0.289	0.332		
Protaper	1.085	0.866		

*Significant (*p*-value of <0.05)

Table 4: Comparison of mean volume difference between different groups using Tukey *post hoc* test

Intergroup comparison		*Mean difference (I – J)*	*p-value*
Pro AF Baby Gold	Kedo SG Blue	–0.398	0.338
Kedo SG Blue	Prime Pedo	0.304	0.570
Prime Pedo	Pro AF Baby Gold	0.094	0.978
Protaper	Pro AF Baby Gold	0.891	0.003*
	Kedo SG Blue	0.493	0.170
	Prime Pedo	0.797	0.008*

*Significant (*p*-value of <0.05)

the newly available pediatric rotary files were compared with the above method.[6]

Even though micro or spiral CT scans have been used for evaluating volumetric changes in primary teeth root canals, the CBCT has supremacy over spiral CT due to various advantages like lower effective radiation doses, easier image acquisition, lower costs, lesser space requirements, interactive display modes like multiplanar reconstruction and the specimen can be used for the future research. Recent studies have shown that CBCT can be used to measure accurately the amount of root dentin removed by various endodontic instruments.[36,37] Therefore, CBCT imaging was used in the present study to evaluate the volumetric changes after preparing primary molar root canals.

In a spiral CT study, the mean distance between the floor of the pulp chamber to furcation was approximately 2 mm in the second primary maxillary and mandibular molars.[38,39] Hence, the diameter of the CS was measured 2 mm apically from the floor of the pulp chamber in our study. The length of the root canal was measured from the center point in the diameter up to a point placed 0.5 mm short of the apex. Clinically, working length estimation of the root canals is usually done by various methods like measuring preoperative radiographs, direct visualization of the file tip through the apex, radiovisiography, and using an apex locator. In a study, the working length estimation using an apex locator, radiovisiography, and conventional radiography were compared, and it was concluded that the apex locator showed a more accurate value than others.[40] In our study, working length was determined individually with an apex locator for all the samples by the method discussed above.

The increase in the postoperative volume of all the groups (Table 1) suggests the removal of considerable amounts of dentin from the root canals, which could be attributed to the cleaning efficiency of the individual file systems. Among the pediatric rotary files, more dentin was removed by the Kedo SG Blue, followed by Prime Pedo and Pro AF Baby Gold. All the files used in this study have a common triangular cross-section, which has already been proven to display an aggressive

and enhanced cutting efficiency compared to other cross-sections in many studies done on adult rotary files.[41] The postoperative volume of Protaper was statistically significant over Pro AF Baby Gold and Prime Pedo, which could be attributed to the variable taper of Protaper, whereas the Pro AF Baby Gold and Prime Pedo are uniformly tapered files. Even though Protaper removed more dentin (Mean difference = 0.493 mm^3) than Kedo SG Blue, it was not statistically significant as both the files have variable tapers.

Katgae et al. studied and compared the cleaning efficacy of two pediatric rotary files using the ink injection method. They concluded that DXL-ProTM showed better cleaning efficacy than Prime Pedo™, but the difference was not statistically significant.[35] Akkam et al. evaluated and compared the volumetric filling after root canal preparation using CBCT among hand files and Kedo S pediatric rotary files. They concluded that Kedo S showed better obturation volume than hand files, but the voids were common in all groups.[42] Ghadge et al. concluded that instrumentation with Prime Pedo™ pediatric rotary files resulted in a better extent of obturation than Protaper Universal™ and conventional H files.[33]

Conclusion

Within the limitations of the study, Protaper removed more dentin than all the pediatric rotary files, but it was not statistically significant over Kedo SG Blue compared with Prime Pedo and Pro AF Baby Gold. Hence, Kedo S could be an alternative for Protaper in primary root canal preparation. Among the pediatric rotary files, Kedo SG Blue removed more dentin than Pro AF Baby Gold and Prime Pedo, but they were not statistically significant.

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