

Original Article

Cleaning Effectiveness of Pediatric Rotary Files Versus Hand K-Files On Extracted Primary Molars -An In Vitro Study

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Abstract

Aim: The purpose of this study was to evaluate the cleaning effectiveness of kedo-S Square pediatric rotary files versus hand K-files systems on extracted primary molars.

Material and method: In this experimental study, 44 roots of 22 extracted primary mandibular molars with at least two-thirds of intact roots were selected. After access cavity preparation, the canals were injected with India ink with an insulin syringe. The roots were randomly assigned into two groups: group I (n= 22): Manual k-files and group II (n = 22): Rotary kedo-S Square files. Each group was instrumented with the respective files. After instrumentation, teeth were decalcified, dehydrated, cleared, and analyzed for the presence of India ink remaining on the root canal walls, which served as evidence of the cleaning capacity of both files.

Result: Kedo-S Square rotary files performed significantly better cleaning of the canals in the coronal third than K-file (P = 0.012). While, in the middle and apical third of the root, the difference between the two groups was not significant (P=0.169) and (P=0.236) respectively.

Conclusion: Kedo-S Square pediatric rotary system showed significantly better cleaning than K-files in the instrumentation of primary molars root canals.

Keywords: Primary Teeth, k-files, Kedo-S Square, Biomechanical preparation, Pediatric rotary files.

I. INTRODUCTION:

Pulpectomy is a root canal procedure for pulp tissue that is irreversibly infected or necrotic due to caries or trauma. The objective of biomechanical preparation in primary teeth is to remove the pulp tissue remnants, debris, and infected dentin from the canals and make a pathway for the irrigants to reach the apical third, providing a space for medicaments and subsequent obturation and preserve the radicular anatomy (Cohen and Hargreaves, 2006 and American Academy of Pediatric Dentistry, 2022).

Although the high success rate of pulpectomy in the treatment of infected primary molars, it remains a challenging procedure due to the difficulty in obtaining adequate access to the root canals in relatively smaller mouths of children, complexity of root canal system in primary molars (tortuous root), the risk of injury to the permanent tooth germ time consumption, and some children-related behavioral problems (Bagherian et al., 2010 and Juliet et al., 2020).

Manual instrumentation is widely used in primary teeth, but it has certain limitations such as long chair time for children, lack of flexibility leading to ledge formation, dentine compaction, perforations, transportation, and instrument failure (Zameer M.2016). Therefore, to overcome the issue of rigidity and low resistance to cyclic fatigue associated with stainless steel instruments, the use of nickel-titanium instruments was advocated (Tabassum et al., 2019).

The mechanical instrumentation of primary teeth using Ni-Ti rotary files was first described by Barr et al., 2000. They possess greater flexibility due to super elasticity, shape memory effect, and better resistance to torsional fracture, providing consistent root canal filling and reduced preparation time. The disadvantages include the high cost, the need to discard the files regularly, and the need for operator training on the technique (Pinheiro et al., 2012).

Kedo-S Square rotary file has revolutionized the arena of pediatric endodontics as being the first exclusive single pediatric rotary file system, which were introduced in 2019. It consists of two files, one file to be used for anterior primary teeth (A1) and one file to be used for posterior primary teeth (P1). These files are beneficial for biomechanical preparation of shorter root lengths, curved and ribbon-shaped canals in primary molars, without risk of over instrumentation (Pitchiah & Shivashankarappa, 2020).

The objectives of this study were to compare newly introduced rotary Ni-Ti files Kedo-S Square for primary teeth with Manual K- files concerning their cleaning efficacy.

II. SUBJECTS AND METHODS:

A. Study setting

This is an in-vitro study was conducted in the Pediatric Dentistry Department, Faculty of Dentistry. The Faculty Research Ethics Committee reviewed the study proposal was gave its approval on 12 / 9/2021 with approval number (1-1-21).

B. Study design and sample preparation

Extracted primary mandibular molars were collected as they were discarded from the Pediatric Dentistry and Dental Public Health Department, Faculty of Dentistry, Cairo University. The reasons for the extraction of primary molars are unrestorable, recurrent pathological infections, and systemic problems. Only molars that met eligibility criteria were included. Twenty-two molars were randomly assigned into two groups: Group (I): Manual K-files and Group (II): Rotary kedo-S Square files. A sequence of randomization was generated using Random.org.

Following the Occupational Safety and Health Administration's regulations and policies, the extracted primary teeth were cleaned and disinfected. Soft tissue debris

attached to the teeth was removed with a hand-scaling instrument, and finally, the samples were stored in a normal saline solution at room temperature until all the samples were selected according to inclusion criteria.

All included teeth should be freshly extracted human primary molars, with no previous treatment, absence of external or internal pathologic root resorption after x-ray assessment, absence of perforation in the internal or external furcation after x-ray assessment, two-thirds of an intact root or with minimal apical resorption. Teeth were excluded where there are any signs of calcification, hypercalcified teeth or badly decayed with root caries.

The access cavities were opened with a round diamond bur (Mani Inc, Tochigi, Japan) using a high-speed handpiece (Foshan COXO Medical Instrument Co., Ltd, China). working length (WL) was determined by inserting a #10 K-file (Mani, Japan) into the canal until reaching the tip of the apical foramen, 1 mm short of the whole initial length which was documented for root canal preparation. As shown in Figure (1).

C. Injection of ink

All specimens were then rinsed with normal saline and isolated with petroleum gel from the outside surface of the tooth. Insulin syringe (30 gauge) was then used to inject India ink dye into the canals from the coronal side until the ink leaked through the apical foramen.

To ensure thorough dye penetration throughout the canals, the ink was reapplied, Furthermore, a #10 K-file was again inserted into the canals to the agitation of the ink. The teeth were stored in wet conditions at room temperature for 48 hours, As shown in Figure (2).

D. Steps for root canal preparation:

- **Group I: Manual instruments (K-files)**

Root canal preparation was performed using stainless steel K-files (Thomas K Files 25mm, France) until size #35, while in narrow canals #30, using quarter-turn-pull motion in a crown-down technique.

Each K-file was was only applied to a maximum of five teeth to keep canal uniformity during preparation. After the last file, each canal was irrigated with 3 ml 1 % NaOCl and 5 ml of distilled water, and after each instrument removal recapitulation was done with a size 10 K-file.

- **Group 2: Pediatric rotary files (Kedo-S Square)**

Filling was performed with NiTi Kedo-S Square pediatric rotary files system (Reeganz Dental Care Pvt. Ltd, India) driveb by Cicada endodontic micro-motor (Guangzhou KEDA Biological Tech Co., Ltd, China) at 300 rpm with torque 2.2 N and in auto-reverse mode. #10 hand files Was used to assess the patency of the canal and #15 hand files for initial enlargement before the use of rotary files.

Prior to instrumentation each instrument was coated with 17% EDTA gel for lubrication as recommended by the manufacturer. After every instrument, 3 mL of 1 % NaOCl was used for irrigation, and 5 mL of distilled water was used to flush the canals at the end of the process.

E. Assessment of cleaning effectiveness:

For evaluation of cleaning efficacy, teeth are processed in three steps, they were decalcified, dehydrated, and then cleared (Kalita et al., 2021), as shown in Figure (3).

- **Decalcification**

For 2 to 10 days, the specimens were washed and put in separate containers of 7 percent hydrochloric acid, with the solution being changed every day to preserve the

solution's effectiveness. Teeth were decalcified and then placed under flowing tap water for twenty-four hours to neutralize the acid.

- **Dehydration**

The samples were immersed in diluted ethyl alcohols in a series of concentrations to allow for dehydration: first, 70% alcohol for 16 hours (changed after eight hours), and then 80%, 95%, and 100% for 8 hours each.

- **Method of clearing of teeth**

All teeth were preserved in methyl salicylate after decalcification and dehydration until they turn translucent. The whole clearing of the teeth took close to six hours. Then, until analysis, all of the samples were kept in the methyl salicylate solution.

- **Analysis of the root canals**

Teeth were first sectioned buccolingually, they immersed in a glass petri dish with methyl salicylate and carefully examined under a stereomicroscope (X 15 magnification), Then, India ink localization was examined in the cervical, middle, and apical thirds according to a 4-point score that evaluates ink removal along the root canal walls, where Score 0 refers to total cleaning, score 1 means almost complete ink removal, score 2 means partial ink removal, and score 3 means no ink removal (Kalita et al., 2021), as shown in Figure (4).

F. Statistical analysis:

Ordinal data were presented as frequency, percentage, mean and standard deviation values. They were analyzed using Mann-Whitney U test for intergroup

comparisons and Friedman's test followed by Nemenyi post hoc test for intragroup comparisons. The significance level was set at $p \leq 0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows (R Core Team, 2022).

III. RESULTS:

Intergroup and Intragroup comparisons mean and standard deviation (SD) values of cleaning effectiveness score for different groups and root sections were presented in Tables (1) and (2).

A. Intergroup comparisons:

For the coronal section and overall, K-files group had a significantly higher score (the worst cleaning efficiency) than Kedo-S Square group ($P= 0.012$). while for the middle ($P=0.169$) and apical sections ($P= 0.236$), the difference was not statistically significant.

B. Intragroup comparisons:

Results of Kedo-S Square showed there was a significant difference between scores measured at different root sections with the apical section having a significant value than the coronal section ($P=0.038$).

Results of K-files showed there was no statistically significant difference between scores measured at different root sections ($P=0.192$). the highest value was found in the apical section (1.36 ± 0.54) followed by the middle section (1.14 ± 0.43) while the lowest value was found in the coronal section (1.01 ± 0.35).

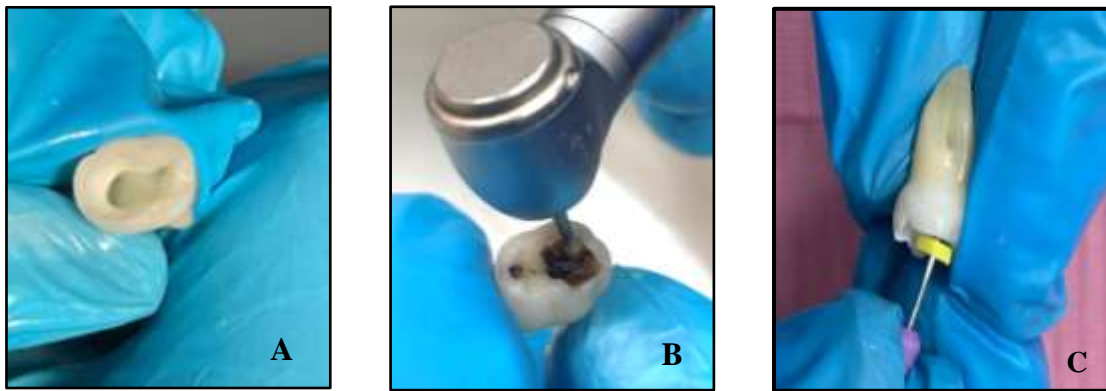


Figure (1): (A) Caries removal, (B) Access cavity, (C) working length determination.

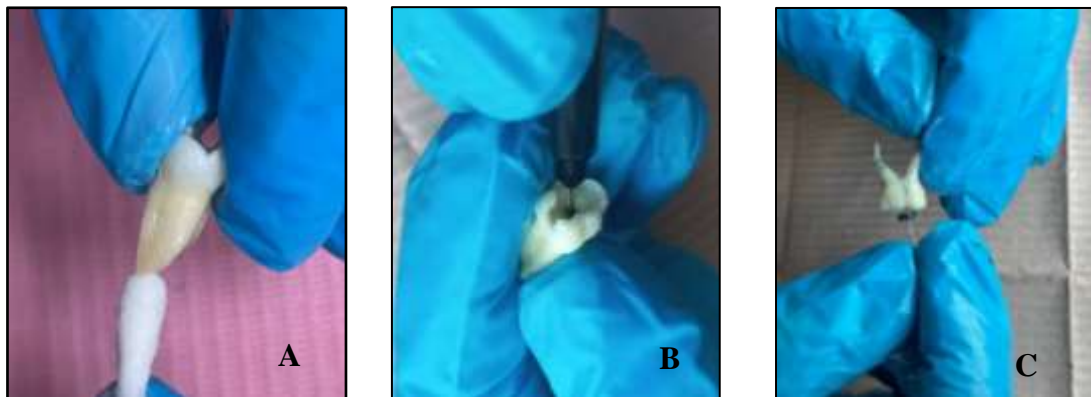


Figure (2): (A) Isolation, (B) Ink injection inside the canals, (C) agitation of the ink.



Figure (3): (A) decalcification in 7% HCL, (B) after dehydration with Alcohol, (C) Clearing the tooth with methyl salicylate.

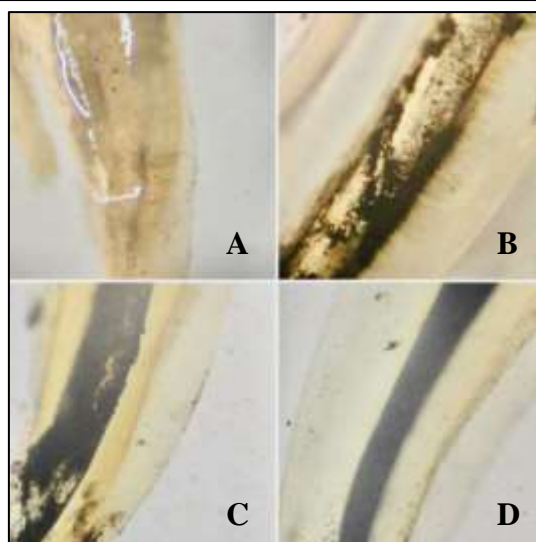


Figure (4): Grading scores for cleaning effectiveness. (A): Score 0: Total cleaning. (B) Score 1: Almost complete ink removal. (C) Score 2: Partial ink removal. (D) Score 3: No ink removal.

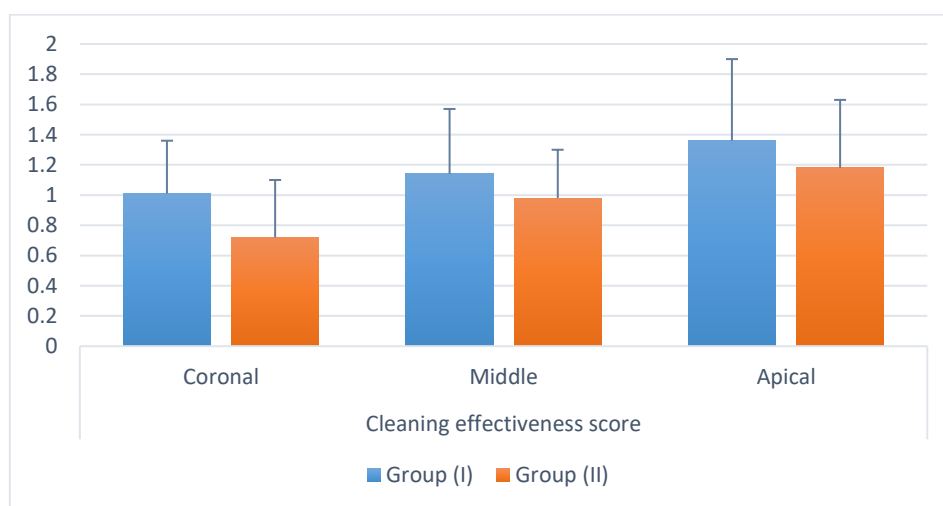


Figure (5): Bar chart showing mean and standard deviation (error bars) of cleaning effectiveness score for different groups.

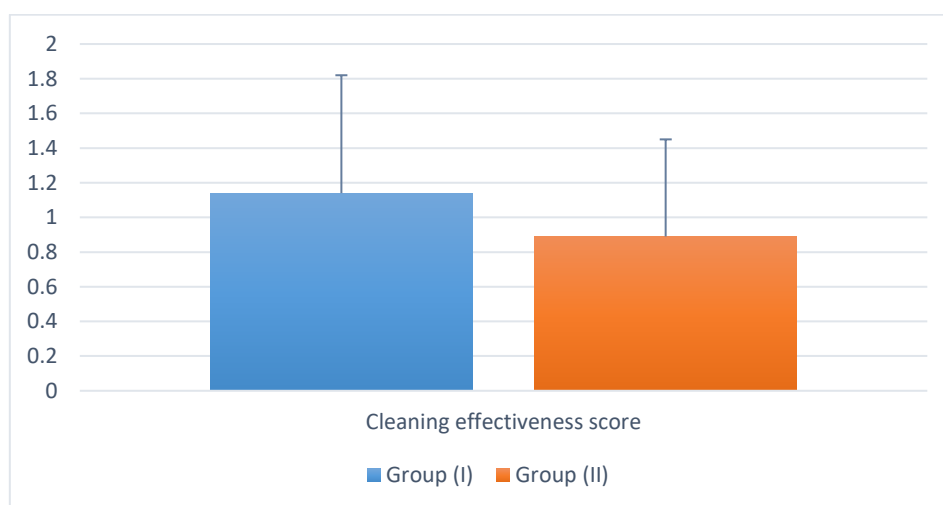


Figure (6): Bar chart showing mean and standard deviation (error bars) of cleaning effectiveness score for different groups.

Table (1): Inter and intragroup comparisons, mean and standard deviation (SD) values of cleaning effectiveness score for different groups and sections.

Root section	Cleaning effectiveness score (Mean±SD)		p-value
	Group (I)	Group (II)	
Coronal	1.01±0.35 ^B	0.72±0.38 ^B	0.012*
Middle	1.14±0.43 ^{AB}	0.98±0.32 ^{AB}	0.169ns
Apical	1.36±0.54 ^A	1.18±0.45 ^A	0.236ns
p-value	0.192ns	0.038*	

Values with different superscript letters within the same vertical column are significantly different*; significant ($p \leq 0.05$) ns; non-significant ($p > 0.05$).

Table (2): Inter and intragroup comparisons, mean and standard deviation (SD) values of cleaning effectiveness score for different groups

Cleaning effectiveness score (Mean ± SD)		p-value
Group (I)	Group (II)	
1.14±0.68	0.89±0.56	0.023*

*; significant ($p \leq 0.05$) ns; non-significant ($p > 0.05$)

IV. DISCUSSION:

Endodontic therapy in primary teeth is more difficult due to complicated anatomical structures and their proximity to the developing permanent tooth bud. Furthermore, managing children's behavior makes pediatric endodontics a challenging field. The main aim of cleaning and shaping involves the removal of pulpal tissue and debridement of the bacterially infected canal spaces (Jeevanandan & Govindaraju, 2018 and Priyadarshini et al., 2020). Therefore, the current study was conducted to evaluate the cleaning effectiveness of manual K-files versus Kedo-S Square rotary file system in primary molars.

For a long period of time, Hand files are reported as the main choice of canal preparation in primary teeth (Hidalgo et al., 2017), K-files were chosen in the current study as they are useful for penetrating and enlarging root canals due to its twisted morphology. Generally, a

reaming motion (i.e., constant file rotation) causes less transportation than a filing motion ("in and out" motion) (Katge et al., 2014 and Elheeny et al., 2015).

Specific anatomical criteria of primary teeth make it difficult to use rotary files designed for permanent teeth due to the risk of lateral perforation, and discomfort for children when they open their mouths due to the length (21–25 mm) of the files. Recently, exclusive pediatric rotary files of length 16 or 17 mm were available for use in primary teeth which specifically designed with a taper and sufficient flexibility to access even the smallest canals in the root canal system (Jeevanandan, 2017; Naidu et al., 2021 and Shah et al., 2021).

The Kedo-S Square is a novel pediatric rotary file selected as they single file that is specifically designed for use in primary teeth, which features avoids dentin loss compared to

multi-file systems. Therefore, it is critical to evaluate its performance and compare it to other products on the market (**Pitchiah & Shivashankarappa 2020 and Bhagyashree et al., 2022**).

The current study followed the instruction of the manufacturers of Kedo-S Square file for instrumentation of the root canals, which suggested the prior use of manual K- files (#10 and #15) to the full working length. This step was essential to secure an open pathway to the canal terminus so that the subsequent instruments can follow (**Lakshmanan et al., 2020**). Furthermore, it reduces the risk of some procedural errors such as canal transportation, ledging and zipping.

In the present study, 1% NaOCl solution was utilized for canal irrigation to gain its antibacterial potential without any drawback in the dentinal microstructure. (**Das et al., 2018**). Lubrication of the rotary files during insertion inside the root canals was achieved using EDTA to reduce the stress from the friction between the narrow dentinal walls and the instrument during preparation to reduce the risk of instrument failure or fracture (**Chandler & Chellappa, 2018**).

There are different techniques to determine the cleaning effectiveness of hand instruments and rotary Ni-Ti in root canals. In our study, tooth assessment after staining and diaphanization process has been chosen as it is a reliable method for three-dimension examination, non-destructive, cost-effective, and more sensitive method to evaluate root canals in three dimensions (**Tomar et al., 2018 and Barrington & Balandrano, 2019**).

The superior result of Kedo-S Square in the coronal section is probably attributed to its wider diameter of rotary files in the coronal one-third, teardrop cross-section, and VV taper (4–8%), which enable better coronal enlargement and straight-line access, resulting in better access for irrigation and complete pulp tissue extirpation. K-file provided the least

cleaning efficacy, this might be due to 2% taper and motion of the hand file during canal preparation (**Katge et al., 2014**).

These results were in accordance with **Ramazani et al., 2016** who reported that Reciproc and Mtwo files both produced better results in cleaning effectiveness than K-files in coronal and middle level. **Kalita et al., 2021** also found that Kedo-S showed better cleaning efficacy than K- files in all thirds of the root canal but with highly significant differences. Also, **Pathank, 2016** stated that Mtwo and WaveOne showed greater effectiveness in cleaning the root canal in the coronal and middle third.

On the other hand, contrary to current results, **Moghaddam et al., 2009** concluded that cleaning effectiveness of K-files are better coronally than Flex Master rotary files. This was mostly attributed to the operators' tendency to arrange hand instruments more coronally. Moreover, it was represented by **Katge et al., 2016** also reported that H-file showed better cleaning than Mtwo file in coronal third. They attributed that to the fact that H-files have a positive rake angle, which provides more cutting efficiency.

• Limitations of the study

This in vitro study does not provide information on the clinical success rate. Furthermore, the findings of this study are limited to mandibular primary molars, which have different anatomical characteristics and morphology than other anterior teeth and maxillary molars.

V. CONCLUSION:

Based on the results and limitations of the current study, it could be concluded that, Kedo-S Square file is an effective tool for root canal preparation in primary molars, Kedo-S Square has superior cleaning effectiveness than K-file, especially in the coronal third and Both K-files and Kedo-S Square files do not perform complete cleaning effectiveness.

VI. CONFLICT OF INTEREST:

The authors declare that there is no conflict of interests.

VII. FUNDING INFORMATION:

No funding was received for conducting this study.

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