Submitted: 03 November, 2024 Accepted: 02 January, 2025 Published: 03 September, 2025 DOI:10.22514/jocpd.2025.109

Journal of Clinical Pediatric Dentistry

ORIGINAL RESEARCH

Comparative evaluation of pediatric rotary file systems and hand files for root canal preparation in primary molars: an *in vitro* study

Sabiha Ceren İlisulu[1,*], Sinem Birant[2], Hakan Amasya[3,4,5]

[1]Department of Pediatric Dentistry, Faculty of Dentistry, Altınbaş University, 34147 İstanbul, Türkiye
[2]Department of Pediatric Dentistry, Faculty of Dentistry, İstanbul University-Cerrahpaşa, 34098 İstanbul, Türkiye
[3]Department of Oral and Dentomaxillofacial Radiology, Faculty of Dentistry, İstanbul University-Cerrahpaşa, 34098 İstanbul, Türkiye
[4]CAST (Cerrahpaşa Research, Simulation and Design Laboratory), Istanbul University-Cerrahpaşa, 34098 İstanbul, Türkiye
[5]Health Biotechnology Joint Research and Application Center of Excellence, 34220 İstanbul, Türkiye

***Correspondence**
ceren.ilisulu@altinbas.edu.tr
(Sabiha Ceren İlisulu)

Abstract

Background: The purpose of the study was to compare pediatric rotary files with hand K-files regarding the amount of dentin removal, root canal transportation, root canal surface area and volume in primary mandibular second molars using Cone-Beam Computed Tomography (CBCT). **Methods**: A total of 36 primary teeth were randomly divided into four groups; K-file, Fanta AF Baby file, EndoArt Ni-Ti Pedo file Gold Kit, MiniSCOPE Ni-Ti Gold Pediatric file. Samples were imaged with CBCT before and after canal instrumentation. For root canal surface area and volume measurements, 3-Matic (Materialize, Belgium) software was used. Linear measurements were performed using NNT iRYS software. Data analysis was conducted using the Dunn's test and the Kruskal Wallis test. A significance level of $p < 0.05$ was used. **Results**: Compared to pediatric rotary files, the K-file was shown to remove a statistically greater amount of dentin at the coronal level ($p = 0.032$). The difference in dentin thickness with the K-file was significantly greater than with the EndoArt file ($p = 0.017$) and the MiniSCOPE file ($p = 0.007$). The volume difference with the MiniSCOPE file was significantly less than with the Fanta file ($p = 0.002$) and the EndoArt file ($p = 0.032$). Root canal transportation was significantly greater with the K-file compared to the Fanta AF Baby file in both the oblique ($p = 0.031$) and buccal-lingual ($p = 0.006$) directions. **Conclusions**: Pediatric rotary files could be considered an efficient alternative to the hand K-file in biomechanical instrumentation. Three dimensional analysis can provide better comprehensive approach to evaluating the pediatric rotary instruments.

Keywords

Primary teeth; Root canal preparation; Cone-beam computed tomography; Endodontics

1. Introduction

Primary teeth are crucial for a child's growth and development, aiding in chewing, speech and aesthetics, preventing abnormal oral habits and preserving space until permanent teeth erupt [1]. Root canal treatment is often the last option for preserving primary teeth when the pulp tissue is irreversibly destroyed by trauma or dental caries [2]. For successful root canal treatment, maintaining the integrity of the radicular anatomy, removing debris and shaping the root canals to serve as pathways for irrigants and proper obturation materials are essential [3]. However, the procedure is considered challenging and time-consuming due to complex anatomical structures, such as accessory canals, thin and tortuous anastomotic canal roots, dynamic changes in the root apex, proximity to the permanent tooth germ and difficulties with behavioral management [4, 5].

Biomechanical preparation is the most crucial step in root canal treatment for primary teeth and it is typically prioritized during canal debridement [6]. Hand files are the most generally used and conventional approach for biomechanical preparation; however, manual preparation techniques have drawbacks such as time-consuming, prone to iatrogenic problems such as ledging, zipping, canal transportation, apical blockage [7]. To address these drawbacks, Barr *et al*. [8] introduced Ni-Ti rotary files in pediatric endodontics, using ProFile 0.04 tapered rotary instruments. This approach has been found to be faster, more cost-effective, and to provide more consistent results. It is highly effective for cleaning the irregular walls of primary root canals and shaping them uniformly, leading to high-quality obturation outcomes [9, 10]. Rotary files, designed primarily for the anatomy of permanent teeth, can be challenging to use on pediatric patients due to limited mouth opening and the risk of lateral perforations in the curved root canals of primary teeth [11, 12]. To overcome these challenges, novel pediatric rotary file systems have been developed, featuring modifications in taper, length and tip size specifically for primary teeth.

From a clinical standpoint, it is crucial to assess the shaping abilities of these endodontic instruments. A number of methods, such as radiography, histological sectioning, electron microscopy, stereomicroscopy, computed tomography (CT), cone-beam CT (CBCT) and micro CT, have been employed to evaluate the shaping abilities of endodontic instruments. CBCT, a new non-invasive 3-Dimensional (3D) digital imaging technique, enables faster image acquisition and reconstruction, producing high-quality and accurate images of the root canals [2, 13].

Given the current lack of data on the amount of dentin removed by different root canal preparation files used in primary teeth, the purpose of this study was to compare pediatric rotary files (Fanta AF Baby, MiniSCOPE Gold Pediatric Files, EndoArt Ni-Ti Gold Pedo Kit) with hand K-files in terms of dentin removal, root canal surface area, root canal volume and root canal transportation in primary mandibular second molars using CBCT imaging. Our first hypothesis is that pediatric rotary files remove more dentin tissue during root canal preparation compared to the hand K-file system, resulting in greater changes in root dentin thickness, root canal surface area and root canal volume. Our second hypothesis is that root canal transportation after preparation is less in pediatric rotary instrument systems than in hand K-file systems.

2. Materials and methods

2.1 Teeth selection and storage

Human mandibular second primary molars that had not undergone endodontic treatment and for which extraction was the sole treatment option were obtained from clinic of the Pediatric Dentistry Departments at Altınbaş University and İstanbul University-Cerrahpaşa, between February 2024 and June 2024. Teeth extracted due to orthodontic treatment or over-retention past the age of exfoliation were also collected for the study. To ensure sample homogeneity, all teeth were examined radiographically and clinically prior to the study's begin. The study included only teeth with distal and mesial roots measuring at least 7 mm in length, and pre-operative cone-beam computed tomography (CBCT) images showing standardized canal curvature angles (10°–20°) and radii (>8 mm) [14]. Teeth with calcification or internal and external root resorption were excluded. To eliminate any residual soft tissue, the chosen teeth were cleaned and rinsed under running water. They were then kept in a 0.1% thymol solution and used for study within one month.

2.2 Sample size calculation and randomization

Based on a prior study [15] the sample size was calculated using G*Power 3.1.9.4 (Franz Faul, Universität Kiel, Kiel, SH, Germany). It was determined that a total of 9 samples per group were required to obtain 80% power at an alpha significance level of 5% and an effect size of 0.595. As a result, the sample size comprised a total of 36 samples, with 9 samples in each group.

The randomization procedure was carried out by an independent investigator (SO). Through the use of the random number generator tool on the random.org website, 36 primary second molar teeth having met the inclusion criteria were divided into 4 groups. Teeth were allocated numbers from one to nine in each group. Flow chart of the study is represented in Fig. 1.

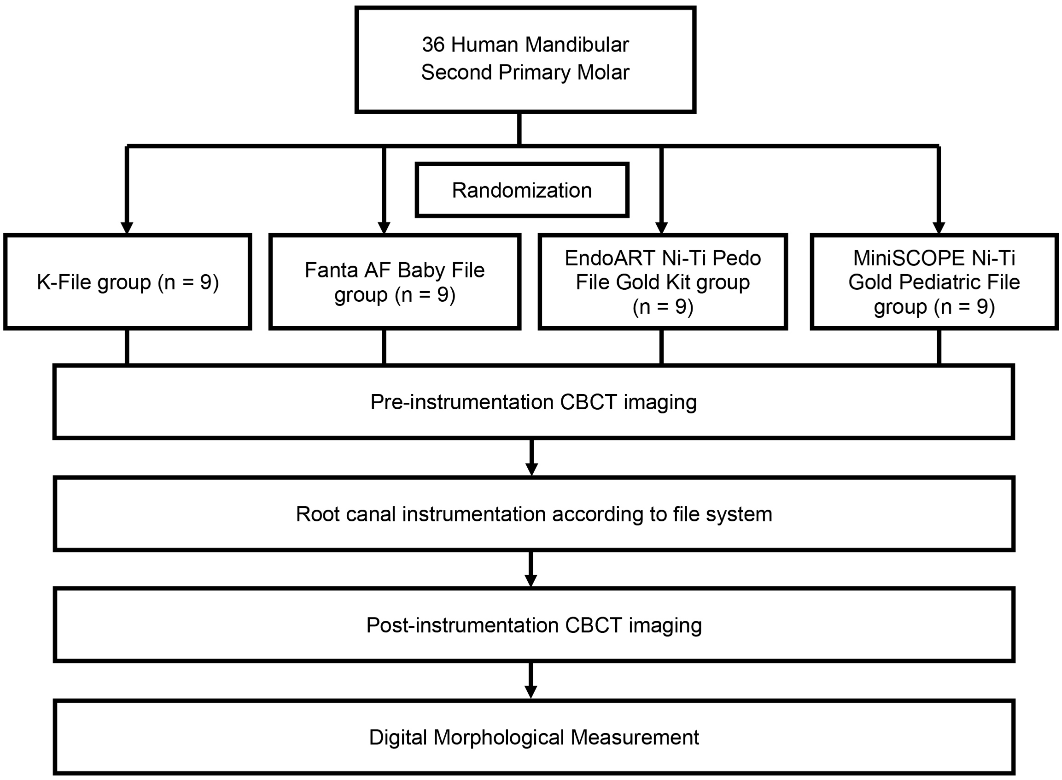

FIGURE 1. Flow chart of the study. CBCT: Cone-Beam Computed Tomography.

2.3 Root canal instrumentation of teeth

To ensure standardization, all clinical procedures were carried out by a single qualified operator (SB) with ten years of expertise treating patients with rotary files.

The endodontic access cavity was prepared using No. 802 round diamond bur (Frank Dental, Germany) under water/air coolant. Once the pulp chamber had been thoroughly irrigated with 2.5% sodium hypochlorite, a #10 K-file (Dentsply/Maillefer, Ballaigues, Switzerland) was introduced into the root canal until its tip appeared through the apical foramen. 1 mm below the apical foramen served as the working length.

K-File group (n = 9)—The root canals were manually shaped using a step-back approach with 21 mm stainless steel K-files of 0.02 taper, beginning with size #15 and finishing with size #30 (Dentsply Maillefer, Ballaigues, Switzerland), utilizing the quarter turn-pull technique.

Fanta AF Baby File group (n = 9)—The root canals were shaped with the Fanta AF Baby file rotary system (Fanta Dental, Shanghai, China) in the following order, per the manufacturer's recommendation: 17/0.08, 20/0.04 (yellow), 25/0.04 (red) and 30/0.04 (blue) at 350 rpm with 2 Ncm torque setting. The Fanta AF Baby File is made from nickel-titanium (Ni-Ti), features a tapered design, and has a triangular cross-section. The file typically has a non-cutting tip [16].

EndoArt Ni-Ti Pedo File Gold Kit group (n = 9)—The root canals were prepared with the EndoArt Ni-Ti Pedo Gold Kit (Inci Dental, İstanbul, Türkiye) rotary system according to the recommended sequence by the manufacturer as follows: 20/0.04 (yellow), 25/0.04 (red) and 30/0.04 (blue) at 350 rpm with 2 Ncm torque setting. The EndoART Ni-Ti Pedo File Gold Kit is made from nickel-titanium (Ni-Ti) with a gold heat treatment [17]. It features a convex triangular cross-section and a non-cutting tip (https://incidental.com.tr/endoart-pedo-gold-46).

MiniSCOPE Ni-Ti Gold Pediatric File group (n = 9)—The root canals were prepared with the MiniSCOPE Ni-Ti Gold Pediatric File (Gtech Dizayn Dental Medikal, Yozgat, Türkiye) rotary system following the manufacturer's instructions. The adopted file sequences were 20/0.04 (yellow), #25/0.04 (red) and #30/0.04 (blue) respectively at 350 rpm with 2 Ncm torque setting. The MiniSCOPE Ni-Ti Gold Pediatric File is made from nickel-titanium (Ni-Ti) with a gold heat treatment. The files feature a tapered design, offering a high degree of flexibility and typically have an equilateral triangle cross-section. They also have a non-cutting tip [18].

All rotary files were activated by Endo-Mate TC2 (NSK, Kanuma, Japan) endo-motor. The crown-down method was used to prepare the root canals in groups of rotary files.

The files were lubricated with 17% Ethylenediaminetetraacetic acid (EDTA) gel (3GPRE7131, RC-Prep, Premier Dental Products, Philadelphia, PA, USA) during root canal instrumentation. Between each file, root canals were irrigated with 2.5% sodium hypochlorite followed by saline in all groups. A side-vented needle (Shinhung, China) with a gauge of 30 was used for irrigation. To ensure uniformity in root canal instrumentation, each hand file and rotary file was used on a maximum of five teeth before discarded [19, 20]. The operator instrumented five teeth to counteract potential operator fatigue-related bias in root canal preparation.

2.4 Radiographic data acquisition

The examiner (HA) was blinded during the CBCT image assessment to minimize potential bias in the evaluation process. Specimens were assigned random letter codes after preparation to ensure blinding. The blinding process was maintained during radiological procedures, including image production and analysis. Information related to the file system used for sample preparation was securely stored.

All the procedures for the four groups were done by a single calibrated operator. Intra-examiner reliability was determined for the three samples used for the pilot study where Intraclass Correlation Coefficient (ICC) values for the dentin thickness (ICC = 0.923), dentin volume (ICC = 0.901), surface area (ICC = 0.930), root canal transportation (ICC = 0.910) showed excellent agreement which indicates good reliability.

Samples were imaged with MyRay X9 Pro (Cefla s.c., Imola, Italy) CBCT device with a 4 cm × 4 cm Field of View (FOV) in "Super High Definition (HD)" mode. All specimens were imaged with constant pulsed 90 kVp, 8 seconds irradiation time and 68 μm theoretical resolution, while the tube current was determined in real time with the device's "Morphology Recognition Technology". Selected specimens were imaged at two separate sessions for before and after root canal preparation, including one sample at a time. Samples that were found to be inappropriate during the first imaging due to root configuration or other reasons were excluded from the study. To fix the specimens during imaging, a piece of sponge was fixed on a wooden stick and a notch was created on it. This assembly was fixed to the chin support apparatus of the device. The specimens were placed in the notch in an upright position. The position of the specimens and their presence in the imaging field were ensured by anteroposterior and lateral scout images. Device data were processed and recorded with the NNT iRYS software 15.0 (Cefla s.c., Imola, Italy). Coronal and axial section of the sample in the CBCT were shown in Fig. 2. Linear measurements were performed in the device own software, while volumetric data for surface and volume calculations were exported in axial, coronal and sagittal slices in Digital Imaging and Communications in Medicine (DICOM) format and numbered.

2.5 Digital morphological measurements and calculations

Linear measurements were performed in iRYS software, and each tooth root was measured independently. For this, the vertical axis of the tooth root to be measured was first aligned. Then, in the coronal, middle and apical third, measurements were made on selected slices. The distance between the outer border of the root canal and the outer border of the dentin was measured in the respective slices, separately for the mesial, distal, buccal and lingual/palatinal directions. Root canal transportation was calculated using the following three formulas [21, 22]:

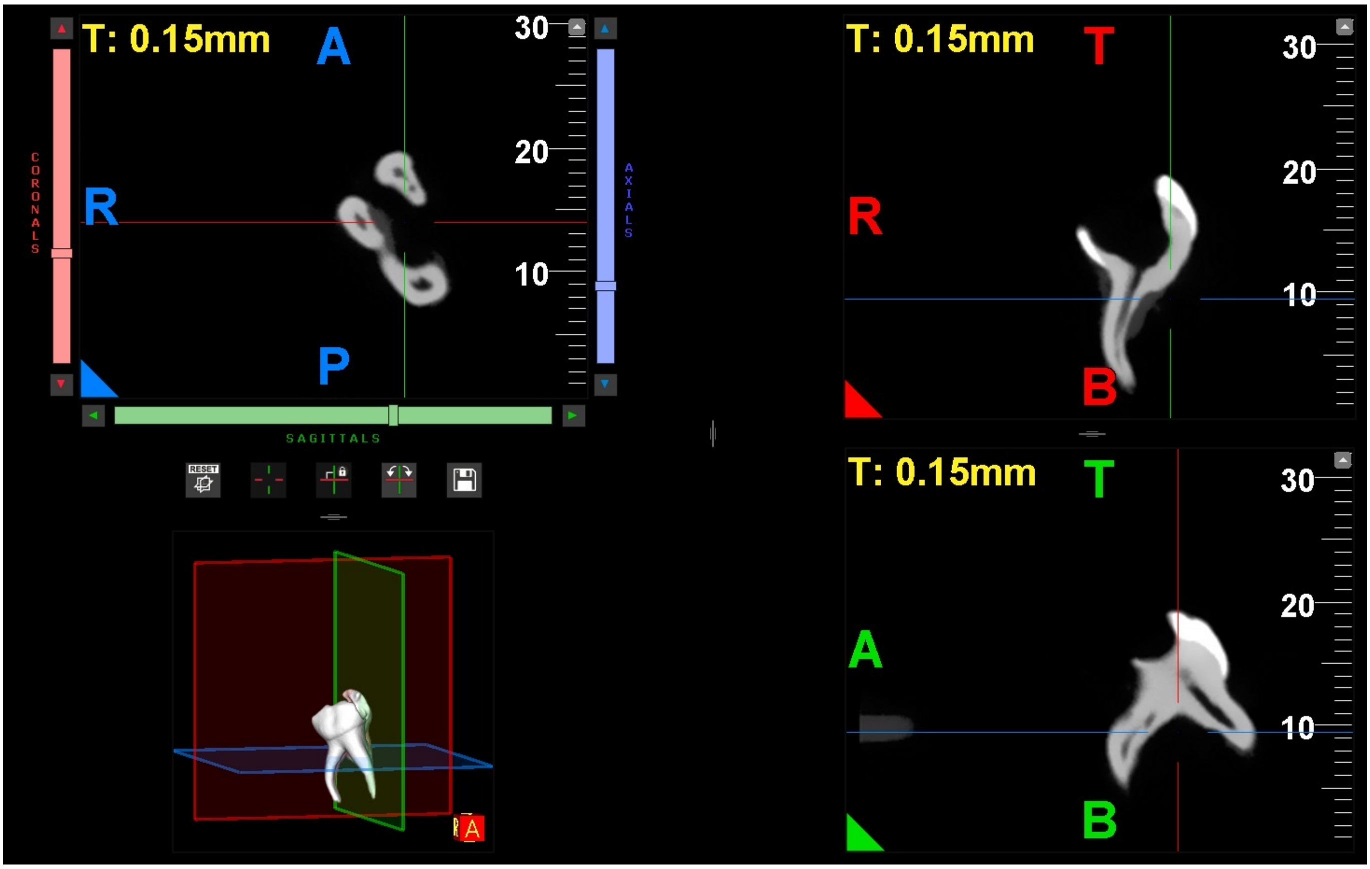

FIGURE 2. Coronal and axial section of the sample in the CBCT. A: Anterior; R: Right; P: Posterior; T: Top; B: Bottom.

$$Mesio - distal\ transport\ (MDT) = |(D1 - D2) - (M1 - M2)|$$

$$Bucco - lingual\ transport\ (BLT) = |(B1 - B2) - (L1 - L2)|$$

$$Oblique\ transport = \sqrt{MDT^2 + BLT^2}$$

In these formulas, *D1* represents the distal side before and *D2* after preparation; *M1* represents the mesial side before and *M2* after preparation; *B1* represents the buccal side before and *B2* after preparation; and *L1* represents the lingual/palatinal side before and *L2* after preparation (Fig. 3). Oblique transport was calculated using the amount of displacement in these two perpendicular axes and the Pythagorean theorem.

For surface and volume measurements, CBCT data in DICOM format were transferred to MIMICS 17.0 (Materialise Technologies, Leuven, Belgium) software, the tooth structures were segmented and the obtained surfaces were transferred to 3-Matic 17.0 (Materialise Technologies, Leuven, Belgium) software (Fig. 4).

The radiographic volumes acquired before and after preparation were superimposed using the point-registration technique and artificial notches on the specimens (Fig. 5). Before the measurements, each tooth root was separated from the crown and become independent. In determining the effect on the root canal surface area, the surface calculated after preparation was subtracted from the surface calculated before preparation. To determine the volumetric effect, the volumetric data before and after preparation were subtracted from each other by applying Boolean operation and the area remaining in the root canal was calculated.

2.6 Statistical analysis

All data were assessed with SPSS software (ver. 22.0; IBM, Armonk, NY, USA). An analysis of the data's normal distribution using the Shapiro-Wilk test was conducted. The Kruskal Wallis test was utilized for inter-group comparisons of the parameters, and Dunn's test was employed to identify the group causing the difference. Descriptive statistical methods, including mean, standard deviation and median, were also applied. Intra-group comparisons of parameters were conducted using the Friedman test and the *post hoc* Wilcoxon sign test. Spearman's rho correlation analysis was used to evaluate the correlation between the parameters. A significance level of $p < 0.05$ was used.

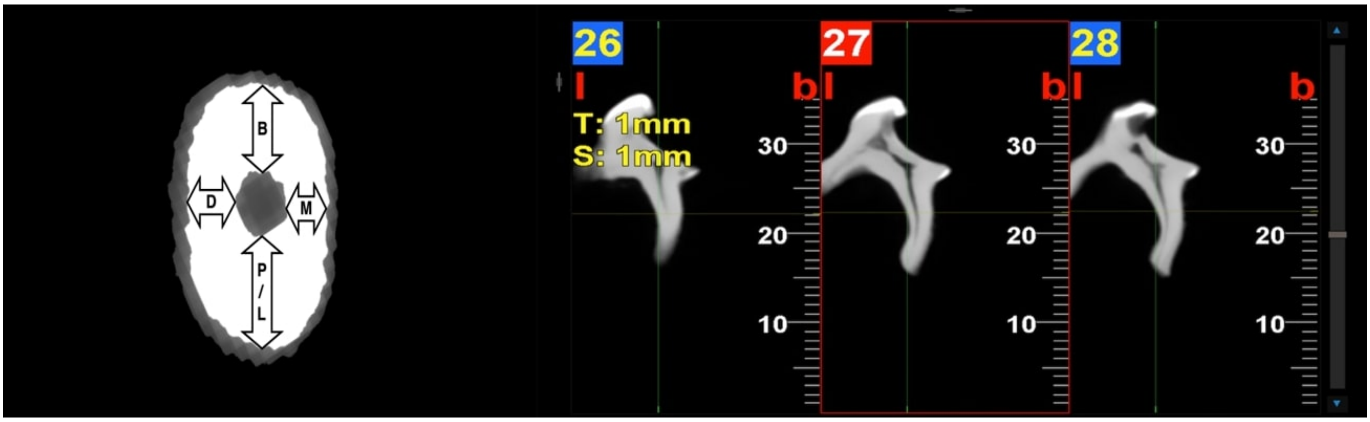

FIGURE 3. Linear measurements were made utilizing CBCT data and the vertical level of the root was determined in cross-sections. Dentin thicknesses were measured in the mesial, distal, buccal and lingual/palatinal direction in each horizontal section. T: Thickness; S: Space; b: Buccal.

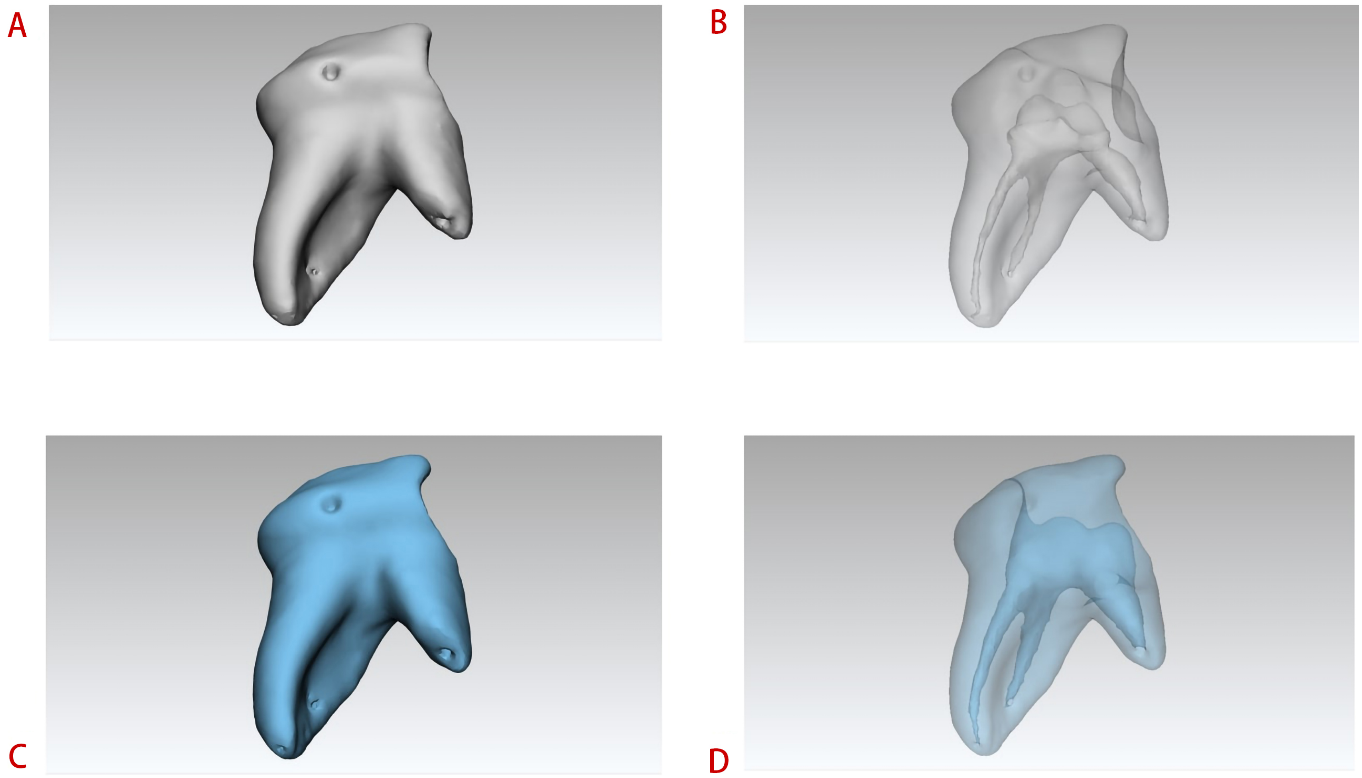

FIGURE 4. 3-dimensional images demonstrating the dentine thickness and the structure of the internal root canals. (A) 3-dimensional image of the tooth before preparation; (B) 3-dimensional image of root canals before preparation; (C) 3-dimensional image of the tooth after preparation; (D) 3-dimensional image of root canals after preparation.

3. Results

3.1 The amount of dentin removal

Table 1 shows the amount of dentin removed at the coronal, middle and apical levels both inter- and intra-group. The amount of dentin removed differed statistically significantly between groups at both the coronal (p = 0.032) and apical (p = 0.013) levels. At the coronal level, the K-file removed significantly more dentin compared to the other files, whereas at the apical level, the MiniSCOPE file removed significantly less dentin than the other files. Within the K-file group, the amount of dentin removed differed significantly between all levels (p = 0.004). In the K-file group, the amount of dentin removed at the coronal level was significantly greater compared to the middle (p = 0.026) and apical (p = 0.026) levels.

Table 2 shows the mean and median values for dentin removal both intra and inter-group at the coronal, middle and apical levels with regard to the buccal, lingual, mesial and distal sides of the root.

3.2 Dentin thickness

Table 3 shows the difference in dentin thickness before and after instrumentation. In terms of mean dentin thickness dif-

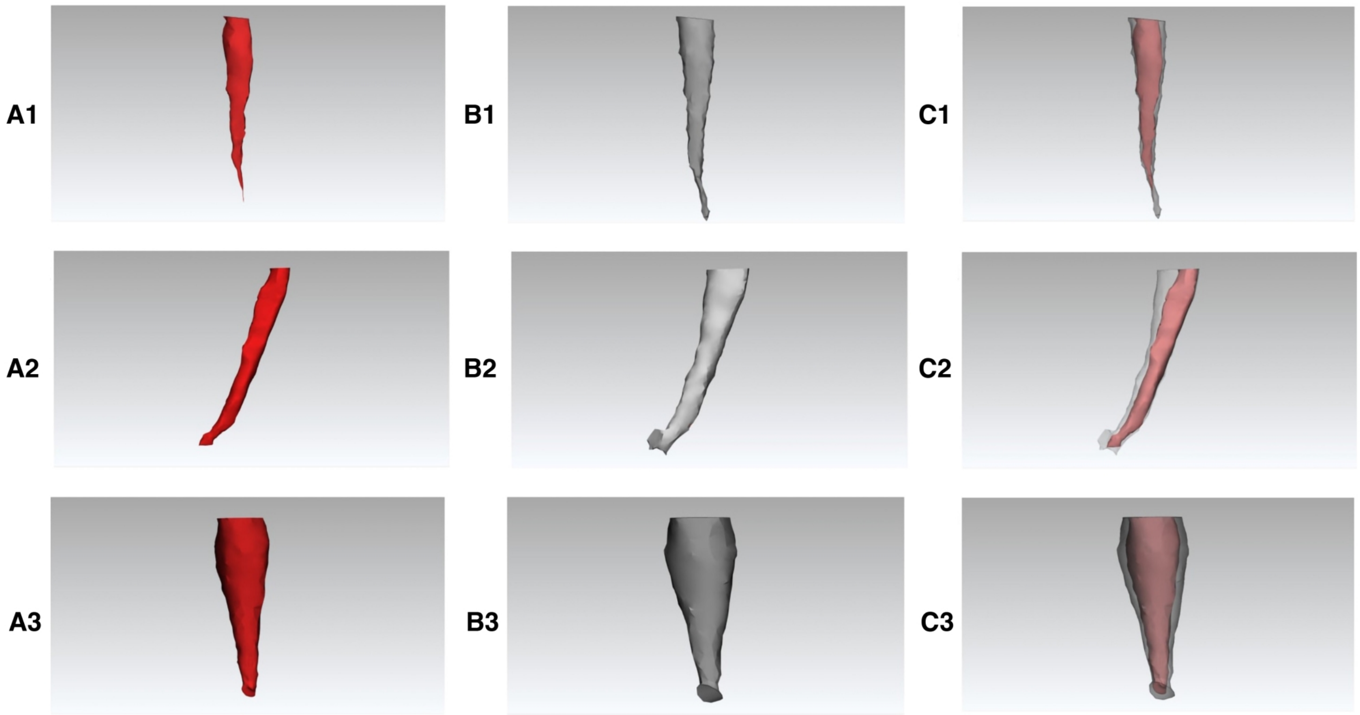

FIGURE 5. The area and volume measurements of each tooth root were calculated independently by separating the roots from the tooth. The image shows the segmentation results of three different tooth roots under different conditions. (A) Root canal shape before preparation; (B) Root canal shape after preparation; (C) Overlapping of the root canal before and after preparation; (1) Mesio-buccal canal; (2) Mesio-lingual canal; (3) Distal canal.

TABLE 1. The mean and median values for the amount of dentin removed inter and intra groups at coronal, middle and apical levels.

	K-File Mean ± SD (Median)	Fanta File Mean ± SD (Median)	EndoArt File Mean ± SD (Median)	MiniSCOPE File Mean ± SD (Median)	^{1}p
Coronal	0.38 ± 0.16 (0.45)^{Aa}	0.15 ± 0.06 (0.13)^{B}	0.18 ± 0.03 (0.18)^{AB}	0.13 ± 0.07 (0.15)^{B}	**0.032***
Middle	0.18 ± 0.07 (0.15)^{b}	0.25 ± 0.15 (0.23)	0.06 ± 0.09 (0)	0.14 ± 0.09 (0.18)	0.082
Apical	0.15 ± 0.04 (0.15)^{Ab}	0.25 ± 0.14 (0.3)^{A}	0.14 ± 0.07 (0.13)^{A}	0.07 ± 0.01 (0.08)^{B}	**0.013***
^{2}p	**0.004***	0.834	0.069	0.513	

^{A,B}There is no significant difference between values with the same capital letter in the same row.
^{a,b}There is no significant difference between values with the same lowercase letter in the same column.
Bold numbers indicate significance.
*^{1}Kruskal Wallis Test; ^{2}Friedman Test; *$p < 0.05$; SD: Standard Deviation.*

ferences, there was a statistically significant difference (p = 0.020) between the file groups. As a result of the post hoc Dunn's test, the dentin thickness difference in the K-file group was significantly greater than that in the EndoArt file group (p = 0.017) and the MiniSCOPE file group (p = 0.007).

3.3 Dentin volume

The difference in dentin volume before and after instrumentation is shown in Table 4. A statistically significant difference in dentin volume was found between the file groups (p = 0.002). The post hoc Dunn's test revealed that the volume difference in the MiniSCOPE file group was significantly lower than in the Fanta file group (p = 0.002) and the EndoArt file group (p = 0.032).

3.4 Surface area

The difference in dentin surface area before and after instrumentation is shown in Table 5. A statistically significant difference in surface area was found between the file groups (p = 0.001). The post hoc Dunn's test indicated that the surface area difference in the MiniSCOPE file group was significantly lower than that in the K-file group (p = 0.033), the Fanta file group (p = 0.001), and the EndoArt file group (p = 0.022).

3.5 Correlation of dentin volume and surface area with dentin thickness

The correlation between dentin volume and surface area with dentin thickness is presented in Table 6. In the EndoArt file group, dentin thickness and surface area showed a strongly significant correlation (r = 1.000; p = 0.001). Accordingly,

TABLE 2. The mean and median values for the amount of dentin removed inter and intra groups at coronal, middle and apical levels in terms of buccal, lingual, mesial and distal surface.

	K-File Mean ± SD (Median)	Fanta File Mean ± SD (Median)	EndoArt File Mean ± SD (Median)	MiniSCOPE File Mean ± SD (Median)	^{1}p
Mesial					
Coronal	0.30 ± 0.18 (0.3)	0.20 ± 0.15 (0.1)	0.17 ± 0.14 (0.2)	0.10 ± 0.09 (0.1)^{a}	0.215
Middle	0.23 ± 0.14 (0.2)	0.20 ± 0.09 (0.2)	0.10 ± 0.15 (0)	0.17 ± 0.14 (0.2)^{b}	0.418
Apical	0.23 ± 0.14 (0.2)^{A}	0.13 ± 0.1 (0.2)^{AB}	0.20 ± 0 (0.2)^{A}	0.03 ± 0.05 (0)^{Ba}	**0.009***
^{2}p	0.513	0.247	0.580	**0.024***	
Buccal					
Coronal	0.27 ± 0.05 (0.3)	0.13 ± 0.14 (0.1)	0.17 ± 0.26 (0)	0.13 ± 0.05 (0.1)	0.182
Middle	0.20 ± 0.09 (0.2)^{AB}	0.23 ± 0.05 (0.2)^{B}	0.07 ± 0.10 (0)^{A}	0.07 ± 0.10 (0)^{A}	**0.015***
Apical	0.13 ± 0.05 (0.1)^{AB}	0.37 ± 0.26 (0.2)^{B}	0.1 ± 0.09 (0.1)^{A}	0.03 ± 0.05 (0)^{A}	**0.003***
^{2}p	0.055	0.580	0.751	0.135	
Distal					
Coronal	0.27 ± 0.05 (0.3)^{a}	0.23 ± 0.1 (0.3)	0.13 ± 0.05 (0.1)	0.27 ± 0.14 (0.3)	0.077
Middle	0.07 ± 0.10 (0)^{b}	0.20 ± 0.15 (0.1)	0.07 ± 0.1 (0)	0.20 ± 0.09 (0.2)	0.071
Apical	0.10 ± 0 (0.1)^{b}	0.17 ± 0.14 (0.2)	0.07 ± 0.1 (0)	0.07 ± 0.10 (0)	0.336
^{2}p	**0.009***	0.247	0.247	0.280	
Lingual					
Coronal	0.70 ± 0.47 (0.9)^{A}	0.03 ± 0.05 (0)^{Ba}	0.27 ± 0.05 (0.3)^{Aa}	0.03 ± 0.05 (0)^{B}	**0.001***
Middle	0.23 ± 0.14 (0.2)^{A}	0.37 ± 0.42 (0.2)^{Ab}	0 ± 0 (0)^{Bb}	0.13 ± 0.10 (0.2)^{A}	**0.021***
Apical	0.13 ± 0.05 (0.1)	0.33 ± 0.19 (0.4)^{b}	0.20 ± 0.09 (0.2)^{a}	0.13 ± 0.14 (0.1)	0.123
^{2}p	0.074	**0.022***	**0.004***	0.074	

^{A,B}There is no significant difference between values with the same capital letter in the same row.
^{a,b}There is no significant difference between values with the same lowercase letter in the same column.
Bold numbers indicate significance.
*^{1}Kruskal Wallis Test; ^{2}Friedman Test; *$p < 0.05$; SD: Standard Deviation.*

TABLE 3. The mean and median values of dentin thickness difference between groups.

	Dentin thickness difference Mean ± SD (Median)
K-File	0.24 ± 0.07 (0.25)^{a}
Fanta File	0.22 ± 0.09 (0.25)^{ab}
EndoArt File	0.13 ± 0.04 (0.13)^{b}
MiniSCOPE File	0.11 ± 0.05 (0.14)^{b}
p	**0.020***

^{a,b}There is no significant difference between values with the same lowercase letter in the same column.
Bold numbers indicate significance.
*Kruskal Wallis Test; *$p < 0.05$; SD: Standard Deviation.*

TABLE 4. The mean and median values of dentin volume difference between groups.

	Dentin volume difference Mean ± SD (Median)
K-File	0.66 ± 0.28 (0.76)^{ab}
Fanta File	1.17 ± 0.38 (1.01)^{a}
EndoArt File	0.98 ± 0.60 (0.84)^{a}
MiniSCOPE File	0.28 ± 0.09 (0.28)^{b}
p	**0.002***

^{a,b}There is no significant difference between values with the same lowercase letter in the same column.
Bold numbers indicate significance.
*Kruskal Wallis Test; *$p < 0.05$; SD: Standard Deviation.*

TABLE 5. The mean and median values of dentin surface area difference between groups.

	Surface area difference Mean ± SD (Median)
K-File	2.88 ± 0.85 (2.93)[a]
Fanta File	4.52 ± 1.06 (3.85)[a]
EndoArt File	2.88 ± 0.67 (3.14)[a]
MiniSCOPE File	0.94 ± 0.17 (1.03)[b]
p	**0.001***

[a,b]There is no significant difference between values with the same lowercase letter in the same column.
Bold numbers indicate significance.
*Kruskal Wallis Test; *p < 0.05; SD: Standard Deviation.*

TABLE 6. Dentin volume and surface area correlation with dentin thickness.

	Dentin thickness	
	r	*p*
K-File		
Dentin volume	−0.500	0.312
Surface area	−0.500	0.312
Fanta File		
Dentin volume	0.500	0.312
Surface area	−0.500	0.312
EndoArt File		
Dentin volume	0.500	0.312
Surface area	1.000	**0.001***
MiniSCOPE File		
Dentin volume	1.000	**0.001***
Surface area	−0.500	0.312

*Spearman's rho correlation test; *p < 0.05.*
Bold numbers indicate significance.

there was a linear correlation between dentin thickness and surface area, with an increase in dentin thickness difference being correlated with an increase in surface area difference. In the MiniSCOPE file group, dentin thickness and dentin volume also showed a strongly significant positive correlation (r = 1.000; p = 0.001). As a result, there was a linear correlation between dentin thickness and dentin volume, with an increase in dentin thickness difference being correlated with an increase in dentin volume difference.

3.6 Root canal transportation

The comparison of root canal transportation buccolingually, mesiodistally and obliquely both inter and intra-groups is shown in Table 7.

Buccolingually, canal transportation at the coronal level was notably greater in the K-file group compared to both the Fanta file group (p = 0.006) and the MiniSCOPE file group (p = 0.017). Conversely, at the apical level, canal transportation was significantly lower in the K-file group compared to the Fanta file group (p = 0.014). Within the K-file group, canal transportation at the coronal level was significantly higher than at the middle (p = 0.026) and apical (p = 0.023) levels. In the EndoArt file group, canal transportation at the coronal level was significantly greater compared to both the middle (p = 0.023) and apical (p = 0.014) levels. In the MiniSCOPE file group, canal transportation at the apical level was significantly greater than at the middle level (p = 0.014).

Mesiodistally, canal transportation at the middle level was significantly less in the EndoArt file group compared to both K-file group (p = 0.018) and the Fanta file group (p = 0.023).

Obliquely, canal transportation at the coronal level was significantly greater in the K-file group compared to the Fanta file group (p = 0.031), while canal transportation at the apical level was significantly less in the EndoArt file group compared to the Fanta file group (p = 0.015). Within the K-file group, canal transportation at the coronal level was statistically greater than at the middle (p = 0.026) and apical (p = 0.026) levels, and canal transportation at the middle level was statistically greater than at the apical level (p = 0.026). In the EndoArt file group, canal transportation at the coronal level was significantly greater compared to both the middle (p = 0.026) and apical (p = 0.023) levels.

TABLE 7. The mean and median values for root canal transportation buccolingually (B-L), mesiodistally (M-L) and obliquely in inter and intra-groups.

	K-File Ort ± SD (Median)	Fanta File Ort ± SD (Median)	EndoArt File Ort ± SD (Median)	MiniSCOPE File Ort ± SD (Median)	^{1}p
B-L					
Coronal	0.50 ± 0.32 $(0.6)^{Aa}$	0.10 ± 0.15 $(0)^{B}$	0.30 ± 0 $(0.3)^{ABa}$	0.10 ± 0 $(0.1)^{Bab}$	**0.009***
Middle	0.17 ± 0.14 $(0.2)^{b}$	0.33 ± 0.29 (0.2)	0.07 ± 0.1 $(0)^{b}$	0.07 ± 0.10 $(0)^{a}$	0.091
Apical	0.07 ± 0.05 $(0.1)^{Ab}$	0.23 ± 0.10 $(0.3)^{B}$	0.10 ± 0 $(0.1)^{ABb}$	0.17 ± 0.10 $(0.1)^{ABb}$	**0.015***
^{2}p	**0.032***	0.513	**0.009***	**0.041***	
M-D					
Coronal	0.17 ± 0.14 (0.2)	0.1 ± 0.09 (0.1)	0.17 ± 0.05 (0.2)	0.23 ± 0.21 (0.1)	0.585
Middle	0.17 ± 0.05 $(0.2)^{A}$	0.13 ± 0.1 $(0.2)^{A}$	0.03 ± 0.05 $(0)^{B}$	0.10 ± 0 $(0.1)^{AB}$	**0.020***
Apical	0.13 ± 0.14 (0.1)	0.1 ± 0.15 (0)	0.07 ± 0.1 (0)	0.2 ± 0.09 (0.2)	0.222
^{2}p	0.580	0.751	0.094	0.135	
Oblique					
Coronal	0.56 ± 0.28 $(0.6)^{Aa}$	0.20 ± 0.09 $(0.2)^{B}$	0.35 ± 0.02 $(0.36)^{ABa}$	0.26 ± 0.19 $(0.14)^{AB}$	**0.019***
Middle	0.26 ± 0.08 $(0.22)^{ABb}$	0.38 ± 0.27 $(0.22)^{A}$	0.07 ± 0.11 $(0)^{Bb}$	0.14 ± 0.06 $(0.1)^{AB}$	**0.036***
Apical	0.15 ± 0.14 $(0.14)^{c}$	0.27 ± 0.14 (0.3)	0.14 ± 0.06 $(0.1)^{b}$	0.26 ± 0.13 (0.22)	0.193
^{2}p	**0.002***	0.513	**0.009***	0.069	

^{A,B}*There is no significant difference between values with the same capital letter in the same row.*
^{a,b}*There is no significant difference between values with the same lowercase letter in the same column.*
Bold numbers indicate significance.
^{1}*Kruskal Wallis Test;* ^{2}*Friedman Test; *$p < 0.05$; SD: Standard Deviation.*

4. Discussion

Anatomically, the complex and intracte structure of primary teeth (existence of accessory canals, ramifications and torturous root canal anatomy) makes biomechanical preparation an important step [23]. From the past to the present, various file systems have been used for biomechanical preparation in endodontic treatment of primary teeth. Therefore, the aim of this *in vitro* study was to evaluate the dentin removal amount, root canal surface area, root canal volume, and root canal transportation of pediatric rotary files (Fanta AF Baby, MiniSCOPE Gold Pediatric Files, EndoArt Ni-Ti Gold Pedo Kit) compared to hand K-files using CBCT.

The findings of the current study rejected the first hypothesis, as the amount of dentin removed at the coronal level was found to be statistically greater with the hand K-file system compared to the Fanta AF Baby and MiniSCOPE pediatric rotary file systems. Ideally, preserving at least 1 mm of dentin on all surfaces of the root is critical for maintaining the tooth's structural integrity and resistance to fractures following root canal preparation [24]. The goal of root canal preparation is to expand the canal without compromising the tooth's structural strength. Therefore, maintaining an adequate amount of remaining dentin, particularly in the coronal area, is crucial for preserving the tooth's resistance to fractures [25, 26]. Previous studies have noted that, at the coronal third, the hand K-file removed significantly more dentin than the Kedo-S rotary file in the axial cut of CBCT images [20, 27], with some suggesting that this may be due to clinicians' tendency for more vigorous instrumentation in the coronal third [28]. Additionally, the change in dentin thickness was greater with the hand K-file system than with the EndoArt and MiniSCOPE pediatric rotary file systems. These findings can be explained through alterations in the design of the file. K-files are stainless steel wire files with tougher cross-sections that can press laterally against the dentin walls, providing effective debridement. This can result in an uncontrollable and violent cutting action of stainless steel hand K-files [29, 30]. Furthermore, these findings could be attributed to Fanta AF Baby files' controlled memory wire technology, which adapts to various canal morphologies without straightening [2, 16]. Fanta AF Baby files, as defined by the manufacturer, are controlled memory (CM) files in which the instruments can be pre-curved prior to being inserted into the root canals because the CM wires are produced using a unique thermomechanical method. As curved canals are being prepared, these files often adjust to the shape of the canal rather than totally straightening. Additionally, this technique aids in achieving stable martensitic at body temperature, decreases form memory, and enhances flexibility. The file is triangular in cross-section, 16 mm long, and uses an advanced tip approach that avoids generating steps [2].

The findings of this study are consistent with earlier studies comparing the rotary Kedo-S files with hand K-files at the middle and coronal levels [20, 27]. Conversely, Güçyetmez *et al.* [5] found that in the coronal and middle thirds of root canal, EndoArt rotary files removed more dentin than hand K-files. The EndoArt Ni-Ti Pedo File Gold has an 18 mm length with a convex triangle cross-section design. The manufacturer claims that the proprietary heat treatment process greatly increases the flexibility and durability of the Ni-Ti alloy wire (incidental). In contrast to our findings, Abd El Fatah *et al*. [2] found a significant difference in the amount of dentin removed by the K-file, Fanta AF Baby file, and Zuanba file in the middle third of the root canal, but not in the coronal or apical thirds. Furthermore, Waly *et al*.'s [31] study, which compared the hand K-file with Kedo-S and Pro AF Baby Gold systems, found no significant difference in the amount of dentin removed among all groups at any levels.

According to the manufacturer, MiniSCOPE pediatric files are made from heat-treated nickel titanium alloy and feature non-sharp, rounded safety tips. The files are designed with a 17-mm length and an equilateral triangle cross-section (triple-blade 60°) [18]. In current study, MiniSCOPE pediatric rotary files removed less dentin at the apical level compared to other rotary and hand K-files. This may be due to the MiniScope files' non-cutting safety tips, whereas stainless steel files exhibit a more aggressive and uncontrolled cutting action. In the literature, studies on MiniSCOPE pediatric rotary files have mostly focused on cyclic fatigue resistance and surface analysis [17, 32, 33]. Since studies comparing shaping abilities of MiniSCOPE files to other pediatric rotary files have not been conducted, this is the first study to compare MiniSCOPE files with other rotary files in terms of shaping ability.

The amount of residual radicular dentin in the canal walls should not be less than 0.3 mm to adequately protect the root from occlusal and lateral stresses. This is likely the most important iatrogenic element determining the root's resistance to fracture [34]. Additionally, in primary teeth, the tooth exfoliates more rapidly as the thickness of the remaining dentin decreases [27]. There is a positive correlation between dentin removal and the aggressiveness of the root canal instrument [3]. In present study, dentin removal with MiniSCOPE files was found to be more rigorous and conservative. This may be preferable for maintaining the integrity of primary root canals with thin walls.

Root canal transportation refers to the unintended alteration of the original canal curvature during the cleaning and shaping process, which can lead to a number of complications in root canal treatment. Transportation typically occurs when files or instruments are not properly aligned with the natural curvature of the root canal, resulting in the enlargement of the canal or deviation from its original path [35, 36]. Root canal transportation could lead to (i) insufficiently cleaned root canals, leaving behind debris and lingering microorganisms, (ii) excessive removal of healthy dentin, potentially weakening the tooth's fracture resistance, and (iii) compromise to the structural integrity of the root [36]. Regarding the impact of root canal instrument design on canal transportation, it can be concluded that: (i) instruments with modified non-cutting tips are more effective at preserving the original canal curvature compared to those with conventional tips; and (ii) certain design features, such as cross-sectional shape, chip space, flute depth, core diameter and spiral pitch, influence the instrument's ability to maintain canal curvature during preparation [37–39].

The second hypothesis was partially rejected, as canal transportation was statistically less with the hand K-file compared to the Fanta Baby file apically in buccolingual direction. However, the hand K-file showed statistically greater canal transportation than the Fanta Baby file coronally in buccolingual and oblique direction (second hypothesis was accepted). The file length may affect canal transportation coronally, as the hand K-file measures 21 mm, while the Fanta AF baby, the EndoArt and MiniSCOPE pediatric rotary files measure 16, 18 and 17 mm, respectively [40]. These findings contrast with a study by Abd El Fatah *et al*. [2], which found that the Fanta AF Baby rotary file exhibited the greatest mesial transportation at the apical third compared to the K-file and Zuanba rotary system. In present study, the Fanta AF Baby file showed greater apical transportation than the hand K-file and pediatric rotary files in buccolingual direction, with no significant difference in the mesiodistal and oblique directions among them. This aligns with prior research indicating no statistically significant difference in apical transportation values in the buccolingual and mesiodistal directions between hand K-files and EndoArt rotary files [5]. The results of the current study suggest that the MiniSCOPE and EndoArt pediatric rotary files may be more effective in preparation of canals with narrow apical diameters.

This study provides several novel insights. It is the first to use three-dimensional software programs and CBCT to assess root canal volume and surface area. The efficacy of rotary instrument systems cannot be fully explained by a parameter that solely evaluates dentin thickness in relation to specific canal reference points. Therefore, by analyzing the surface area and volume of the root canal, this study offers a comprehensive approach to evaluating pediatric rotary instruments. Additionally, our study assessed root canal transportation not only in the mesiodistal direction but also in the buccolingual and oblique directions. While previous studies measured canal transportation in a single horizontal section, this study analyzed the apical, middle, and coronal sections and compared the efficacy of the files in these three regions.

The limitation of this study is the small sample size. Further longitudinal or randomized controlled studies with larger sample sizes are recommended to confirm these findings in primary molar teeth.

The findings highlight the trade-offs between dentin removal efficiency and root canal preservation when using different instrumentation techniques. Clinicians should consider these factors when selecting endodontic instruments for pediatric patients to optimize both dentin preservation and canal shaping. Further research with larger sample sizes and varying conditions could provide more insights into the ideal instrumentation strategy for primary molars.

Although measures were taken to ensure standardisation of the teeth in our study, the different morphology of the teeth is one of the limitations of the study. Furthermore, since an *in vitro* study does not normally replicate the oral environment, total control over the experiment's conditions is not possible. Thus randomized studies are required in pediatric patients.

5. Conclusions

The following conclusions can be drawn in considering the limitations of this *in vitro* study:

- Dentin thickness change was significantly greater in manual K-file than in EndoArt and MiniSCOPE pediatric rotary files.

- Root canal volume and surface area changes were significantly lower in MiniSCOPE files than in other pediatric rotary files.

- Root canal transportation was greater in manual K-file than Fanta AF Baby file in oblique and buccolingual direction.

This study demonstrated that pediatric rotary files offer a promising alternative to hand K-files for root canal instrumentation in primary mandibular second molars. Overall, the findings suggest that pediatric rotary files are efficient and effective in preserving dentin integrity and maintaining canal shape, making them a viable option for endodontic treatment in primary teeth. Three-dimensional analysis, as employed in this study, provides a more comprehensive understanding of the biomechanical performance of different instruments, supporting the use of rotary files in pediatric endodontics for enhanced precision and safety.

AVAILABILITY OF DATA AND MATERIALS

The datasets used during the current study available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

SCİ, SB—Conceptualization. SCİ, SB, HA—methodology; validation; formal analysis; investigation; resources and data curation; writing-review and editing; supervision. SCİ—writing-original draft preparation. All authors have read and agreed to the published version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of İstanbul University-Cerrahpaşa (2024/01). Approval date: 03 January 2024. Informed consent was obtained from all legal guardians' tooth donor.

ACKNOWLEDGMENT

We would like to thank İstanbul University-Cerrahpaşa CAST (Cerrahpaşa Research Simulation and Design Centre) for their support.

FUNDING

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Akhil JEJ, Prashant B, Shashibushan KK. Comparative evaluation of three obturation techniques in primary incisors using digital intra-oral receptor and CBCT—an *in vitro* study. Clinical Oral Investigations. 2019; 23: 689–696.

[2] Abd El Fatah YAM, Khattab NMA, Gomaa YF, Elheeny AAH. Cone-beam computed tomography analysis of primary root canals transportation and dentin loss after instrumentation with two-pediatric rotary files. BMC Oral Health. 2022; 22: 214.

[3] Musale PK, Mujawar SAV. Evaluation of the efficacy of rotary *vs.* hand files in root canal preparation of primary teeth *in vitro* using CBCT. European Archives of Paediatric Dentistry. 2014; 15: 113–120.

[4] Govindaraju L, Jeevanandan G, Subramanian EMG. Comparison of quality of obturation and instrumentation time using hand files and two rotary file systems in primary molars: a single-blinded randomized controlled trial. European journal of dentistry. 2017; 11: 376–379.

[5] Güçyetmez Topal B, Falakaloğlu S, Türkoğlu H. Comparison of shaping ability between continuous rotary and manual instrumentations in Pediatric Endodontics. Journal of Dentistry Indonesia. 2021; 28: 70–75.

[6] Coll JA, Sadrian R. Predicting pulpectomy success and its relationship to exfoliation and succedaneous dentition. Pediatric Dentistry. 1996; 18: 57–63.

[7] Silva LA, Nelson-Filho P, Leonardo MR, Tanomaru JM. Comparison of rotary and manual instrumentation techniques on cleaning capacity and instrumentation time in deciduous molars. Journal of dentistry for children. 2004; 71: 45–47.

[8] Barr ES, Kleier DJ, Barr NV. Use of nickel-titanium rotary files for root canal preparation in primary teeth. Pediatric dentistry. 2000; 22: 77–78.

[9] Crespo S, Cortés O, García C, Pérez L. Comparison between rotary and manual instrumentation in primary teeth. Journal of Clinical Pediatric Dentistry. 2008; 32: 295–298.

[10] Hadwa SM, Ghouraba RF, Kabbash IA, El-Desouky SS. Assessment of clinical and radiographic efficiency of manual and pediatric rotary file systems in primary root canal preparation: a randomized controlled clinical trial. BMC Oral Health. 2023; 23: 687.

[11] Priyadarshini P, Jeevanandan G, Govindaraju L, Subramanian EMG. Clinical evaluation of instrumentation time and quality of obturation using paediatric hand and rotary file systems with conventional hand K-files for pulpectomy in primary mandibular molars: a double-blinded randomized controlled trial. European Archives of Paediatric Dentistry. 2020; 21: 693–701.

[12] Panchal V, Jeevanandan G, Subramanian EMG. Comparison of instrumentation time and obturation quality between hand K-file, H-files, and rotary Kedo-S in root canal treatment of primary teeth: a randomized controlled trial. Journal of Indian Society of Pedodontics and Preventive Dentistry. 2019; 37: 75–79.

[13] Shah DY, Wadekar SI, Dadpe AM, Jadhav GR, Choudhary LJ, Kalra DD. Canal transportation and centering ability of protaper and self-adjusting file system in long oval canals: an: *ex-vivo*: cone-beam computed tomography analysis. Journal of Conservative Dentistry. 2017; 20: 105–109.

[14] Pruett JP, Clement DJ, Carnes DL III. Cyclic fatigue testing of nickel-titanium endodontic instruments. Journal of Endodontics. 1997; 23: 77–85.

[15] Nabeeh PK, Peedikayil FC, Premkumar CT, Kottayi S, Narasimhan D. Comparison of volumetric changes in primary molar root canals by four different file systems: a cone-beam computed tomography study. Journal of South Asian Association of Pediatric Dentistry. 2021; 4: 112–116.

[16] El-Desouky SS, El Fahl BN, Kabbash IA, Hadwa SM. Cone-beam computed tomography evaluation of shaping ability of kedo-S square and fanta AF™ baby rotary files compared to manual K-files in root canal preparation of primary anterior teeth. Clinical Oral Investigations. 2024; 28: 340.

[17] Surme K, Akman H, Özkan HB, Er K. Comparison of cyclic fatigue resistance of four pediatric rotary file systems at body temperature: an *in vitro* study. BMC Oral Health. 2024; 24: 992.

[18] Scope Endo. 2020. Available at: https://scopeendo.com.tr/MiniSCOPE.pdf (Accessed: 11 February 2025).

[19] Jeevanandan G, Govindaraju L. Clinical comparison of Kedo-S paediatric rotary files *vs* manual instrumentation for root canal preparation in

primary molars: a double blinded randomised clinical trial. European Archives of Paediatric Dentistry. 2018; 19: 273–278.
[20] Mohamed RH, Abdelrahman AM, Sharaf AA. Evaluation of rotary file system (Kedo-S-Square) in root canal preparation of primary anterior teeth using cone beam computed tomography (CBCT)—*in vitro* study. BMC Oral Health. 2022; 22: 13.
[21] Gambill JM, Alder M, del Rio CE. Comparison of nickel-titanium and stainless steel hand-file instrumentation using computed tomography. Journal of Endodontics. 1996; 22: 369–375.
[22] Xu F, Zhang Y, Gu Y, Ping Y, Zhou R, Wang J. Shaping ability of four single-file systems in the instrumentation of second mesiobuccal canals of three-dimensional printed maxillary first molars. Annals of Translational Medicine. 2021; 9: 1425.
[23] Prabhakar AR, Yavagal C, Dixit K, Naik SV. Reciprocating *vs* rotary instrumentation in pediatric endodontics: cone beam computed tomographic analysis of deciduous root canals using two single-file systems. International Journal of Clinical Pediatric Dentistry. 2016; 9: 45.
[24] Kuttler S, McLean Alex, Dorn S, Fischzang A. The impact of post space preparation with Gates-Glidden drills on residual dentin thickness in distal roots of mandibular molars. The Journal of the American Dental Association. 2004; 135: 903–909.
[25] Nisar P, Katge F, Bhanushali P, Deshpande S, Poojari M, Shetty S. Comparative *in vitro* evaluation of remaining dentine thickness following instrumentation with hand and rotary endodontic files during pulpectomy in primary molars: a systematic review. European Archives of Paediatric Dentistry. 2023; 24: 15–32.
[26] Silva EJNL, Attademo RS, da Silva MCD, Pinto KP, Antunes HDS, Vieira VTL. Does the type of endodontic access influence in the cyclic fatigue resistance of reciprocating instruments? Clinical Oral Investigations. 2021; 25: 3691–3698.
[27] Seema T, Ahammed H, Parul S, Cheranjeevi J. Comparative evaluation of dentin removal and taper of root canal preparation of hand K file, ProTaper rotary file, and Kedo S rotary file in primary molars using cone-beam computed tomography. International Journal of Clinical Pediatric Dentistry. 2020; 13: 332.
[28] Ghahramani Y, Mohammadi N, Zangooei-Booshehri M, Shirdel S. Comparing the amount of removed dentin thickness in root canal treated primary molar teeth using different instrumentation techniques: *in-vitro* study using CBCT. European Archives of Paediatric Dentistry. 2022; 23: 255–260.
[29] Atmeh AR, Watson TF. Root dentine and endodontic instrumentation: cutting edge microscopic imaging. Interface Focus. 2016; 6: 20150113.
[30] Mehlawat R, Kapoor R, Gandhi K, Kumar D, Malhotra R, Ahuja S. Comparative evaluation of instrumentation timing and cleaning efficacy in extracted primary molars using manual and NiTi rotary technique—*in vitro* study. Journal of Oral Biology and Craniofacial Research. 2019; 9: 151–155.
[31] Waly AS, Yamany I, Abbas HM, Alsairafi MAA, Bazzaz RMF, Bogari DF, *et al*. Comparison of two pediatric rotary file systems and hand instrumentation in primary molar: an *ex vivo* cone-beam computed tomographic study. Nigerian Journal of Clinical Practice. 2021; 24: 1492–1498.
[32] Toker SM, Orhan EO, Beklen A. Nickel ion release and surface analyses on instrument fragments fractured beyond the apex: a laboratory investigation. BMC Oral Health. 2023; 23: 703.
[33] Orhan EO, Ertuğrul İF, Tosun S. Monotonic torsional resistance and fatigue resistance of novel SCOPERS instruments. Microscopy Research and Technique. 2021; 84: 62–70.
[34] Eldemery NA, Elshehawy O, Nasr RA, Badr MM. Evaluation of remaining dentine thickness after manual and rotary instrumentation in primary molars using cone beam computed tomography. (An *in-vitro* study). Future Dental Journal. 2021; 7: 95–98.
[35] Bürklein S, Schäfer E. Critical evaluation of root canal transportation by instrumentation. Endodontic Topics. 2013; 29: 110–124.
[36] Schäfer E, Dammaschke T. Development and sequelae of canal transportation. Endodontic Topics. 2006; 15: 75–90.
[37] Schäfer E, Tepel J. Relationship between design features of endodontic instruments and their properties. Part 3. Resistance to bending and fracture. Journal of Endodontics. 2001; 27: 299–303.
[38] Diemer F, Calas P. Effect of pitch length on the behavior of rotary triple helix root canal instruments. Journal of Endodontics. 2004; 30: 716–718.
[39] Biz MT, Figueiredo JAP. Morphometric analysis of shank-to-flute ratio in rotary nickel–titanium files. International Endodontic Journal. 2004; 37: 353–358.
[40] Abdelkafy H, Eldehna AM, Salem NA. Canal transportation and centring ratio of paediatric *vs* regular files in primary teeth. International Dental Journal. 2023; 73: 423–429.

How to cite this article: Sabiha Ceren İlisulu, Sinem Birant, Hakan Amasya. Comparative evaluation of pediatric rotary file systems and hand files for root canal preparation in primary molars: an *in vitro* study. Journal of Clinical Pediatric Dentistry. 2025; 49(5): 146-157. doi: 10.22514/jocpd.2025.109.