



Comparison of Shaping Ability of a Newly Developed Pediatric Rotary File and the Conventional Rotary Instruments in Simulated Curved Canals: 2-Dimensional Computerized Study

Yeni Geliştirilmiş Pediatric Döner Eğe ile Konvansiyonel Döner Aletlerin Simüle Eğri Kanallarda Karşılaştırılması: İki Boyutlu Bilgisayarlı Çalışma

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ABSTRACT

Objective: Deciduous teeth require special instruments for mechanical preparations due to the anatomical differences in the root canal morphology. This study aimed to assess the preparation features of a newly developed pediatric rotary file system in simulated curved canals versus conventional rotary systems.

Materials and Methods: Twenty-eight simulated canals in resin blocks were divided into groups for Endoart Pedo Smart Gold and Endoart Smart Gold instruments. Preparation was held on the crown-down technique. Pre-/post-operative digital images were superimposed, and aberrations were detected. The removed resin amount was measured at 10 points, and the mean values of outer and inner width differences were recorded. The centering ratio was also detected for each sample.

Results: The analyses from the apex revealed that the groups showed similar results in inner measurements except for the points of 0 mm ($P < .001$), 3 mm ($P < .001$), and 9 mm ($P = .036$). The statistical differences were also detected in the outer wall at the apical third, curved area, and middle third of the root length ($P < .05$). Endoart Pedo Smart Gold group showed statistically better-centering ability at the coronal entrance of the simulated root canals.

Conclusion: The root canal preparation with pediatric rotary systems revealed better results regarding centering ability and caused less dentin removal.

Keywords: Root canal treatment, root canal preparation, pediatric rotary files

ÖZ

Amaç: Süt dişleri, kök kanal morfolojisindeki anatomik farklılıklar nedeniyle mekanik hazırlıklar için özel aletler gerektirir. Bu çalışma, simüle edilmiş kavimli kanallarda yeni geliştirilen pediatric döner eğri eğe sisteminin geleneksel döner sistemlere göre preparasyonlarını değerlendirmeyi amaçlamıştır.

Gereç ve Yöntem: Endoart Pedo Smart Gold ve Endoart Smart Gold aletleri için reçine bloklarda yirmi sekiz simüle kanal gruplarına ayrıldı. Crown-down tekniği ile preparasyonlar yapıldı. İşlem öncesi/sonrası dijital görüntüler üst üste bindirildi ve sapmalar tespit edildi. Çıkarılan reçine miktarı 10 noktada ölçülerek dış ve iç genişlik farklılıklarının ortalama değerleri kaydedildi. Her numune için merkezleme oranı da tespit edildi.

Bulgular: Analizler, grupların apeksten itibaren 0 mm ($P < .001$), 3 mm ($P < .001$) ve 9 mm ($P = .036$) noktaları dışında iç ölçümlerde benzer sonuçlar gösterdiğini ortaya koydu. İstatistiksel farklılıklar,

kök uzunluğunun apikal 1/3'ünde, kavisli alanda ve orta 1/3'ünde dış duvarda tespit edildi ($P < .05$). Endoart Pedo Smart Gold grubu, simüle edilmiş kök kanallarının koronal girişinde istatistiksel olarak daha iyi merkezleme yeteneği gösterdi.

Sonuç: Pediatrik döner sistemlerle kök kanal preparasyonu, merkezleme kabiliyeti açısından daha iyi sonuçlar ortaya koydu ve daha az dentin çıkarılmasına neden oldu.

Anahtar kelimeler: kök kanal tedavisi, kök kanal preparasyonu, pediatrik döner eğeler

INTRODUCTION

The progressive characteristic of dental caries may cause pulpal damage when left without treatment. Once the pulp is involved, vital pulp therapies or root canal treatments may be needed to maintain the dental arch of primary dentition according to the pulp's clinical and histopathological status. Root canal therapies are the treatment of choice when the pulp is irreversibly affected by pathogenic factors.^{1,2} The primary purpose of this application is to disinfect the canals and fill the sanitized area with a biocompatible material.³ Mechanical preparation and irrigation are the 2 essential components of the disinfection procedure.⁴ Since the infected dentinal tissue with remaining pulp is removed by mechanical preparation and thus the effectiveness of the chemo-mechanical agent is enhanced, this stage is one of the most critical phases of root canal treatments.⁵

Conventional K and H-type files have been used in mechanical preparation and recently many studies have shown that nickel-titanium (Ni-Ti) rotary files may also be used for this aim.⁶⁻⁹ The rotary systems lessen the time-lasting procedure of mechanical preparation. Additionally, the root canals are more likely to be enlarged by preserving the original root anatomy; thus, the risk of canal transporting is minimized. The conventional rotary systems have drawbacks when used in primary teeth due to the taper and the length of the files, which may cause perforation in the lateral wall of the curved primary tooth root canal system. Considering the morphology of primary root canals, which is different from permanent ones by being shorter, thinner, and ribbon-shaped, the need for a particular system for primary teeth has become a current issue.^{6,10} Accordingly, a few pediatric rotary file systems have been developed in different regions of the world, and recently, Endoart Pedo Smart Gold (EPSG) has presented to the dental markets in Turkey.

In the literature review, many studies have detected assessing the efficiencies of different rotary systems compared to conventional H and K files and various commercial pediatric rotary files¹¹⁻¹⁴; however, no study was detected analyzing the preparation capacity of EPSG. In light of the beforementioned data, the purpose of the recent study was to compare EPSG with the conventional rotary file system of the same brand on the curved root canal system of resin blocks. Previously, comparisons of rotary files in different brands have been made in various studies. However, no study has been detected in the literature that compares pediatric files and conventional files produced with the same manufacturer and the same heat treatment (thermal processing) technology. The null hypothesis of the study is that no difference will be observed between the preparation performances of the two compared rotary file systems.

MATERIALS AND METHODS

A power analysis was performed for sample size calculation (G*Power Software) according to a previous study.⁵ A total of 14 samples per group were calculated to be required to obtain an 85% power on an effect size of 0.28 and an alpha significance level of 5% (0.05). Thus, a total of 28 samples were planned to be used for the study.

Twenty-eight simulated polyester resin blocks (Endo Bloc, ENB012, Piramit Dental, Istanbul, Turkey) were used to observe the effect of instrumentation on the root canal system. The simulated root canals were compatible with ISO standard size 15 file, with a 40° curvature, in accordance with the Schneider method.¹⁵ The canals were 13 mm long from the apex, which has a straight part of 5 mm and a curved part of 8 mm. Since mean values of deciduous root length were detected as 9-11 mm in a previous study,¹⁶ a reshaping of 3 ± 0.2 mm to all blocks was done to stimulate deciduous teeth root canal length. The blocks were divided into 2 groups and prepared by 2 Ni-Ti rotary file systems: Endoart Smart Gold Files (ESG) (inci Dental, Istanbul, Turkey) and EPSG (inci Dental, Istanbul, Turkey). One experienced operator carried out the preparation stage. A second examiner, unaware of the experimental groups, held the measurements.

Crown-down instrumentation technique was done following the manufacturer's introductions. 16:1 reduction rotary handpiece X-Smart Contra-Angle (Dentsply-Maillefer) at a rotation speed of 300 rpm was used with X-Smart (Dentsply-Maillefer) torque-limited electric motor. The canals were prepared to a working final size of 25, 0.004 taper files for all groups. All the rotary files were used to enlarge 2 canals and excluded from the study. Before use, the root canal system was irrigated with distilled water.

Canal Preparation

The following procedure was applied to both ESG and EPSG groups. Following the recommendations by the manufacturer for curved canal structure, the working files were arranged as follows:

- (i) Initially, a 10 K-file instrument was used to create a guiding path.
- (ii) An Endoflare 0.12 taper size 25 instrument was used to 5 mm.
- (iii) A 0.06 taper size 15 instrument was used to 9 mm.
- (iv) In the end, a 0.04 taper size 25 instrument was used to 10 mm, the entire working length.

Assessment of Canal Preparation and Data Analysis

The assessment of prepared canal shapes was carried out in accordance with a previous study held by Aydin et al,⁵ with a computer program Corel Graphics Suite 11 (Corel Inc., Ottawa, Canada). A charged coupled device camera (Canon S2 IS, Canon, Tokyo, Japan) was used to view pre-post instrumentation of root canal shapes in a standardized manner. Each canal's pre-post

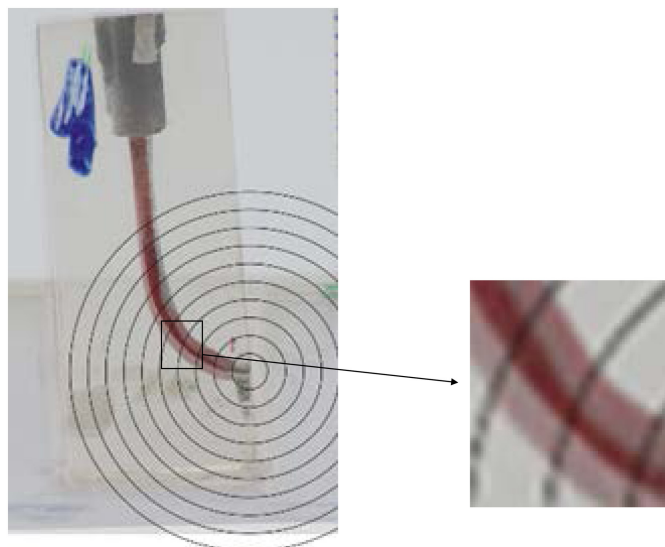


Figure 1. Composite images of the canal were produced from pre- and post-instrumentation images showing the 10 measuring points.

instrumentation images were superposed by Corel Capture 11 software (Corel Inc., Ottawa, Canada) computer program. Superimposition was aided by vertical and circular guidelines drawn on the resin blocks' images. The center of the circular lines was the apical endpoint of the root canal system. The measurements of the amount of internal and external resin removed from the root canal system were made on digital images by Corel Photo-Paint 11 program. The measurement precision was calibrated at 0.001 mm. by the program developers and the assessments were performed on an accuracy level of 0.001 mm. For this purpose, standard channels were viewed on the same camera, at the same magnification settings and fixed distance. The first measuring point was just the apical endpoint of the root canal system. A total of 20 measurements were made from the inner and outer sides of all root canal systems, in 1 mm intervals, apico-coronally.¹⁷ All measurements were made perpendicular to the margin of the root canal walls (Figure 1).

Several canal aberrations such as perforation, ledge, danger zone, and apical zip associated with the elbow were assessed using superimposed images. Thompson and Dummer's descriptions were used to define canal aberrations.¹⁸

The formula calculated the centering ability of the instruments; resin removed from the inner wall/resin removed from the outer wall. The values closer to "1" indicate better centering ability.⁵

Statistical Analyses

Statistical Package for the Social Sciences 13.0 software (SPSS Inc.; Chicago, IL, USA) was used to perform all statistical analyses. According to the Shapiro–Wilk normality test results, the data did not show a normal distribution. Paired comparisons between 2 groups were performed by Mann–Whitney *U*-test. The level of statistical significance was accepted as *P* < .05.

RESULTS

Instrument Failure and Canal Aberrations

No instrument fractures occurred in the 2 compared groups.

Canal Aberrations

The ESG group showed more canal aberrations (3 zips and 2 ledges) than the ESGP group. Both observed systems did not show danger zones or perforations.

Width Measurements

The mean values of resin removed from the inner area are shown in Table 1, and the mean values removed from the canals' outer sides are shown in Table 2. According to mean values, EPSG and ESG removed a similar amount of resin from the inner side except for the points of the apical end (*P* = .00), 3 mm (*P* = .00), and 9 mm (*P* = .036) from the apex. The mean values of resin removed at the point of 0 mm were 0.031 mm for the ESG group and 0.016 for the group of EPSG. 0.092 mm resin was removed by ESG and 0.014 mm by EPSG at the point of 3 mm, on average. The mean values of resin removed at the point of 9 mm were 0.032 for ESG and 0.016 for EPSG.

The ESG removed significantly more material than EPSG at the apical third (0,2), curved area (3), and middle thirds (4,5,7) of the root length (*P* < .05) on the outer canal wall. The mean values of removed resin were 0.044 mm for ESG and 0.018 mm for the pediatric system at the apical endpoint (0 mm distance). The amount of removed resin by ESG was 0.047mm, and 0.017 mm was removed by EPSG at a 2 mm distance from the apex (*P* = .005). At 3 mm, the Pedo system removed 0.014 mm of resin, and ESG removed a mean amount of 0.036 mm (*P* = .018). Meanly 0.041 mm resin was removed by ESG and 0.011 by EPSG at 4 mm (*P* = .007). The mean values for removed resin at 5 mm were 0.043 for ESG and 0.012 for EPSG (*P* = .040). Finally, the mean values determined at the point of 7 mm were 0.038 and 0.013 mm for ESG and EPSG groups, respectively (*P* = .02) (Table 2).

Centering Ability

The mean values of the centering ability can be seen in Table 3. The best centering ability was determined at the apical end of the simulated resin root (0 mm), and the values for centering ability

Table 1. Mean Values of Resin Removed from the Inner Area

Groups		Reference Points from the Apex (mm)										
		0	1	2	3	4	5	6	7	8	9	10
ESG	Mean	0.031	0.029	0.027	0.092	0.031	0.026	0.030	0.027	0.032	0.032	0.037
	SD	0.013	0.020	0.009	0.031	0.031	0.015	0.019	0.018	0.023	0.022	0.053
	Median	0.025	0.022	0.025	0.098	0.022	0.022	0.028	0.024	0.022	0.022	0.018
	Percentiles 25	0.021	0.017	0.021	0.072	0.012	0.016	0.010	0.012	0.016	0.014	0.010
	Percentiles 75	0.044	0.029	0.031	0.115	0.028	0.039	0.049	0.049	0.06	0.051	0.042
EPSG	Mean	0.016	0.017	0.018	0.014	0.017	0.024	0.029	0.023	0.020	0.016	0.018
	SD	0.008	0.008	0.010	0.008	0.008	0.009	0.014	0.009	0.004	0.008	0.005
	Median	0.014	0.015	0.020	0.014	0.020	0.025	0.029	0.024	0.020	0.016	0.018
	Percentiles 25	0.010	0.010	0.009	0.005	0.010	0.018	0.019	0.018	0.017	0.009	0.013
	Percentiles 75	0.018	0.025	0.026	0.022	0.024	0.031	0.037	0.030	0.026	0.022	0.022
	<i>P</i>	.000*	.065	.056	.000*	.382	.645	.908	.800	.488	.036*	.646

EPSG, Endoart Pedo Smart Gold; ESG, Endoart Smart Gold; SD, standard deviation. **P* < .05.

Table 2. Mean Values of Resin Removed from the Outer Area

Groups		Reference points from the apex (mm)										
		0	1	2	3	4	5	6	7	8	9	10
ESG	Mean	0.044	0.047	0.047	0.036	0.041	0.043	0.034	0.038	0.038	0.034	0.039
	SD	0.058	0.066	0.061	0.036	0.073	0.071	0.043	0.057	0.059	0.045	0.068
	Median	0.024	0.03	0.028	0.025	0.019	0.022	0.021	0.024	0.021	0.021	0.017
	Percentiles 25	0.020	0.014	0.020	0.013	0.013	0.009	0.010	0.010	0.011	0.012	0.010
	Percentiles 75	0.039	0.046	0.041	0.040	0.030	0.039	0.037	0.036	0.030	0.034	0.039
EPSG	Mean	0.018	0.022	0.017	0.014	0.011	0.012	0.014	0.013	0.013	0.018	0.016
	SD	0.009	0.008	0.008	0.008	0.005	0.005	0.008	0.006	0.007	0.006	0.010
	Median	0.016	0.023	0.015	0.014	0.012	0.014	0.015	0.012	0.013	0.020	0.013
	Percentiles 25	0.012	0.013	0.013	0.007	0.007	0.007	0.007	0.006	0.005	0.012	0.008
	Percentiles 75	0.025	0.027	0.022	0.018	0.015	0.016	0.022	0.020	0.020	0.023	0.025
	P	.011*	.214	.005*	.018*	.007*	.040*	.168	.020*	.056	.519	.213

EPSG:Endoart Pado Smart Gold; ESG, Endoart Smart Gold; SD, standard deviation.

*P < .05.

tended to decrease through the coronal entrance. The values were 0.76 and 0.71 for ESG and EPSG groups at the apical end, respectively. Furthermore, the Pado system showed statistically better-centering ability at the coronal entrance (10 mm) of the simulated root canals ($P = .016$).

DISCUSSION

The current study examined the preparation features of a pediatric rotary file versus a conventional rotary file system. Accordingly, the root canal preparation with pediatric rotary systems revealed better results regarding centering ability and caused less dentin removal than the conventional rotary system. The null hypothesis was rejected.

Manual H and K-type files have been widely used to prepare permanent and deciduous teeth. Ni-Ti rotary systems have been developed to overcome the drawbacks of manual files, such as long preparation time and the standard form for each size that does not show taper.^{6,19} Recently, pediatric rotary file systems have been developed to suit the particular anatomy of deciduous teeth. Although various studies were conducted to assess the preparation features of Kedo-S files versus manual files and conventional rotary systems,^{11-13,20} No study was determined assessing the shaping ability of EPSG versus conventional rotary files in the literature review. Accordingly, the present study aimed to compare the preparation features of this newly developed pediatric rotary system versus the conventional rotary system of the same brand. Thus, helping the clinicians to make a decision-making choice in using the most effective rotary file system for the endodontic treatment of deciduous teeth.

The preparation features of instruments were examined in simulated resin root canals under strictly controlled laboratory

conditions in the present study. This design allows standardization of the curvature by means of degree, location, and radius. The computerized superimposition technique was preferred to assess the pre-and post-operative outlines of the canal anatomy. This method facilitates the measurements of deviations at any point of root canals and ease of application.²¹

The outcomes of the present study showed that the groups revealed similar results in inner measurements except for the points of 0 mm, 3 mm, and 9 mm from the apex of the root canal system. Regarding the removed resin measurements in the outer line, statistical differences were detected at the apical end, curved area, and the middle third of the simulated root. The centering ability of the pediatric rotary system was higher than the compared group. This result means that the pediatric systems perform the canal preparation adhering to the original canal anatomy. Additionally, the resin amount removed by the pediatric system was lesser than the values obtained by the conventional rotary system of the same brand. These findings may enhance the preferability of the pediatric systems since the main aim of root canal preparation is preserving the original root anatomy, causing a minimal removal from the surrounded dentin while shaping the root canals to enhance the effect of irrigation solutions and leading to a tapered form for an adequate root filling.

In a previous study,²² different pediatric rotary files' preparation capacity was compared to K-files in a total of 72 canals of 24 freshly extracted deciduous molars. Accordingly, rotary file systems have shown superior results than hand instrumentation, and a statistical difference was observed at the cervical level regarding centering ability. The values of Pado-S were higher compared to Pro Af Baby Gold and manual files. However, no significant difference

Table 3. Centering Ability

Groups		Reference Points from the Apex (mm)										
		0	1	2	3	4	5	6	7	8	9	10
ESG	Mean	0.764	0.668	0.641	0.380	0.623	0.600	0.530	0.627	0.580	0.589	0.372
	SD	0.204	0.239	0.247	0.268	0.235	0.250	0.240	0.241	0.199	0.224	0.264
	Median	0.785	0.625	0.690	0.290	0.615	0.530	0.530	0.660	0.625	0.635	0.290
	Percentiles 25	0.657	0.477	0.427	0.200	0.357	0.395	0.320	0.492	0.405	0.415	0.195
	Percentiles 75	0.927	0.970	0.832	0.657	0.830	0.822	0.700	0.805	0.715	0.800	0.535
EPSG	Mean	0.710	0.640	0.509	0.430	0.504	0.465	0.475	0.485	0.540	0.545	0.587
	SD	0.156	0.258	0.227	0.172	0.264	0.191	0.232	0.276	0.269	0.212	0.248
	Median	0.725	0.650	0.500	0.445	0.445	0.460	0.415	0.400	0.520	0.560	0.530
	Percentiles 25	0.597	0.415	0.342	0.265	0.330	0.325	0.302	0.257	0.257	0.450	0.420
	Percentiles 75	0.840	0.890	0.707	0.522	0.745	0.580	0.705	0.820	0.762	0.670	0.795
	P	.301	.764	.161	.358	.190	.168	.581	.168	.662	.535	.016*

EPSG: Endoart Pado Smart Gold; ESG: Endoart Smart Gold; SD, standard deviation.

*P < .05.

between all the groups regarding canal transportation and removed dentin thickness was detected. Although the comparison of hand files and manual files was held and conventional rotary systems were not included, this study is essential since it supports the idea of preferring pediatric rotary systems in deciduous teeth's root canal preparations compatible with the recent study we held.²²

Mohamed et al¹¹ planned a study in which they observed the preparation ability of a pediatric rotary file (Kedo-S square) versus stainless steel K and H files. The study results showed that the amount of dentin removed by Kedo-S was statistically lesser than the values of other groups. In another similar study, Seema et al¹³ evaluated the root canal shaping features of Kedo-S rotary files, Pro Taper system, and manual K files. Accordingly, Kedo-S removed significantly less dentin than the hand file in the apical and coronal third of the root. At the same time, unlike the recent study we held, no statistical difference was detected between Kedo-S and Pro Taper system values. Kalita et al¹⁴ have also conducted a similar study in which the comparison of a pediatric rotary file system (Kedo-S), manual K files, and Pro Taper system was made. Accordingly, the centering ability was found to be superior in Kedo-S system compared to manual files, while no difference was detected between the values of Pro Taper and Kedo-S systems, contrary to the result of the present study we held. Since the centering ability reveals the original root canal preserving the performance of the mechanical instruments, this feature may also enhance the preference for pediatric rotary systems.

In vitro studies on root canal therapies may be held on both extracted teeth and simulated root models. Since the root resorption degree of deciduous teeth may differ in each extracted tooth, a standardized simulated resin root model was used in the present study. However, the simulated resin root canals may not reflect the biological environment of teeth as in the oral cavity.¹⁷ This model may also eliminate the variables encountered in tooth root canals.²³ Although the preparations were under conditions in which an irrigation procedure was followed, the heat generated by the applications may soften the resin blocks.²⁴ These points can be listed as the limitations of the present study.

CONCLUSION

Within the limitations of the present in vitro study, it was concluded that the root canal preparation with pediatric rotary systems revealed better results regarding centering ability and caused less dentin removal. Since maintaining the original root anatomy while enlarging the canals to form an adequate width for irrigation, disinfection, and filling process, is the desired approach for mechanical preparation, the less removal of dentin with a better centering ability put the pediatric rotary system to a preferable stage compared to conventional file systems. These advantages may also lead clinicians to use pediatric rotary systems as a choice of treatment approach. However, in the future, in vivo studies should be conducted to assess the clinical features of this newly developed preparation system.

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