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Evaluation of the effect of different pediatric rotary file systems used in canal shaping of primary teeth on apical debris extrusion

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Purpose: The aim of this study is to evaluate the apical debris extrusion after root canal preparation using different pediatric rotary file systems in mandibular second primary molars.

Methods: Forty mandibular second primary molars were used in this study. Teeth were randomly divided into four experimental groups for the shaping of their distal roots. Group (G)1: Hand files, G2: Endoart Pedo Blue, G3: M3 Immature Blue, and G4: AF Baby rotary file were used for root canal preparation. The Myers and Montgomery model was used to measure the amount of apical debris by evaluating the pre- and post-weight of the Eppendorf tube. Data were analyzed using one-way analysis of variance and Tukey post-hoc tests ($p < 0.05$).

Results: Among all file systems, the highest apical debris extrusion was observed in the G1 (hand file) group, and the least apical debris extrusion was observed in the G4 (AF Baby) group. However, there was no statistically significant difference between the G2 (Endoart Blue), G3 (M3 Immature Blue), and G4 (AF Baby) groups ($p > 0.05$).

Conclusion: All shaping techniques used in the study resulted in apical debris extrusion.

Keywords: Debris extrusion; pediatric rotary endodontic files; primary teeth.

Introduction

Primary teeth have several important functions, such as the development of the jaw bone and muscle tissue, the proper eruption of permanent teeth, and phonation (1). Therefore, preserving primary teeth within the oral cavity is crucial. Endodontic treatments in primary teeth are routinely performed in cases of irreversible pulpitis, infected, or necrotic pulp (2,3). One of the key factors determining the success of endodontic treatment in primary teeth is chemomechanical preparation (3). During chemomechanical preparation, dentin fragments, pulp tissue, and microorganisms can be apically extruded and cause harm to periradicular tissues. Due to the large apical foramen in primary teeth, the extrusion of debris into periradicular tissues is facilitated (4). Preventing the movement of debris from the root canal system to the periradicular tissues is a factor affecting the success of endodontic treatment. Apical debris extrusion can damage periradicular stem cells and the permanent tooth germ located beneath the primary tooth (4,5). Hand files, as well as single or multi-tapered nickel-titanium (Ni-Ti) instruments, are used for the preparation of primary tooth canals. The use of Ni-Ti rotary file systems in primary teeth provides faster, safer, and more effective root canal preparation, reducing fa-

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tigue for both the patient and the dentist (6).

The mechanical preparation of root canal treatments in primary teeth is traditionally performed using K-file hand files (4,5). However, due to advancements in the field of pediatric dentistry, rotary file systems are often used to prepare primary tooth root canals. Endoart Pedo Blue (Inci Dental, Istanbul, Türkiye) is a rotary file system specifically designed for pediatric root canal treatment. It is claimed that the proprietary heat treatment technology makes the Ni-Ti alloy wire much more flexible and durable (7). M3 Immature Blue (Bondent, China) is a rotary file system specifically designed for primary teeth and patients with a small oral aperture, made from shape-memory alloy (CM) coated with blue nanoparticles (8). AF Baby (Fanta Dental, Shanghai, China) is a flexible rotary file system produced for pediatric root canal treatment. It is claimed by the manufacturer that this file system has maximum adaptability to the canal anatomy and curved canals due to its flexibility (9). Upon reviewing the literature, very few studies have evaluated the amount of apically extruded debris in primary teeth compared to permanent teeth after root canal preparation. Moreover, no study evaluates these specially produced rotary file systems for primary teeth. The aim of this study is to compare the amount of apically extruded debris after root canal preparation using hand files and three different rotary file systems in extracted mandibular second molar primary teeth. The null hypothesis of this study is that there is no difference in terms of the amount of apically extruded debris between the file systems used.

Materials and Methods

The manuscript of this laboratory study has been written according to the Preferred Reporting Items for Laboratory Studies in Endodontology (PRILE) 2021 guidelines (10) (Table 1). The study protocol was conducted by the ethical standards of the institutional and/or national research committee and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Ethical approval for the study was obtained from the Ethical Committee of Fırat University (ethical committee number: 2023/12–24). The sample size for the study was calculated using the G*Power software package (version 3.1.9.2). The sample size was determined to be a total of 40 samples (n = 10, 4 groups) with an α error value of 0.05, 95% confidence interval, 0.5 effect size, and 80% power ($1-\beta = 0.80$) (11).

In this study, the distal canals of mandibular second primary molars were extracted due to periapical pathology and orthodontic reasons. The teeth were stored in distilled water at 4°C. The teeth were included in the study according to criteria defined by Schneider (12). Radiographs were taken mesiodistally and buccolingually to determine the distal canal anatomy and confirm the presence of a single canal. Teeth affected by less than one-third root resorption were included in the study, as determined by digital measurement of the distance between the cementoenamel junction and the first visible root resorption point. Endodontic access cavities were prepared using diamond burs under water cooling with a high-speed handpiece. Canal patency was checked using a #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland). Teeth with an apical foramen larger than a #15 hand file were not included in the study. Under a dental operation microscope (Zumax 2360, Suzhou New District, China), a #15 K-file was placed in the canal and advanced until it could be seen from the apex; the working length was set 1 mm short from this point. All the teeth meeting the inclusion criteria were randomly divided into four groups for root canal preparation.

For evaluating debris extrusion, an experimental model described by Myers and Montgomery was used (13). Eppendorf tube caps were removed, and the tube without the cap was weighed 3 times to determine its initial weight using an electronic balance (Denver Instrument, New York, ABD) with 10^{-5} precision. A hole was made in the tube cap, and each tooth was placed up to the cementoenamel junction. A 27-gauge needle (Ayset, Adana, Türkiye) was placed next to the cap to equalize the internal and external air pressure. The cap, tooth, and needle were then placed in the Eppendorf tube, and the tubes were placed in bottles covered with aluminum foil to prevent the operator from seeing the debris formed during instrumentation.

The root canal preparation for each group was performed as follows:

Group 1 (hand file): Root canal preparation was done using the step-back technique with K-files #15, 20, 25, and 30 in sequence. After each filing, the root canal system was flushed with distilled water.

Group 2 (endoart pedo blue): With the aid of an endodontic motor (X-Smart, Dentsply Ballaigues, Switzerland), the root canal was prepared using rotary files #20, 25, and 30 in sequence, operating at 300 rpm and 1.6 N*cm torque as per manufacturer guidelines. The canal was flushed with distilled water after each file change.

Group 3 (M3 immature blue): The root canal was prepared using rotary files #20, 25, and 30 in sequence with the aid of an endodontic motor (X-smart), operating at 350 rpm and 1.5 N*cm torque as per manufacturer guidelines. The canal was flushed with distilled water after each file change.

Group 4 (AF baby): The root canal was prepared using rotary files #20, 25, and 30 in sequence with the aid of an

Table 1. Preferred reporting items for laboratory studies in endodontology 2021 guidelines

Section/topic	Item number	Checklist items	Reported on page number
Title	1a	The Title must identify the study as being laboratory-based, e.g. “laboratory investigation” or “in vitro,” or “ex vivo” or another appropriate term	1
	1b	The area/field of interest must be provided (briefly) in the Title	1
Keywords	2a	At least two keywords related to the subject and content of the investigation must be provided	1
Abstract	3a	The rationale/justification of what the investigation contributes to the literature and/or addresses a gap in knowledge must be provided	1
	3b	The aim/objectives of the investigation must be provided	1
	3c	The body of the Abstract must describe the materials and methods used in the investigation and include information on data management and statistical analysis	1
	3d	The body of the Abstract must describe the most significant scientific results for all experimental and control groups	1
	3e	The main conclusion(s) of the study must be provided	1
Introduction	4a	A background summary of the scientific investigation with relevant information must be provided	2
	4b	The aim(s), purpose(s) or hypothesis(es) of an investigation must be provided ensuring they align with the methods and results	3
Materials and Methods	5a	A clear ethics statement and the ethical approval granted by an ethics board, such as an Institutional Review Board or Institutional Animal Care and Use Committee, must be described	3
	5b	When harvesting cells and tissues for research, all the legal, ethical, and welfare rights of human subjects and animal donors must be respected and applicable procedures described	3
	5c	The use of reference samples must be included, as well as negative and positive control samples, and the adequacy of the sample size justified	3
	5d	Sufficient information about the methods/materials/supplies/samples/specimens /instruments used in the study must be provided to enable it to be replicated	3
	5e	The use of categories must be defined, reliable and be described in detail	3
	5f	The numbers of replicated identical samples must be described within each test group. The number of times each test was repeated must be described	3
	5g	The details of all the sterilization, disinfection, and handling conditions must be provided, if relevant	3
	5h	The process of randomization and allocation concealment, including who generated the random allocation sequence, who decided on which specimens to be included and who assigned specimens to the intervention must be provided (if applicable)	4
	5i	The process of blinding the operator who is conducting the experiment (if applicable) and the examiners when assessing the results must be provided	4
	5j	Information on data management and analysis including the statistical tests and software used must be provided	4
Results	6a	The estimated effect size and its precision for all the objective (primary and secondary) for each group including controls must be provided	5
	6b	Information on the loss of samples during experimentation and the reasons must be provided, if relevant	5
	6c	All the statistical results, including all comparisons between groups must be provided	5
Discussion	7a	The relevant literature and status of the hypothesis must be described	5
	7b	The true significance of the investigation must be described	5
	7c	The strength(s) of the study must be described	5
	7d	The limitations of the study must be described	6
	7e	The implications for future research must be described	6
Conclusion(s)	8a	The rationale for the conclusion(s) must be provided	6
	8b	Explicit conclusion(s) must be provided, i.e. the main “take-away” lessons	6
Funding and support	9a	Sources of funding and other support (such as supply of drugs, equipment) as well as the role of funders must be acknowledged and described	6

Conflicts of interest	10a	An explicit statement on conflicts of interest must be provided	6
Quality of images	11a	Details of the relevant equipment, software and settings used to acquire the image(s) must be described in the text or legend	–
	11b	If an image(s) is included in the manuscript, the reason why the image(s) was acquired and why it is included must be provided in the text	–
	11c	The circumstances (conditions) under which the image(s) were viewed and evaluated must be provided in the text	–
	11d	The resolution and any magnification of the image(s) or any modifications/ enhancements (e.g. brightness, image smoothing, staining etc.) that were carried out must be described in the text or legend	–
	11e	An interpretation of the findings (meaning and implications) from the image (s) must be provided in the text	–
	11f	The legend associated with each image must describe clearly what the subject is and what specific feature(s) it illustrates	–
	11g	Markers/labels must be used to identify the key information in the image(s) and defined in the legend	–
	11h	If relevant, the legend of each image must include an explanation whether it is pre-experiment, intra-experiment or post-experiment and, if relevant, how images over time were standardised	–

endodontic motor (X-smart), operating at 350 rpm and 2 N*cm torque as per manufacturer guidelines. The canal was flushed with distilled water after each file change.

After root canal preparation, the teeth were removed from the bottles and Eppendorf tubes, and the root surface was rinsed with 1 mL of distilled water to collect any adhering debris. The tubes were then stored in a 70°C incubator for 5 days to allow for moisture evaporation before the dry debris was weighed. An average value for each tube was recorded from three consecutive weighings. The weight of the apically extruded dry debris was calculated by subtracting the pre-preparation weight from the post-preparation weight.

Statistical Analysis

Data were evaluated using SPSS 22.0 (Statistical Package for Social Science Version 22). A one-way analysis of variance was conducted to assess the data. The Tukey test was employed to identify any groups or sets of groups that showed differences based on the results of the analysis. Values equal to or less than $p<0.05$ were considered statistically significant.

Results

The average values and standard deviations for all groups are displayed in Table 2. Among all the file systems, the highest amount of apical debris extrusion was observed in the G1 (hand file) group, while the least amount of apical debris extrusion was observed in the G4 (AF Baby) group. Additionally, no statistically significant difference was found between the G2 (Endoart Blue), G3 (M3 Immature Blue), and G4 (AF Baby) groups ($p > 0.05$).

Discussion

The null hypothesis of the study was rejected, as there were differences in the amount of apical debris extrusion among the file systems used.

Cleaning and preparing the root canal is one of the most critical stages of endodontic treatment. Problems such as post-treatment pain, inflammation, and patient dissatisfaction may be associated with debris extrusion during canal preparation. This can disturb the balance between the host and bacterial invasion, leading to flare-ups requiring emergency dental visits (4).

The protection of the root cells and apical papillary mesenchymal stem cells in the permanent tooth follicle under-

Table 2. Mean weights of apically extruded debris among file systems

Groups	n	Weight of Apically Extruded Debris±SD (In Milligrams)
G1 (Hand file)	10	0.13 ± 0.017A
G2 (Endoart blue)	10	0.11 ± 0.013B
G3 (M3 ımmature blue)	10	0.11 ± 0.020B
G4 (AF baby)	10	0.10 ± 0.012B

The different uppercase letters represent the difference in the columns. *p<0.05 was accepted as significance level.

neath the primary teeth is important for the reperfusion and maturation of the underlying permanent tooth's root (14). Because the apical foramen of primary teeth is generally larger than that of permanent teeth, debris extrusion into the periapical tissue is more frequent during root canal treatment (15). As such, necrotic debris extrusion may harm the root cells. For this study, the distal roots of mandibular second primary molars were used to minimize anatomical variations and standardize the groups. The experimental model developed by Myers and Montgomery was employed to evaluate debris extrusion, providing a practical, repeatable, and standardized measurement (9).

In our study, distilled water was used as the irrigation solution during canal shaping instead of sodium hypochlorite, as the remaining sodium crystals from the evaporated irrigation solution could significantly alter the results (16). Debris extrusion varies depending on the type, size, and shape of rotary file systems. It is also affected by instrumentation techniques, the working length of the root canal, and the irrigation solutions used (17). Special pediatric rotary files with altered length, taper, and tip size have been reported to be more effective and efficient in pulpectomy of primary teeth (18,19), hence, we used a pediatric rotary file system in our study.

According to our results, the highest amount of apical debris extrusion was found in the K-files. Previous studies have also reported the highest amounts of debris extrusion with hand files (20,21). This might be the reason why K-files carry more debris. Additionally, the filing motion of the hand file, which can act as a piston when passed into the apical third of the canal, may also be responsible for further debris overflow. Continuous rotary motion in file systems with endomotors and balanced force causes less extrusion as it tends to pull debris coronally (22).

The use of continuous rotary motion helps to collect debris and facilitates its exit in a coronal direction rather than an apical one (23,24). This might be one of the reasons why all three rotary file systems used in our study showed less debris extrusion compared to hand files.

Suresh et al. (25) evaluated the amount of apical debris removed by rotary instruments and traditional methods in primary teeth and reported that blue rotary files removed more apical debris. In their study evaluating the effects of different single file systems on apical debris extrusion, Tüfenkçi et al. (26) reported that blue rotary files created more debris extrusion. Topçuoğlu et al. (27) evaluated the apical debris extrusion of blue file, gold file, and resicproc file systems and observed that the most apical debris extrusion was observed in resiproc files and then in blue rotary files. This may be due to the difference in the thermal treatment protocols applied during the production of the blue file system. In addition, the gold plating of the grooves of the AF baby files (25) may have allowed for more preparation of the canal near the canal orifice, which may have allowed more debris to accumulate in the coronal direction. This leads to easier coronal movement of debris and may reduce apical debris extrusion.

Peedikayil et al. (28) in their comparative evaluation of apical extrusion of debris in primary teeth using hand files and rotary instruments, reported that pediatric blue rotary files extruded less debris. Several studies by Priyadarshini et al. (29) and Sruthi et al. (30) also reported a significant reduction in the instrumentation time of the blue pediatric rotary file, which may result in less apical extrusion. On the contrary, in our study, blue rotary files caused higher apical debris extrusion. This may be due to the different processing of the files used and the different shapes of the grooves.

Conclusion

Within the limitations of the current study, it was observed that all file systems used during root canal treatment caused apical debris extrusion. Among the compared file systems, rotary files were found to cause less extrusion compared to hand files. Among the rotary files, blue files caused more apical debris extrusion. More in vivo and in vitro studies are needed to evaluate the clinical application of pediatric rotary file systems.

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Informed consent: Written informed consent was obtained from patients who participated in this study.

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