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Official Publication of Istanbul University Faculty of Dentistry

Eur Oral Res 2024; 58(2): 58-63

Original research

The effect of three different primary teeth rotary instrument systems on the amount of apically extruded debris in pulpectomy of primary teeth

Mushfig Abdulhaligov[1], **Nagehan Yilmaz**[1], **Tamer Tüzüner**[1], **Ozgul Baygın**[1], **Cansu Emeksiz**[1]

Purpose
The objective of this study is to evaluate the amount of apically extruded debris and working time during root canal treatment with three different primary teeth rotary instrument systems.

Materials and Methods
A total of 80 extracted primary second molar teeth were randomly divided into four groups (n=20) stratified by the instruments used: AF Baby Rotary, Easyinsmile Baby Rotary, Endoart Pedo Gold, and hand files. The apical extrusion of debris was collected then dried in Eppendorf tubes that were pre-weighed with 10^{-4} precision micro-balance. The incubation period was set as 14 days at 37°C. The dry weight was procured by deducting the preoperative weight from the postoperative weight. The systems' working time was calculated by chronometer. Mann Whitney U test with Bonferroni correction was used for pairwise comparison following the variance analysis with Kruskal Wallis test. Wilcoxon test was used for intragroup comparison.

Results
Although all instruments caused apically extruded debris ($p<0.001$), there was no statistically significant difference between the groups in debris extrusion. However, the longest working time was found in the manual K files, the Endoart Pedo Gold system had the shortest working time ($p<0.001$).

Conclusion
Our results demonstrate that all instrument systems caused apical extrusion of debris. Furthermore, the rotary instrument systems designed for primary teeth exhibited significantly shorter working time.

Keywords: *Apical debris, primary teeth, root canal preparation, rotary system, time*

Introduction

Maintaining the health of the primary dentition is critical for regular jawbone development, natural muscle function, clear speaking, and even the natural eruption of permanent dentition. Additionally, early loss of primary teeth has been linked to a variety of issues, including poor oral habits, alterations in arch proportions, and disruptions in the eruption sequence of permanent dentition (1, 2).

One of the most common reasons for early tooth loss is periapical infection (3). As a therapeutic option to preserve the primary tooth as a natural space maintainer, pulpectomy is being considered (4). Root canal treatment involves completely removing the pulp tissue from the primary tooth, followed by debridement, shaping, drying, and filling of the root canals with a resorbable material (5, 6).

ORCID IDs of the authors: M.A. 0000-0002-3524-1686; N.Y. 0000-0001-9523-2899; T.T. 0000-0001-5817-5928; Ö.B. 0000-0003-0836-7619; C.E.0000-0003-2970-1217

[1]*Department of Pediatric Dentistry, Faculty of Dentistry, Karadeniz Technical University, Trabzon, Turkiye*

Corresponding Author: Nagehan Yilmaz

E-mail: nagehany89@yahoo.com

Received: 14 January 2022
Revised: 22 April 2023
Accepted: 5 May 2023

DOI: 10.26650/eor.20241057693

How to cite: *Abdulhaligov M, Yilmaz N, Tuzuner T, Baygin O, Emeksiz C. The effect of three different primary teeth rotary instrument systems on the amount of apically extruded debris in pulpectomy of primary teeth. Eur Oral Res 2024; 58(2): 58-63.* DOI: 10.26650/eor.20241057693

Although manual instrumentation has been the most common method for root canal treatment in primary teeth, it is time-consuming and often tiring for both the operator and the child (7). Numerous studies have reported the success of rotary instrument systems in conserving the original root canal anatomy of primary teeth (6, 8).

Furthermore, rotary instrument systems have minimized complications that occur during the traditional treatment process when using standard manual files (6, 8). The use of Nickel-Titanium (Ni-Ti) rotary instruments accelerates and simplifies root canal treatment while reducing file breakage. Moreover, Ni-Ti instruments provide better shaping for the cleaning procedure, irrigation, and obturation during root canal treatment (8).

In response to ongoing advancements in the field of pediatric dentistry, innovative pediatric rotary systems have been introduced (such as AF Baby Rotary, Easyinsmile Baby Rotary, Endoart Pedo Gold, etc.). These systems aim to provide more convenient and efficient pulpectomy in primary teeth by offering exclusive pediatric rotary files with modified length, taper, and tip size (9).

AF Baby Rotary files are made of Ni-Ti heat-treated material and feature advanced memory AF-H alloy with a noncutting tip. The files have a triangular cross-section design (10). Easyinsmile Baby Rotary files also utilize advanced memory AF-H alloy material and a noncutting tip. The cross-section design of these files is convex triangular (11). Endoart Pedo Gold files, on the other hand, are made of Ni-Ti heat-treated material, and they feature a guiding noncutting tip and convex triangular cross-section with advanced memory alloy material (12).

Chemo-mechanical preparation plays a crucial role in root canal treatment and involves cleaning with files and solutions. However, during canal preparation, dentine shavings, pulpal pieces, debris, and solutions are inadvertently extruded into the periapical area (13). The extrusion of these elements into the periapical tissues can lead to unfavorable outcomes such as inflammation, postoperative discomfort, delays in periapical healing, and damage to permanent teeth germs (14). Therefore, it is recommended to prevent apical debris extrusion for effective primary tooth root canal treatment (13).

Additionally, considering children's shorter attention span, working time becomes an important factor in their acceptance of root canal treatment (15). Working time is particularly critical in dental treatments conducted under general anesthesia or sedation due to the limited time available (16). The working time for root canal treatment on primary teeth varies depending on the doctor's experience, skill, and the number and type of instruments used (17).

Previous studies have compared rotary systems in primary teeth in terms of instrumentation time and apical debris extrusion. However, to the best of our knowledge, no other study utilizing the primary rotary systems used in our research has been found in the literature (18, 19). Our study aims to determine the amount of apically extruded debris and the preparation time during root canal treatment using three different rotary instrument systems for primary teeth. The null hypothesis states that there will be no difference between the rotary instrument systems in terms of working time and the amount of apically extruded debris.

Materials and methods

Ethical approval

Approval from the Scientific Research Ethics Committee of the Karadeniz Technical University Medical Faculty (2021/40) was obtained for this study.

Sample size determination:

The sample size was determined based on the study conducted by Kucukyilmaz *et al.* (20). It was concluded that 18 teeth per group would be sufficient, considering an alpha error of 0.05 and a beta error of 0.20. However, to account for possible data loss (10%), it was decided to include 20 teeth in each group for the research.

Inclusion criteria and sample preparation:

For this study, the distal canals of 80 primary second molars were selected. These canals had a single and wide canal, a smooth outer contour, and fewer intracanal branches compared to the mesial root (18). The molars were extracted from children aged 4-6 years due to periapical infection and for preventive orthodontic treatment. External debris and soft tissue remnants were removed from the teeth, which were then stored in distilled water at room temperature until the experimental process. Teeth with at least two-thirds of the root length, no pathological root resorption, no obvious root caries or fractures, and a root curvature angle of less than 20° (evaluated according to Schneider's protocol) were included in the study (21). Buccolingual and mesiodistal radiographs were taken for each tooth to confirm the root curvature angle, presence of a single canal, resorption, and canal obliteration. Before the experimental process, the mesial roots of each tooth were removed at the furcation level using a low-speed diamond borer with underwater cooling. Endodontic access cavities were prepared using a diamond bur and a high-speed handpiece. Canal patency was established using a size 10 K-file (VDW, Munich, Germany). An apical opening with a diameter of 0.12 mm was created by advancing the file 1 mm from the apical foramen, and teeth with wider apical foramens were excluded from the study. Canals larger than the International Organization for Standardization size 15 were removed, resulting in 80 teeth that met the size requirements (22). The working length was determined by advancing a size 10 K-file into the root canal until the tip of the file was visible at the apical foramen. The canal length was established by subtracting 1 mm from this point. To prevent debris extrusion from lateral canals, the distal root surfaces of the teeth were covered with nail polish up to one-third of the apical area.

Debris collection

For this study, the experimental model developed by Myers and Montgomery (23) was utilized. Eppendorf tubes without stoppers were weighed with a micro-balance (Kern ABJ, Gottingen, Germany) to an accuracy of 10^{-4} g before canal instrumentation. Each tube's weight was measured three times consecutively, and the average values were recorded. The eighty teeth were coded and divided into four groups of

twenty specimens using a computer-based randomization program (Research Randomizer) (24).

Next, the stoppers of the Eppendorf tubes were perforated, and the teeth were inserted up to the cementoenamel junction. To equalize air pressure inside and outside the Eppendorf tubes and serve as a drainage cannula, a 27-Gauge (G) needle (INMED Medical Products, Istanbul, Turkey) was placed alongside the stopper. The stoppers, along with the teeth and needles, were securely attached to their respective Eppendorf tubes. The tubes were then placed in vials covered with foil to prevent the practitioner from observing apically extruded debris during the root canal treatment. The entire device was handled through the vial, and the Eppendorf tubes were never touched with fingers.

Instrumentation and working time

Hand file group: In the manual preparation of this group, a stainless-steel K-file (VDW, Munich, Germany) with a taper of 0.02 was used. The standardized technique was followed, starting with size 15 and progressing in the following order: 20.02, 25.02, and 30.02 (n=20).

AF Baby Rotary group: AF Baby Rotary files (Fanta Dental Materials, Shanghai, China) were employed for canal preparation in this group, up to a main apical size of 30 (10). The rotary files were used with an endodontic motor (COXO, Foshan, China) at 350 rpm and a torque of 2 Ncm, following the manufacturer's recommendations. The sequence of files used was 17.08, 20.04, 25.04, and 30.04. The 17.08 file was utilized to widen the canal's coronal two-thirds. The brushing action was performed gently inward and outward (n=20). Easyinsmile Baby Rotary group: In this group, Easyinsmile Baby Rotary files (Easyinsmile International Corp., Changsha, China) were employed. The files were used in the following sequence: 20.04, 25.04, and 30.04, with the same endodontic motor at a rotational speed of 350 rpm and a torque of 2.6 Ncm, as per the manufacturer's recommendations (11). The brushing action was performed gently inward and outward (n=20). Endoart Pedo Gold group: All canals in this group were prepared using Endoart Pedo Gold files (Endoart, Istanbul, Turkey). The files were used with the same endodontic motor at a rotational speed of 350 rpm and a torque of 1.5 Ncm for the 15.06 file, 1 Ncm for the 25.04 file, and 2 Ncm for the 30.04 file, according to the manufacturer's recommendations (12). The brushing action was performed gently inward and outward (n=20).

In all groups, a new set of instruments was used for each root canal, and after each file preparation, a 10 K-file was used for recapitulation. These procedures were consistently performed by the same trained operator to eliminate biases and ensure consistency. Additionally, the root canals in each group were irrigated with distilled water using a 27-G needle before preparation, between instrument changes, and at the end of the preparation. Furthermore, after the instrumentations, the surfaces of the roots were irrigated with 1 ml of distilled water to collect any adhered debris. To maintain standardization, a total of 10 ml of distilled water was used for each tooth. The working time of the file systems, including the duration of the file in the canal, file change time, and irrigation time, was measured in seconds using a chronometer.

Evaluation of apically extruded debris

The evaluation of apically extruded debris was conducted by a second examiner who was blinded to the group allocations. After the completion of canal preparation, the Eppendorf tubes were removed from the vials. Subsequently, the tubes were placed in an incubator set at 37 °C for 14 days to allow the distilled water to evaporate. Each tube was measured three times consecutively after evaporation, and the average values were recorded. The net weight of the dry debris was calculated by subtracting the original weight of the empty Eppendorf tube from the gross weight.

Statistical analysis

The Shapiro-Wilk test was utilized to evaluate the conformity of the data to a normal distribution. For pairwise comparisons, the Mann-Whitney U test and Bonferroni correction were employed following the Kruskal-Wallis test if necessary. Intragroup comparisons before and after preparation were analyzed using the Wilcoxon test. A p-value of less than 0.05 was considered statistically significant. The data were analyzed using the SPSS 17.0 program (Statistical Package for the Social Sciences, SPSS Inc., Chicago, IL, USA).

Results

The results indicated that all instruments caused apically extruded debris (p<0.001). Although the difference in weight values of the apically extruded debris between the groups was not statistically significant, the highest percentages were observed in the manual K files group, while the lowest percentages were observed in the AF Baby Rotary file systems group (Table 1). Except for the Easyinsmile Baby Rotary-Endoart Pedo Gold comparison, a statistically significant

Table 1: *The weight values of the Eppendorf tubes before and after the preparation, the weight (g) of the extruded debris, and the percentage ratios*

Groups	N	Weight before preparation (Mean ± SD)	Weight after preparation (Mean ± SD)	Extruded debris weight (Mean ± SD)	Extruded debris ratio (%)	p**
AF Baby Rotary	20	0.783330±0.0082904	0.784460±0.0079219	0.001130±0.0007794	0.144048135	p<0.001
Easyinsmile Baby Rotary	20	0.783920±0.0065121	0.785155±0.0065753	0.001235±0.0009455	0.157293783	p<0.001
Endoart Pedo Gold	20	0.782735±0.0083258	0.784215±0.0084813	0.001480±0.0011719	0.188723756	p<0.001
Manual K	20	0.783785±0.0102417	0.786170±0.0109049	0.002185±0.0018508	0.27792971	p<0.001
p*		0.751	0.996	0.131		p<0.001

SD: Standard Deviation p*: Comparison between groups Kruskal Wallis test, p* <0.05, p**: Intragroup comparison Wilcoxon Signed Ranks test, p**<0.05

difference was found among the groups in terms of working time (p=0.003, p<0.001). The manual K files group had the longest working time, whereas the Endoart Pedo Gold file systems group had the shortest working time (Table 2).

Table 2: *Pairwise comparisons of working time (sec) variable*

Groups	Working Time (Mean Value± SD)		P*
AF Baby Rotary-Easyinsmile Baby Rotary	282.2975±51.83196	219.3660±48.81846	p=0.003[a]
Easyinsmile Baby Rotary –Manual K	219.3660±48.81846	375.2600±61.06917	p<0.001[b]
AF Baby Rotary-Endoart Pedo Gold	282.2975±51.83196	183.2605±13.46420	p<0.001[c]
AF Baby Rotary- Manual K	282.2975±51.83196	375.2600±61.06917	p<0.001[d]
Easyinsmile Baby Rotary - Endoart Pedo Gold	219.3660±48.81846	183.2605±13.46420	p>0.01[e]
Endoart Pedo Gold - Manual K	183.2605±13.46420	375.2600±61.06917	p<0.001[f]

*Bonferroni correction with Mann-Whitney U test. p^a=0.003; p <0.01, $p^{b,c,d,f}$<0.001, p^e >0.01.

Discussion

Apical extrusion is a potential complication that can occur during root canal treatment when an instrument is used in an apical orientation or acts as a plunger (25). The extrusion of debris in the apical region during root canal treatment of primary teeth is of critical importance due to the proximity of the permanent tooth germs (13).

The success of primary root canal treatment is influenced by various factors, including the exclusion of apical debris and working time. Therefore, the objective of our research was to compare the amount of apically extruded debris and working time among different primary rotary file systems (20). Among several methods available for measuring apical debris, we employed the method described by Myers and Montgomery, which is widely used in dental literature (23, 26). In this study, distilled water was used as a solution to prevent potential crystallization of sodium hypochlorite. This was done because sodium crystals that form after the solution evaporates cannot be distinguished from the debris, which could significantly impact the results (27). Additionally, we did not attempt to simulate the presence of periapical tissue as it may affect the results by absorbing the irrigant and debris. The use of materials such as floral foam to mimic periapical tissue can alter the outcome, and in vivo models may produce different results due to the influence of normal or pathological periapical tissue acting as a natural barrier to debris extrusion (28).

The null hypothesis of this study was accepted for apically extruded debris but rejected for working time. The results demonstrated that all groups resulted in apically extruded debris during root canal preparation (p<0.001). This finding is consistent with previous studies on apical extrusion and confirms that chemo-mechanical preparation of the root canal system always leads to the extrusion of debris (26, 29). Similar to previous research, manual K files showed the highest percentage of apically extruded debris, although the difference was not statistically significant according to the results of this study (18, 19, 29).

The lack of statistical difference between K files in our study might be linked to the fact that, unlike other studies, we used files made for primary teeth (18, 20). At the same time, this result is assumed to be linked to various characteristics of file systems, such as cross-sectional design, kinematic movement, cutting efficiency, flexibility, and alloy qualities, as indicated in other studies (26, 30).

Rathi *et al.* (26) evaluated the cleaning efficiency and apically extruded debris during root canal treatment with Kedo-S and Pro AF Baby Gold primary file systems. Similar to this study, rotary file systems caused apically extruded debris. The apical extrusion of debris was detected less in the Pro AF Baby Gold rotary file system than in the Kedo-S rotary file system. Similarly, although it was not statistically significant in this study, AF Baby Rotary file systems had the least percentage of apically extruded debris. AF Baby Rotary file systems were files with control memory, 'AF' wire structure, inactive cutting tip, and heat-treated like Pro AF Baby Gold file systems. The reason why there was no statistically significant difference in this study, as stated by Rathi *et al.* (26), might be due to their characteristic features such as different cross-sections and working mechanisms.

Reduced instrumentation time is extremely important in influencing the behavior and cooperation of the child in the dental chair, besides lowering weariness caused by shorter working hours in the operator, resulting in speedier treatment delivery (31). This study showed that the rotary files significantly reduced working time in comparison with hand K-files, which is consistent with findings from previous clinical trials (15, 32). Kalita *et al.* (32) evaluated the cleaning efficiency and working time during canal preparation with Kedo-S, ProTaper rotary systems, and manual K files. Working time with manual files was shown to be longer than with rotary file systems, similar to the outcomes of this study. The reason for this is that the rotary file systems were used with endo motors. Also, in our study, the longer working time of the manual files was assumed to be related to that.

Shah *et al.* (15) compared Kedo-S, Pro-AF Baby Gold rotary systems, and manual files in terms of working time and root filling quality. They found that working time with manual files was longer compared to rotary file systems, which is consistent with the results of our study. The authors also reported that using rotary file systems reduced operator fatigue and increased productivity. Additionally, they observed that the reduced working time may be attributed to the decreased number of files. Similarly, in our study, the AF Baby Rotary file system, consisting of four files, resulted in a longer working time compared to the Easyinsmile Baby Rotary and Endoart Pedo Gold file systems, which only required three files.

It should be noted that the apical extrusion of debris can vary depending on whether the tooth is vital or devital. In vital teeth, the pulp tissue acts as a barrier, preventing debris and irrigation solution from being extruded into the periapical tissues (33). Therefore, the limitation of this study is that it does not fully replicate the in vivo conditions, highlighting the need for more comprehensive future studies.

Conclusion

Our results demonstrate that all instrument systems caused apical extrusion of debris. Furthermore, the rotary instrument systems designed for primary teeth exhibited significantly shorter working time.

Türkçe özet: *Üç farklı süt dişi döner eğe sistemi ile süt dişi kök kanal tedavisi sırasında taşan debris miktarının ve çalışma zamanının incelenmesi. Amaç: Çalışmamızın amacı üç farklı süt dişi döner eğe sistemi ile süt dişi kök kanal tedavisi sırasında taşan debris miktarını ve çalışma zamanını belirlemektir. Gereç ve Yöntem: Toplam 80 adet çekilmiş süt ikinci azı diş, kullanılan aletlere göre rastgele dört gruba (n=20) ayrıldı: AF Baby Rotary, Easyinsmile Baby Rotary, Endoart Pedo Gold ve el eğeleri. Apikale taşan debris toplandı ve 10^{-4} hassas mikro terazi ile önceden tartılan Eppendorf tüplerinde kurutuldu. İnkübasyon süresi 37°C'de 14 gün olarak belirlendi. İşlem sonrası ağırlıktan işlem öncesi ağırlık değerleri çıkarılarak kuru debris ağırlığı elde edildi. Eğe sistemlerinin çalışma zamanı kronometre ile hesaplandı. Gruplar arası karşılaştırmada Kruskal Wallis testi sonrası Mann Whitney U testi ve Bonferroni düzeltmesi kullanıldı. Grup içi karşılaştırmada Wilcoxon testi uygulandı. Bulgular: Bütün eğe sistemleri apikalden debris taşmasına neden olsada ($p<0.001$), eğe sistemleri arasında debris taşırmada istatistiksel olarak anlamlı bir fark bulunmamıştır ($p>0.05$). En uzun çalışma zamanı manuel K eğelerinde, en kısa çalışma zamanı ise Endoart Pedo Gold sisteminde tespit edilmiştir ($p<0.001$). Sonuç: Tüm sistemler apikal debris ekstrüzyonuna neden olmuştur. Süt dişleri döner alet sistemleri önemli ölçüde daha hızlı çalışma süreleri nedeniyle tercih edilebilir. Anahtar kelimeler: Apikal debris, süt dişi, kök kanal tedavisi,döner sistemler, zaman*

Ethics Committee Approval: Ethics committee approval was obtained from the Scientific Research Ethics Committee of the Karadeniz Technical University Medical Faculty (2021/40).

Informed Consent: Not required.

Peer-review: Externally peer-reviewed.

Author contributions: MA, NY participated in designing the study. TT participated in generating the data for the study. MA, CE participated in gathering the data for the study. OB, CE participated in the analysis of the data. MA wrote the majority of the original draft of the paper. CE participated in writing the paper. NY has had access to all of the raw data of the study. MA, NY have reviewed the pertinent raw data on which the results and conclusions of this study are based. MA, NY, TT, OB, CE have approved the final version of this paper. NY guarantees that all individuals who meet the Journal's authorship criteria are included as authors of this paper.

Conflict of Interest: The authors declared that they have no conflict of interest.

Financial Disclosure: The rotary file systems used in our study are provided free of charge by Fanta Dental Turkey, Ömer Şen Diş Marketi and İnci Dental companies.

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