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Comparative Evaluation of *Kedo- 'S'square* Files with Manual Instrumentation in Primary Molars: An Invitro Study

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Abstract: The pulpectomy procedure includes the complete removal of the pulpal tissue, debridement, and preparation of the canal space, followed by obturation. The standard method of cleaning and shaping the canals in primary teeth uses hand files, which can lead to iatrogenic errors. *Kedo S* files are exclusive pediatric rotary file systems of which the *Kedo S Square* file system (IV generation) have various advantages. The study aims to evaluate and compare the cleaning efficacy of *Kedo S Square* files and manual K files in root canals of primary teeth**:** An In-vitro comparative study was conducted, which included 56 root canals from 25 primary molars. 2-3ml of India ink dye was injected into canals and were randomly divided into two groups in which instrumentation was done using *Kedo S Square* files and Manual K files, respectively. The teeth were subjected to decalcification and dehydration and observed under a stereomicroscope for traces of Indian ink in the canals. Results were recorded and statistically analyzed using the Chi-Square test. *Kedo S Square files* had statistically better cleaning efficacy compared to *the K* file in the coronal(P=0.001), middle(P=0.000), and apical third(P=0.001) of the root canal. The cleaning efficacy of both *Kedo S Square* and *K* files varied in different thirds of the canals, but it was not statistically significant. Pediatric rotary *Kedo S Square* files were effective compared to Manual *K* Files concerning cleaning efficacy.

Keywords: Pediatric rotary files, Pulpectomy, Primary teeth, Cleaning and Shaping.

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1. INTRODUCTION

The main goal in pediatric dentistry is to retain the primary teeth in the oral cavity until their physiological exfoliation to preserve arch integrity[1]. One of the treatment options for pulpally affected primary molars is pulpectomy, which is preferred over-extraction and placement of space maintainers because of the increased chance of decalcification of the abutment teeth and supra-eruption of opposing teeth. Therefore, the best space maintainer is the primary tooth [2]. Pulpectomy in children is challenging due to the complex root canal anatomy in primary molars, i.e., tortuous canals, lateral branching, connecting fibrils, and apical ramification[1]. The main goal of pulpectomy is achieving success through these complexities by eliminating microorganisms via proper chemo-mechanical preparation[2,3]. Hand instrumentation, the most acceptable and widely used method, however, can lead to iatrogenic errors such as ledging, zipping, apical blockage, canal transportation, and instrument breakage[4]. Lengthy endodontic appointments and behavior management problems are additional challenges in children[5].The standard method of cleaning and shaping the canals in primary teeth is using hand files. Hand instrumentation, despite being the most acceptable and widely used method, is time-consuming and can lead to iatrogenic errors such as ledging, zipping, apical blockage, canal transportation, and instrument breakage[6]. Lengthy endodontic preparation and behavior management problems are additional challenges[7]. Over the years, Rotary Nickel-Titanium instrumentation techniques have been developed and introduced to overcome these problems. The first case of biomechanical preparation with adult rotary files in primary teeth was reported using Profile 0.04 taper permanent rotary instruments[6]. Studies have reported using adult rotary files with better cleaning efficacy in primary teeth compared to K files[7,8]. However, some studies did not show a significant difference in cleaning efficacy between the two techniques[9–11]. It could be attributed to the relatively thin canal walls, high chance of lateral perforation, and difficulty in complete instrumentation of flat, oval, curved, and irregularly shaped canals in primary teeth[12]. In addition, Pediatric patients have limited mouth openings and the longer length of adult rotary files makes it more difficult to use them[5].An evolution in pediatric endodontics occurred with introduction of an exclusive Paediatric Rotary System *Kedo-S* file system. The newer IV generation *Kedo S Square* file system consists of only 2 files, i.e., the P1 file for molars and the A1 file for interiors, thereby reducing instrumentation time compared to Manual files[13]. Apart from the variable taper and variable diameter, the *Kedo S Square* files are designed with a triangle (3-point contact) cross section in the apical 5mm and tear drop-shaped cross section (2-point contact) in the coronal 7mm enabling its preparation of less aggressive on dentin, particularly in the apical third of the root canals. It has also been reported that the fracture rate of *Kedo S Square files* and post-operative pain following instrumentation was less compared to manual instrumentation[14,15]. However, data available on the cleaning efficacy of the single pediatric files- *Kedo S Square* files in the narrow and curved root canals of primary molars are scarce. Therefore, this in vitro study aimed to compare the cleaning efficacy of rotary *Kedo S Square* files with manual *K files* in the root canals of primary molar teeth using the 'clearing technique' under Stereomicroscope.

2. MATERIALS AND METHODS

2.1. Ethical statement

The Institutional Review Board approved the methodology for the study (IRB) & Institutional Ethical Committee (IEC) IEC number – IGIDSIEC2020NRP53PGKDPPD. The study was conducted according to Helsinki Declaration as revised in 2013, and the participant's consent was obtained for using their extracted teeth.

2.2. Inclusion criteria

- Primary maxillary and mandibular molars with at least two third of root intact extracted due to dental caries, non-restorable coronal structure, recurrent periapical infection, and over-retention due to altered root resorption pattern.

2.3. Exclusion criteria

- ***Teeth with internal resorption, perforation in the furcation***

Based on the inclusion and exclusion criteria, twenty-five primary molars were selected (15 Maxillary molars and 10 Mandibular molars), and 56 canals were instrumented (21 Mesiobuccal canals, 8 Mesiolingual canals, 13 Distobuccal canals, 3 Distolingual canals, 2 Distal canals, 9 Palatal canals)

2.4. Collection of teeth and Sample Preparation

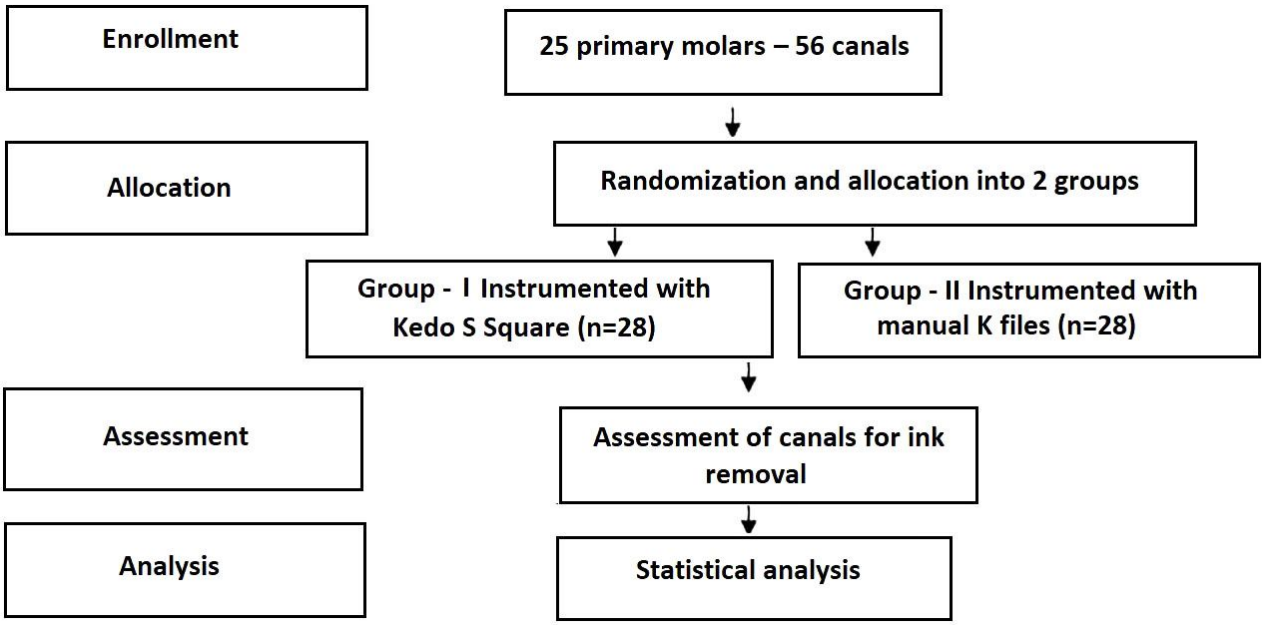
The Extracted primary teeth were stored in distilled water to prevent dehydration. They were later immersed in 0.5% sodium hypochlorite for disinfection for 1 week, and the samples were then mounted on wax blocks.

2.5. Method of Root Canal Preparation

The access cavity was prepared using a large round diamond bur. The occlusal surfaces of the teeth were flattened, leaving 2mm of coronal tooth structure. The pulp chamber and root canals were irrigated with 3% sodium hypochlorite solution for the dissolution of organic tissues using a side vent 23-gauge, 5ml syringe. A # 10 K-file was used to determine the radiographic initial working length. Next, 2-3 ml of India Ink dye was injected into the canals using a 30-gauge insulin syringe, following which the root canals were randomly divided into two groups by lottery method. In Group 1, 28 root canals (11 Mesiobuccal, 4 Mesiolingual, 6 Distobuccal, 2 Distolingual, 1 Distal, 4 Palatal canals) were instrumented using Pediatricrotary*Kedo S Square* files with an Endodontic Motor at 300 rpm and 2.2 Ncm torque. In Group 2, 28 root canals (10 Mesiobuccal, 4 Mesiolingual, 7 Distobuccal, 1 Distolingual, 1 Distal, 5 Palatal canals) were instrumented with manual 21mm *K*files in a filing motion up to #30 file. Next, 5 mL of 2% sodium hypochlorite was used for irrigation of the canal. After every use, the *K* and *Kedo S Square file*s were inspected for deformation/fracture. *K files* were disposed of after a maximum of 4 canals[16], and *Kedo S square files* were used for the instrumentation of 10 teeth (According to the manufacturer's instruction, a maximum of 12 teeth can be instrumented by *Kedo S square file*). Root canals in both groups were dried with paper points. The coronal cavity was sealed with Intermediate Restorative Material (IRM), and the teeth were removed from the modeling wax blocks. The apices were then sealed with sticky wax to prevent acid entry during decalcification.

2.6. *Decalcification and Dehydration*

The teeth were decalcified using 7% hydrochloric acid for two days, and the solution was changed every day. After decalcification, the samples were washed under running water and immersed in a diluted ethyl alcohol solution for dehydration. Initially, 70% alcohol for 16 hours (changed every 8 hours) was used, followed by 80% alcohol for 8 hours, 95% alcohol for 8 hours, and 100% alcohol for 8 hours. Finally, the dehydrated teeth were cleared by immersing them in methyl salicylate for 6 hours.



A consort flow chart followed during the different stages of this *in vitro* study.

1.1 Stereomicroscopic Analysis

The teeth were then immersed in glass petri dishes with methyl salicylate and observed for remaining traces of India ink in the coronal, middle, and apical third of the canals using a Stereo microscope under 10X magnification, which determines the cleaning efficacy of the respective files used for instrumentation. Grading was scored by three independent examiners using the Silva LA et al. [17] scoring criteria.

Score 0: Total clearing (canal was completely clean)
Score 1: Almost complete ink removal (traces of ink in some areas)
Score 2: Partial ink removal (remnants of ink found on some walls in some areas)
Score 3: No ink removal (appreciable amount of ink present)

2. STATISTICAL ANALYSIS

A non-parametric test was used for the data analysis. Pearson's Chi-Square test was used to compare the cleaning efficacy between the groups. SPSS 17 version software was used and p value <0.05 was considered statistically significant.

3. RESULTS

56 canals in 25 extracted primary molars were assessed under Stereomicroscope for remaining traces of India Ink in the coronal, middle, and apical third of the canals. The mean cleaning efficacy of *KedoSsquare* files was better than Manual K files (Table 1). The data were qualitative, expressed as a percentage, and a non-parametric test was used for further analysis. In the coronal third, 20 out of 28 canals instrumented with *KedoSsquare*files resulted in complete clearing of ink, whereas with manual files, only 8 out of 28 canals showed complete clearing of ink (Table 2), and the difference was statistically significant. In the Middle third, 3 out of 28 canals instrumented with *Kedo S Square* files showed complete clearing of ink, and only 1 out of 28 canals that were instrumented with manual *K* files showed complete clearing of ink (Table2)(Figures a and b) and the difference was also found to be statistically significant. In the apical third, 13 out of 28 canals instrumented with *Kedo S*[2]files exhibited complete ink clearing. In comparison, only 5 out of 28 canals instrumented with manual *K* files showed complete clearing of ink (Table 2), and the difference was also statistically significant. *Kedo S Square* files demonstrated complete clearing in almost half of the samples in each of the sections of the root canal, more so in the coronal third (71.42%). In addition, no sections of the canals instrumented with *Kedo S Square files* were assessed and scored 3 (Appreciable amount of ink present)

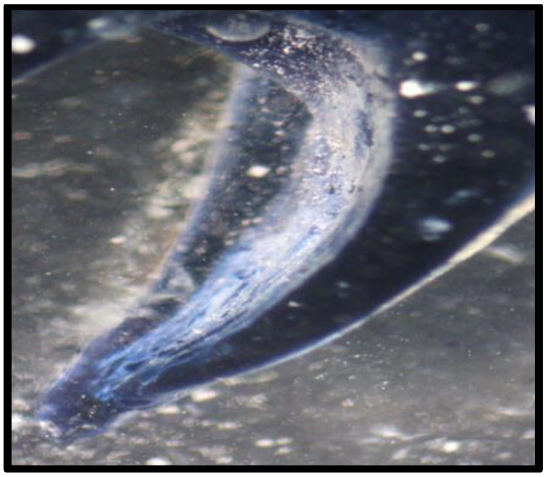


Fig a- Canal Instrumented with Kedo S^2 showing Complete ink removal Score '0'

illustrates completely clean canals in the coronal third of the canal showing the total clearing

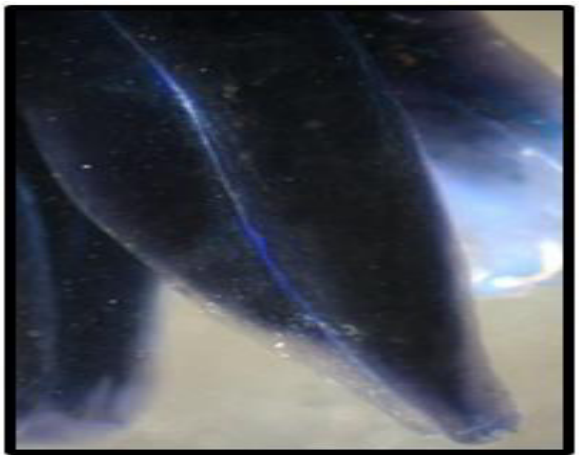


Fig b - Canal Instrumented with Manual K file showing Partial ink removal Score '2'

Illustrates remnants of ink found on some walls in some areas showing partial ink removal

Table 1- Mean Cleaning Efficacy scores for each group at each third of the canal			
Groups	**Coronal third**	**Middle third**	**Apical third**
***Kedo S Square* rotary files**	0.3214	0.6071	0.6071
Manual *K* files	1.2857	1.5	1.4642

Table 1 illustrates the mean cleaning efficacy scores in the coronal, middle, and apical third of canals instrumented with *Kedo S Square* rotary and Manual K files, respectively.

Table 2-Comparison of Cleaning Efficacy of Kedo*S Square* file& manual *K* file in coronal, middle and apical thirds of canals

		0 Total clearing n (%)	1 Almost complete ink removal n (%)	2 Partial ink removal n (%)	3 No ink removal n (%)	Chi-square	df	p-value
Coronal Third	**Rotary** N=28	20(71.4%)	7(25.0%)	1 (3.6%)	0	17.12	3	0.001*
	Manual N=28	8 (28.6%)	8 (28.6%)	8 (28.6%)	4 (14.3%)			
Middle Third	**Rotary** N=28	13 (46.4%)	13 (46.4%)	2 (7.1%)	0	21.87	3	0.000*
	Manual N=28	1 (3.6%)	14 (50.0%)	11 (39.3%)	2 (7.1%)			
Apical Third	**Rotary** N=28	13 (46.4%)	13 (46.4%)	2 (7.1%)	0	15.78	3	0.001*
	Manual N=28	5 (17.9%)	9 (32.1%)	10 (35.7%)	4 (14.3%)			

**** - Denotes statistical significance p<0.05***

Table 2 compares the cleaning efficacy scores in the coronal, middle, and apical third canals instrumented with *Kedo S Square* rotary and Manual K files, respectively.

3. DISCUSSION

Instrumentation of primary teeth root canals is usually done either with manual or rotary instruments[18]. The use of manual instrumentation is time-consuming and leads to iatrogenic errors such as ledging, zipping, canal transportation, and instrument breakage. Similarly, using adult rotary instruments leads to over-instrumentation of the relatively thin primary root canals, and the longer length of adult rotary files makes it difficult to use in children[4]. *The keto-S* file system is an exclusive pediatric rotary file system with modified - length, taper, and tip diameter, which prevents the instrumentation of the thin primary root canals. The *Kedo S Square* file system (IV generation) is the latest exclusive single file system, and it is important to know if these files are ideal concerning cleaning efficacy. Since it is a new file system and few studies have been done, this study was conducted to compare the Cleaning efficacy of *Kedo S Square* files with Manual *K* files in root canals of primary molars using an ink clearing technique under Stereomicroscope. In the present study, extracted primary molars (multirooted) were used as their complex canal morphology makes the Cleaning and shaping procedure highly challenging and significant for proper obturation determining the success of pulpectomy compared to primary anterior (single-rooted)[1]. Various methods for determining the cleaning efficiency of instrumentation are 'Canal staining and clearing technique,' Volumetric analysis using Computed tomography, Spiral Computed Tomography, Splitting the tooth longitudinally for microscopic evaluation, etc. Among these, the Canal Staining-Clearing Method is considered less invasive and cost-effective, allowing visualization of root canals in a three-dimensional view. Using Stereomicroscope makes it more sensitive, accurate, and consistent[16]. Hence, the clearing technique and Stereomicroscope were utilized in this study to examine the traces of ink in the canals, thereby determining the cleaning efficacy of the files. In our study, *Kedo S Square files* have better clinical efficacy than manual *K* files in all thirds of the canals. Stereomicroscopic evaluation of *Kedo S Square* files at the coronal third of the canals revealed better cleaning efficacy (p= 0.001), with 71.4% of canals showing complete ink removal compared to Manual *K* Files, which showed only 28.6% of canals with complete ink removal. It Can be attributed to the variable taper of *Kedo S Square* files which engages more dentin during instrumentation. Similar results are supported by a study conducted by Lakshmi et al. 13. In the middle third of the canals, *Kedo S Square* files had significant cleaning efficacy (p <0.001) with 46.4% canals showing the total clearing of ink compared to Manual *K* Files (3.6%). In the apical third of the canals, *Kedo S Square* files had significantly better cleaning efficacy (p=0.001), with 46.4% of canals showing complete ink removal compared to Manual *K* Files, where only 17.9% of canals showed complete ink removal. SampannaKalita et al. [19] reported that *KedoS* rotary file (First generation) had significantly better cleaning efficacy (p= 0.0001) in the coronal, middle, and middle apical third when rotary *Protaper*files were compared to Manual *K* files. Similarly, Hend A Alfadhli et al. [20] reported that Kedo SG (Second Generation) had significantly higher cleaning capacity than Manual K files (p= 0.013). On comparing two pediatric rotary files, NileshRathi et al. [16] reported that *Pro AF Baby Gold* files had better cleaning efficacy than the *Kedo S* rotary file (First generation) at all thirds of the canal. Still, the difference was significant only in the apical third of the canal. However, the files used in the mentioned studies are multi-file systems. In our study, *Kedo S Square* files are single file systems with the added advantage of variable - cross-section, taper, and diameter.This study showed that *Kedo S Square* files have significantly better cleaning efficacy compared to Manual *K* files at all thirds of the canal. It can be attributed to its taper and cross-section [13], i.e., 3-point contact in the apical 5 mm of the file with a triangle-shaped cross-section and 2-point contact in the coronal 7 mm of the file with a teardrop-shaped cross-section. The variable taper of rotary file improves cleaning efficacy[21], increases flexibility[22], and resistance to cyclic fatigue[23,24]. A variable cross-section of the rotary file increases cutting efficiency and fracture resistance of the files during constant taper, and constant cross section cause excessive screwing within the canal, thereby increasing the incidence of fracture [23,25]. In this study, the files had no deformation or incidence of fracture. *Kedo S Square files* demonstrated better obturation in shorter instrumentation time and reduced postoperative pain compared to hand files[13].In an in-vitro study, the results may not reflect their clinical efficacy. Therefore, other factors that contribute to the efficiency of *Kedo S Square files,* such as shaping & centering ability, acceptance by the patient concerning time & post-operative pain, and the Operators competence, could be studied in the future.

4. CONCLUSION

We conclude that the Pediatric rotary *Kedo S Square* files were more effective than Manual *K* Files regarding cleaning efficacy. Therefore, it could be a promising tool in Pediatric Endodontics. Nevertheless, Clinical studies are required to confirm these results and to evaluate patient acceptance, efficiency, and treatment outcome. Therefore, a randomized clinical trial is in progress using these pediatric *Kedo S Square files*, which will be shared soon.

5. AUTHORS CONTRIBUTION STATEMENT

Dr. G.S. Prathima conceived of the presented idea. Dr. A.P.Pragadeesh developed and performed the study. Dr. G.S. Prathima and Dr. S.Nandakumar verified the analytical methods. All authors discussed the results and contributed to the final manuscript.

6. CONFLICT OF INTEREST

Conflict of interest declared none.

7. REFERENCES

1. Hiremath MC, Srivastava P. Comparative evaluation of endodontic pressure syringe, insulin syringe, jiffy tube, and local anesthetic syringe in obturation of primary teeth: an in vitro study. J Nat Sci Biol Med. 2016;7(2):130-5. doi: 10.4103/0976-9668.184698, PMID 27433062.
2. Hargreaves KM, Berman LH. Cohen's pathways of the pulp. 11th ed. St. Louis: Mosby; 2015.

3. Nagarathna C, Vishwanathan S, Krishnamurthy NH, Bhat PK. Primary molar pulpectomy using two different obturation techniques: A clinical study. Contemp Clin Dent. 2018 Jun;9(2):231-6. doi: 10.4103/ccd.ccd_826_17, PMID 29875566.
4. George S, Anandaraj S, Issac JS, John SA, Harris A. Rotary endodontics in primary teeth – a review. Saudi Dent J. 2016 Jan;28(1):12-7. doi: 10.1016/j.sdentj.2015.08.004, PMID 26792964.
5. Katge F, Ghadge S, Poojari M, Jain K, Patil D. Comparative Evaluation of Cleaning Efficacy of Prime PedoTM and DXL-ProTM Pedo Rotary Files with Conventional H Files in Root Canals of Primary Teeth: an In Vitro Study. JCDR. 2019. doi: 10.7860/JCDR/2019/41425.12983.
6. Barr ES, Kleier DDJ. Use of nickel-titanium rotary files for root canal preparation in primary teeth. Vol. 2.
7. Al Rwaily AKJ. Rotary systems versus manual K-file system in primary molar root canals -In vitro study. IPDOAJ. 2018 Oct;2(2). doi: 10.32474/IPDOAJ.2018.02.000132.
8. Azar MR, Mokhtar M. Rotary Mtwo system versus manual K-file instruments: efficacy in preparing primary and permanent molar root canals. Indian J Dent Res. 2011;22(2):363. doi: 10.4103/0970-9290.84283, PMID 21891918.
9. Bahrololoomi Z, Tabrizizadeh M, Salmani L. In vitro comparison of instrumentation time and cleaning capacity between rotary and manual preparation techniques in primary anterior teeth. J Dent;4(2):4.
10. Ramezanali F, Afkhami F, Soleimani A, Kharrazifard MJ, Rafiee F. Comparison of Cleaning Efficacy and Instrumentation Time in Primary Molars: Mtwo Rotary Instruments vs. Hand K-Files. Iran Endod J. 2015;10(4):240-3. doi: 10.7508/iej.2015.04.006, PMID 26523138.
11. 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. J Oral Biol Craniofac Res. 2019 Apr;9(2):151-5. doi: 10.1016/j.jobcr.2019.03.003, PMID 30963021.
12. Jeevanandan G, Govindaraju L. Clinical comparison of Kedo-S pediatric rotary files vs. manual instrumentation for root canal preparation in primary molars: a double-blinded randomized clinical trial. Eur Arch Paediatr Dent. 2018 Aug;19(4):273-8. doi: 10.1007/s40368-018-0356-6, PMID 30003514.
13. Lakshmanan L, Jeevanandan G. Evaluation of quality of obturation and instrumentation time using Kedo-S Square File, H File, And K File In Primary Molars–A Randomized Controlled Trial. Int J Pharm Res;2020(1).
14. Lakshmanan L. Comparison of postoperative pain after pulpectomy using Kedo-S square File, hand H File, and K File - A randomized controlled trial. IJDOS. 2021:2272-6. doi: 10.19070/2377-8075-21000449.
15. Lakshmanan L, Jeevanandan G, Maganur PC, Vishwanathaiah S. Fracture Incidence of Kedo-S Square Pediatric Rotary Files: a Prospective Clinical Study. Eur J Dent. 2022;16(3):594-8. doi: 10.1055/s-0041-1735935. PMID 34863082.
16. Rathi N, Jain SA, Thosar N, Baliga S, Ahmed F, Mehta J. Comparative evaluation of cleaning efficiency and apical extrusion of debris using two pediatric rotary endodontic files: an in vitro study. Int J Clin Pediatr Dent. 2021;14(2):196-200. doi: 10.5005/jp-journals-10005-1918, PMID 34413591.
17. Silva LA, Leonardo MR, Nelson-Filho P, Tanomaru JM. Comparison of rotary and manual instrumentation techniques on cleaning capacity and instrumentation time in deciduous molars. J Dent Child (Chic). 2004;71(1):45-7. PMID 15272656.
18. Shah HS, Patil VM, Kamath AP, Mathur AA. Comparative evaluation of instrumentation time, obturation time, and radiographic quality of obturation using two rotary systems and manual technique for primary molar pulpectomies – in vivo study. Contemp Clin Dent. 2021;12(1):55-62. doi: 10.4103/ccd.ccd_83_20, PMID 33967539.
19. Kalita S, Agarwal N, Jabin Z, Anand A. Comparative evaluation of cleaning capacity and efficiency of Kedo-S pediatric rotary files, rotary ProTaper, and hand K Files in primary molar pulpectomy. Int J Clin Pediatr Dent. 2021 Sep 29;14(3):383-7. doi: 10.5005/jp-journals-10005-1958, PMID 34720511.
20. Alfadhli H, Fawzy M, Hassan M. A comparative in vitro study of rotary versus manual instruments for canal preparation of primary molars. ADJ-for Girls. 2021 Jul 1;8(3):501-6. doi: 10.21608/adjg.2021.30764.1264.
21. Buchanan LS. The standardized-taper root canal preparation–Part 1. Concepts for variably tapered shaping instruments. Int Endod J. 2000 Nov;33(6):516-29. doi: 10.1046/j.1365-2591.2000.00384.x, PMID 11307255.
22. Bergmans L, Van Cleynenbreugel J, Beullens M, Wevers M, Van Meerbeek B, Lambrechts P. Progressive versus constant tapered shaft design using NiTi rotary instruments. Int Endod J. 2003 Apr;36(4):288-95. doi: 10.1046/j.1365-2591.2003.00650.x, PMID 12702124.
23. Campbell F, Cunliffe J, Darcey J. Current technology in endodontic instrumentation: advances in metallurgy and manufacture. Br Dent J. 2021 Jul;231(1):49-57. doi: 10.1038/s41415-021-3170-1, PMID 34244648.
24. Koch K, Brave D. Real world endo: design features of rotary files and how they affect clinical performance. Oral Health. 2002;92(2):39-49.
25. Khasnis SA, Kar PP, Kamal A, Patil JD. Rotary science and its impact on instrument separation: A focused review. J Conserv Dent. 2018;21(2):116-24. doi: 10.4103/JCD.JCD_240_17, PMID 29674810.