

# Evaluation of the Smear Layer Removal Ability of Various Rotary Files with/without Chemical Agents on Primary Teeth: An *In Vitro* Study

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## ABSTRACT

**Aim:** The aim of the current study was to assess the cleaning and smear layer removal efficacy of two different rotary files with or without chemical agents on primary teeth.

**Materials and methods:** For the study, 90 extracted primary maxillary incisors without internal or external resorption and with at least two-thirds of complete roots were chosen. Then, based on the kind of instruments used to clean and shape the canals, they were randomly assigned to three experimental groups, each consisting of 30 teeth. Group-I: The canal was instrumented manually with K-files, Group-II: The canal was instrumented with Kedo-S files, Group-III: The canal was instrumented with Kedo-SG Blue files. After the canals were finally instrumented, 2 mL of QMix™ solution was used to irrigate 15 samples from each group. The samples were subsequently allowed to remain in the canals for 90 seconds in order to eliminate the smear layer. After that a stereomicroscope was used to assess the cleaning effectiveness.

**Results:** With irrigant solution, the highest mean value was found in manual K-files ( $2.86 \pm 0.34$ ), followed by Kedo-S files group ( $1.34 \pm 0.26$ ) and Kedo-SG Blue files ( $1.28 \pm 0.18$ ). Without irrigant solution, the highest mean value was found in manual K-files ( $2.92 \pm 0.22$ ) followed by Kedo-S files group ( $1.44 \pm 0.18$ ) and Kedo-SG Blue files ( $1.36 \pm 0.14$ ). There was a statistically significant difference found at all the three levels.

**Conclusion:** On conclusion, the current study's findings demonstrated that irrigation solution was significantly more effective in cleaning and removing smear layers from pediatric rotary files than manual K-files.

**Clinical significance:** The effectiveness of endodontic therapy depends on a successful chemomechanical preparation. The canals are instrumented using either hand files or rotary instruments; there are several irrigation and instrumentation techniques. In order to completely sterilize the canals, chemical agents are utilized for irrigation during instrumentation. Due to their numerous biological, antibacterial, anti-inflammatory, and antioxidant qualities, many natural compounds are also utilized as irrigants.

**Keywords:** Chemical agents, Primary teeth, Rotary files, Smear layer.

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## INTRODUCTION

One important aspect that supports phonation, mastication, and esthetics is the preservation of primary teeth until physiological exfoliation. Additionally, it keeps children from developing improper behaviors and aids in the proper eruption of the next set of permanent teeth. The goal of endodontic treatment is to maintain the tooth's health within the dental arch. This is crucial for kids since losing their primary teeth too soon might interfere with the stomatognathic system's development, prevent the permanent dentition from being installed, and cause emotional, psychological, and behavioral issues.<sup>1</sup>

One of the crucial clinical techniques utilized to treat pulp treatments in children is pediatric endodontics. In the realm of pediatric dentistry, space loss resulting from the loss of primary teeth is a significant issue that requires consideration. The key to a successful root canal treatment is biomechanical preparation, which aims to remove both hard and soft tissue from the root canals in order to clean and shape them.<sup>2</sup> Thus, space is created in the radicular structure for irrigants to the apical third, medications, and obturating material that follows. Hand files, reamers, burs, and sonic instruments are typically used for biomechanical preparation; more recently, rotary devices have been used.<sup>3,4</sup>

Kedo-S Ni-Ti rotary files are distinguished by a progressive taper increase that encourages straight access and coronal enlargement.

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This taper variation preserves the inner wall of the root surface and improves cleaning efficiency and canal preparation.<sup>5</sup> Kedo-SG Blue files are heat-treated and have regulated memory, which gives them exceptional flexibility and up to a 75% resistance against cycle fatigue because of the titanium oxide content.<sup>6</sup>

When root canals are instrumented mechanically, a smear layer of inorganic and organic materials remains on the dentinal walls. This coating can harbor germs and prevent intracanal disinfectants and sealants from penetrating the dentinal tubules. In addition to an antibacterial agent, the root canal system needs to be cleaned

and disinfected using both organic and inorganic solvents. New irrigating solutions, such as QMix™, have been produced to address these issues with the irrigation of the root canal system. These solutions have the ability to remove smear layer and serve as bactericidal in a single application.<sup>7</sup> The majority of investigations on the use of rotary files in primary teeth has focused on three main areas: instrumentation time, prepared canal shape, and cleaning ability. Regarding the cleaning capacity of rotary instruments in relation to manual techniques and the use of chemical agents or not, there are, nevertheless, conflicting data. Hence, the aim of the current study was to assess the cleaning and smear layer removal efficacy of two different rotary files with or without chemical agents on primary teeth.

## MATERIALS AND METHODS

### Selection and Preparation of Samples

The current *in vitro* study was conducted in the Department of Preventive Dental Sciences, Prince Sattam Bin Abdulaziz University, Saudi Arabia during the year of 2024, and Institutional approval was obtained. For the present study, 90 extracted primary maxillary incisors without internal or external resorption and with at least two-thirds of complete roots were chosen. The incisors were removed from healthy children as they were retained beyond the normal time of exfoliation. Following a radiological assessment of each tooth, teeth showing signs of internal resorption, calcification, or abnormalities were removed. After that, the teeth were cleaned with water and kept for a week in normal saline solution. A broach was used to remove the remaining pulp tissue after the crowns had been removed with a diamond disc. Using a #15 file, the canal's patency was determined.

Then, based on the kind of instruments used to clean and shape the canals, they were randomly assigned to three experimental groups, each consisting of 30 teeth.

#### Group-I: The Canal was Instrumented Manually with K-files

Using K-files (Dentsply, Maillefer, Ballaigues, Switzerland), root canal preparation was done. The step-back technique was employed in this group to prepare the root canals using #15–#30 files.

#### Group-II: The Canal was Instrumented with Kedo-S Files

The total length of the three Ni-Ti rotary files in this system is 16 mm. The D1, E1, and U1 files are accessible and include a configurable taper (Reeganz Dental Care Pvt. Ltd.). Because of its bigger tip diameter (0.40 mm), U1 was employed in anterior teeth. A constant torque operation between 150 and 300 rpm was employed with this system.

#### Group-III: The Canal was Instrumented with Kedo-SG Blue Files

In accordance with the manufacturer's instructions, all teeth were instrumented with Kedo-SG Blue pediatric rotary files (Reeganz Dental Care Pvt. Ltd.). For canal preparation, U1 rotary files were utilized, with torque applied between 2.2 and 2.4 Ncm and speed between 250 and 300 rpm.

### Irrigation with/without QMix™ Solution

After the final instrumentation, 15 samples from each group received only 3 mL of distilled water irrigation and all samples were rinsed with normal saline solution. In order to remove the smear layer, 15 samples from each group received 2 mL of QMix™ solution

**Table 1:** Mean cleaning and smear layer removal ability of various rotary files with chemical agents

| Rotary files                  | n  | Mean ± SD   |
|-------------------------------|----|-------------|
| Group-I: Manual-K files       | 15 | 2.86 ± 0.34 |
| Group-II: Kedo-S files        | 15 | 1.34 ± 0.26 |
| Group-III: Kedo-SG Blue files | 15 | 1.28 ± 0.18 |

(DENTSPLY, Tulsa, USA) irrigation, and the samples were left in the canals for 90 seconds.

### Evaluation of the Smear Layer Efficacy of Rotary Files

After instrumentation, paper points were used to dry each tooth. Subsequently, the samples underwent stereomicroscopy (Olympus, Japan) assessment with ×10 magnification after sectioned buccolingually using a double-faced diamond disc. Single investigator participated in the present study. The evaluation of the smear layer removal efficacy was recorded at coronal, middle and at apical third of the root. The following scores were observed for the removal of the smear layer:

*Score 1:* Less than 25% of the substance had a smear layer, the majority of tubules were visible and patent.

*Score 2:* Little to moderate or patchy smear layer mounts, affecting 25–50% of the specimen, with numerous visible and patent tubules.

*Score 3:* 50–75% of the specimen has a moderately dispersed or aggregated smear layer; there is little to no tubule visualization or patency.

*Score 4:* More than 75% of the specimen was covered in a thick coating of smears; no tubule orifices were apparent or patent.

### Statistical Analysis

The Statistical Programs for Social Sciences (SPSS) software, version 20.0 for Windows (SPSS Inc., Chicago, IL), was used to analyze the data. The statistical analysis was conducted using the Mann-Whitney *U* test and the Kruskal-Wallis tests. The acceptable level for statistical significance was set at  $p < 0.05$ .

## RESULTS

**Table 1** presents the mean cleaning and smear layer removal ability of various rotary files with chemical agents. The highest mean value found in manual K-files was  $2.86 \pm 0.34$ , followed by Kedo-S files group ( $1.34 \pm 0.26$ ) and Kedo-SG Blue files ( $1.28 \pm 0.18$ ).

**Table 2** depicts the mean cleaning and smear layer removal ability of various rotary files with chemical agents at coronal, middle, and apical third. At coronal third, the least mean value was found in Kedo-S files group ( $0.34 \pm 0.03$ ); at middle third and at apical third, the least value was found in Kedo-SG Blue files group ( $0.44 \pm 0.08$ ,  $0.46 \pm 0.04$ , respectively). Statistically significant difference was observed at all the three levels.

**Table 3** presents the mean cleaning and smear layer removal ability of various rotary files without chemical agents. The highest mean value was found in manual K-files ( $2.92 \pm 0.22$ ), followed by Kedo-S files group ( $1.44 \pm 0.18$ ) and Kedo-SG Blue files ( $1.36 \pm 0.14$ ).

**Table 4** depicts the mean cleaning and smear layer removal ability of various rotary files without chemical agents at coronal,

**Table 2:** Assessment of mean cleaning and smear layer removal ability of various rotary files with chemical agents at coronal, middle and apical third

| Rotary files                  | Mean ± SD at coronal third | Mean ± SD at middle third | Mean ± SD at apical third |
|-------------------------------|----------------------------|---------------------------|---------------------------|
| Group-I: Manual K-files       | 0.72 ± 0.16                | 0.96 ± 0.10               | 1.18 ± 0.08               |
| Group-II: Kedo-S files        | 0.34 ± 0.03                | 0.48 ± 0.12               | 0.52 ± 0.11               |
| Group-III: Kedo-SG Blue files | 0.38 ± 0.06                | 0.44 ± 0.08               | 0.46 ± 0.04               |
| K-ANOVA Value                 | 24.320                     | 26.186                    | 25.382                    |
| p-value                       | 0.001*                     | 0.001*                    | 0.001*                    |

\*Statistically highly significant

**Table 3:** Mean cleaning and smear layer removal ability of various rotary files without chemical agents

| Rotary files                  | n  | Mean ± SD   |
|-------------------------------|----|-------------|
| Group-I: Manual K-files       | 15 | 2.92 ± 0.22 |
| Group-II: Kedo-S files        | 15 | 1.44 ± 0.18 |
| Group-III: Kedo-SG Blue files | 15 | 1.36 ± 0.14 |

**Table 4:** Assessment of mean cleaning and smear layer removal ability of various rotary files without chemical agents at coronal, middle and apical third

| Rotary files                  | Mean ± SD at coronal third | Mean ± SD at middle third | Mean ± SD at apical third |
|-------------------------------|----------------------------|---------------------------|---------------------------|
| Group-I: Manual K-files       | 0.80 ± 0.10                | 1.04 ± 0.08               | 1.08 ± 0.04               |
| Group-II: Kedo-S files        | 0.37 ± 0.07                | 0.52 ± 0.02               | 0.55 ± 0.09               |
| Group-III: Kedo-SG Blue files | 0.42 ± 0.02                | 0.44 ± 0.4                | 0.50 ± 0.08               |
| K - ANOVA value               | 23.714                     | 25.202                    | 26.638                    |
| p-value                       | 0.001*                     | 0.001*                    | 0.001*                    |

\*Statistically highly significant

middle, and apical third. At coronal third, the least mean value was found in Kedo-S files group (0.37 ± 0.07); at middle third and at apical third, the least value was found in Kedo-SG Blue files group (0.44 ± 0.4, 0.50 ± 0.08, respectively). There was a statistically significant difference found at all the three levels.

The inference of the present study shows that the overall better cleaning and smear layer removal efficacy was found with irrigation solution in both rotary pediatric rotary files than in the manual K-files.

## DISCUSSION

The primary goal of root canal therapy in children is to completely eliminate the infected tissue and seal the canal with a biocompatible material. Furthermore, the majority of practitioners have always been interested in ending the root canal surgery quickly while still offering high-quality care.<sup>8</sup>

The ability of endodontic files to remove debris and smear layer—a necessary precondition for the successful completion of endodontic treatment—can be used to assess their canal cleaning capacity. Smear and debris layer causes the following problems during endodontic treatment: it contains bacteria and their by-products, necrotic tissue, which is a reservoir of microbial

irritants allowing their deeper penetration in the dentinal tubules, and an unpredictable thickness and volume due to greater water portion limit, its removal and optimum penetration of disinfectants. The endodontic instrument’s design (size, taper, cross-section, etc.), technique (rotational or vibrational), and preparation technique (step-back or crown down) all affect the removal of debris and smear layers.<sup>9</sup>

For primary teeth, a practical pulpectomy procedure necessitates a minimal number of consultations and a brief course of therapy. It should debride the root canal effectively without compromising the integrity of the tooth or the neighboring permanent teeth, and it should continue to work until it exfoliates.<sup>10</sup> Nevertheless, manual methods take a lot of time, which wears out the pediatric patients as well as the operator and has a big effect on behavior control. Established by Barr et al. in 2000, rotary Ni-Ti files are regarded as the state-of-the-art advancements in endodontic treatments of primary teeth.<sup>11</sup> Using files with larger tapers should allow for more apical deposition of the irrigant, making it easier to remove bacteria, necrotic debris, pulp tissue, and dentin by the cleansing action of chemical and physical irrigation.<sup>12</sup>

In the current investigation, Kedo-SG Blue files had the best smear layer removal efficacy, followed by Kedo-S files group and K-files. The current investigation bears similarities to a study done by Priyadarshini et al.,<sup>13</sup> which found that Kedo-SG rotary files produced 80% optimal filling. Because Kedo-SG files feature a titanium covering that facilitates the easy removal of the smear layer, optimal obturation quality, and flow of obturating material, they are more flexible in negotiating even the tightest canal in primary teeth. Furthermore, compared with its previous file system, its great flexibility reduces the risk of file breaking, enhancing its efficacy and effectiveness in canal preparation.

Both the Kedo S and Kedo S-SG Blue rotary files demonstrated improved cleaning efficacy in the current investigation. Similar outcomes were reported by Kalita S et al.<sup>5</sup> and Jeevanandan G and Thomas E<sup>14</sup> because of the Kedo-S Ni-Ti rotary files’ steady taper increase, which promotes straight access and coronal expansion. This taper variation preserves the inner wall of the root surface and improves cleaning efficiency and canal preparation. One reason for the variation in cleaning capacity could be the operator’s technique, among other things. Rotary instrumentation is not only dependent on the operator’s abilities; it also depends on the operator’s experience and expertise as well as the hand motion used during root canal preparation. For adequate canal preparation in the apical and middle thirds, a file with a 0.25 tip size and 4% taper is needed; in the cervical one-third, a file with a 6% taper encourages better canal preparation.

In order to successfully remove the pulp tissue and/or germs from the root canal system, chemical agents must be used during



instrumentation to thoroughly clean every part of the system. The dynamics of irrigation are significant; the efficacy of irrigation is contingent upon the irrigant's mechanism(s) of action and its capacity to interact with the bacteria and tissue debris present in the root canal. In this investigation, a chemical irrigant called QMiX was employed. Similarly, Kour G et al.<sup>15</sup> state that in order to effectively remove the debris from teeth, irrigations must come in contact with the dentin walls and enter the root canal system more easily, creating more surface area that is available for action. The surface tension of this contact directly affects how close it is; an irrigant with a low surface tension is excellent.

The limitation of the present study includes that the *in vitro* nature of the current study was a limitation because of significant differences from the clinical condition (children's compliance and mouth opening degree), which should be taken into consideration in future studies even though using human extracted teeth can in some way examine the performance of different instruments.

## CONCLUSION

Within the limitations, the current study's findings demonstrated that irrigation solution was significantly more effective in cleaning and removing smear layers from pediatric rotary files than manual K-files. A reduced working time can help maintain patient cooperation by diminishing the potential for tiredness. The use of appropriate rotary instrumentation equipment seems to be a promising strategy in preparing root canals in primary teeth.

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