

Clinical effectiveness of pediatric rotary instrumentation systems in pulpectomy of primary teeth: A systematic review

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Highlights

Pediatric rotary instrumentation may reduce chairside time and improve clinical efficiency during pulpectomy of primary teeth.

Rotary systems generally demonstrated favorable outcomes regarding postoperative pain, instrumentation time, and obturation quality.

Further well-designed multicenter studies are needed to establish evidence-based recommendations for pediatric rotary instrumentation.

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Abstract

The aim of this systematic review was to compare the efficiency of pediatric rotary systems used in the pulpectomy of primary teeth. The research protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO). An electronic search was conducted across four databases: PubMed via MEDLINE, the Cochrane Central Register of Controlled Trials, ScienceDirect, and the Wiley Online Library using search equations formulated through combinations of keywords and Boolean operators. Reference management was performed using Zotero. Of the 128 records initially identified, 30 studies met the inclusion criteria. An additional 21 studies were included through manual searching of the reference lists of the selected articles. Consequently, a total of 51 studies were included in the present systematic review. The quality assessment was performed using the RoB 2 tool, and the overall risk of bias was judged to be low. The latest generations of the Kedo-S pediatric rotary systems, namely Kedo-S Plus, Kedo-S Square, and Kedo-SG Blue, were the most frequently investigated systems and generally demonstrated favorable outcomes, including reduced postoperative pain and bacterial load, shorter chairside time, improved obturation quality, and higher clinical success rates. WaveOne Gold and XP-Endo Shaper systems also showed promising efficiency; however, evidence regarding their performance remains limited. Comparisons of rotary techniques suggested that reciprocating motion may be associated with reduced chairside time and enhanced obturation quality. Nevertheless, heterogeneity among studies, inconsistent evaluation methods, and the predominance of studies conducted in India may limit the generalizability of the findings. In addition, important in vitro pulpectomy parameters, such as canal trajectory preservation and debris extrusion, were not assessed. Therefore, further well-designed multicenter clinical and in vitro studies comparing multiple pediatric rotary systems are required to establish definitive clinical recommendations.

Keywords: Dental Pulp Cavity; Endodontics; Obturation; Pain, Postoperative; Pulpectomy; Root Canal Preparation; Tooth, Deciduous

INTRODUCTION

Premature loss of primary teeth is the most critical issue in pediatric dentistry practice since it results in various troubles damaging both aesthetics and oral functions of the child.¹ Pulpectomy is a pulp therapy aiming to retain primary teeth with irreversibly pulp involvement until their physiological exfoliation. Compared to extraction, pulpectomy offers multiple advantages since it preserves arch space and its integrity, saves speech and chewing abilities, guarantees a normal eruption of succedaneous permanent teeth and maintains the aesthetic appearance of the child ensuring his normal psychological development. In the other hand, it prevents crowding and tongue deforming habits. Also, this therapeutic procedure eliminates the inflammation or the infection of the affected pulp and prevents its further spread which retains the primary teeth in a healthy condition.²⁻³

The success of such a procedure ultimately depends on the quality of the chemo mechanical preparation of the canals.⁴ In fact, root canal instrumentation aims to clean and shape the canal system by removing the infected content of the pulp chamber without damaging the integrity of the root canal. Furthermore, this mechanical preparation must facilitate the propagation of the irrigation solution until the apical third of the root ensuring a total disinfection of the root canal system and guide its tridimensional filling by creating a continuous tapered preparation.³ In fact, two factors should be considered so as to guarantee a perfect root canal preparation: the instrument used and the technique employed. Considering the technique, multiple ones were suggested including the coronapical and the apicocoronal techniques.³ Regarding the instrument used, Stainless steel instruments have been conventionally used. Hand instrumentation is associated with multiple prejudices such as uneven preparation, iatrogenic lateral perforation, ledge formation, zipping, canal transportation, instrument fracture and apical

blockage.⁵⁻⁶⁻⁷ In addition, being a time-consuming procedure, it lengthens the dental appointment and may affect his behavior.⁴⁻¹ Thus, since the duration of dental appointment has a huge impact on the child's behavior, rotary instrumentation made a substantial rise in the realm of pediatric dentistry.

Rotary file systems were invented in order to overcome the disadvantages of the conventional approach. Ni-Ti rotary files were first described in primary teeth by Barr et al. in 2000 and ever since, the use of rotary instrumentation has been developed in pediatric endodontics.⁴ Barr et al. admitted that the use of rotary instrumentation in deciduous teeth pulpectomy reduces the overall time needed for root canal preparation and obturation, facilitates the root canal access, and guarantees more predictable and consistently dense fills.⁸ Also, in comparison to manual files, rotary file systems guarantee the preservation of the anatomical form of primary teeth, prevent procedural errors such as instrument fracture and allow an easier dental practice with less practitioner fatigue.³⁻⁷ These benefits of rotary instrumentation go back to the greater flexibility and shape memory of Ni-Ti of which rotary file systems are made.⁹

Various rotary systems have been invented over the years. At the beginning, NiTi files used for root canal treatment of permanent teeth were integrated with a modified sequence to be used in deciduous teeth; This includes Protaper, M2, and K3. In one hand, ProTaper Next was introduced in 2000 and made of MWire NiTi and had a distinctive design allowing to enhance the flexibility and cyclic fatigue resistance.⁷ In the other hand, Mtwo rotary system consists in 4 instruments with inactive tips and is characterized with a more shaping ability, more cleaning efficiency in curved root canals, and highest cyclic fatigue resistance in apical abrupt curvatures, when compared with other rotary systems.¹⁰⁻¹¹ Moreover, K3 NiTi rotary file system was designed by Dr. John McSpadden in 2002 and it consists in 5 files with different sizes,

used from the largest to the smallest.¹² However, the increasing length and taper of these files limited their use in pedodontics and launched the need of a unique rotary file with an adjusted length and taper.¹³ From here, the Kedo rotary file was first introduced in 2017 by Jeevanandan G who recommended this exclusive rotary file system as an effective time gaining method to debride uneven walls of primary root canals and to guarantee a predictable and uniform root canal fill.⁶ These individualised files are characterized with a variably variable taper (VV) ensuring both flexibility and efficiency. Kedo-S, Kedo-SG and Kedo-SH was launched as a result of the continuous progression of the Kedo pediatric rotary file. Kedo-SG blue rotary file consists of D1, E1, and U1 files, while Kedo-SH hand file consists of P1, P2, and P3 stainless steel files and D1, E1, and U1 nickel–titanium files.³ Whilst, a single file system called Kedo-S Square was the latest version of it. Kedo-S Square is composed of two files : A1 is used in the anterior canals, whereas P1 is used for posterior canals.⁴ The above mentioned systems are used with a continuous motion. In contrast, other rotary file systems were manufactured to be used with a reciprocating motion : The NiTi reciprocating systems including WaveOne and Reciproc, which have been adopted by Dr. Yared.¹⁴ WaveOne is a one file reciprocating system that has been introduced by Dentsply Maillefer in 2011.¹⁴ In fact, it consists of a single file of three sizes : small (for fine canals), primary (for the majority of canals), and large (for large canals).¹⁵ From the other side, Reciproc is a single-file NiTi system consisting of three files, including the R25, R40, and R50.¹⁴

This systematic review aimed to compare the clinical effectiveness of the different commercially available rotary file systems and to deduce the one or ones that ensure(s) the highest efficiency. This comparison included all the clinical parameters of the pulpectomy procedure and made the manual approach as a reference.

METHODS

This systematic review followed the PRISMA guidelines. The research question was formulated based on the PICO system (Population : children ; Intervention : pulpectomy of primary teeth ; Comparison : success of the pulpectomy ; Outcome : the most effective rotary system) and it was the following : Which rotary system(s) should we choose when performing pulpectomy of primary teeth in children ?

The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) under the following record : CRD42024621231 and the electronic research was carried out through four databases (Pubmed, Cochrane library, ScienceDirect, and Wiley Online library) using different equations which were formulated by the combination of keywords (rotary system, primary teeth, instrumentation, root canal preparation, postoperative pain, root canal treatment, pulpectomy, obturation) and the boolean operators (AND, OR, NOT).

The electronic search was conducted between November and December 2024 and led to the obtaining of 328 references and the management of references was performed using Zotero. After duplicate removal 268 references remained. The title screening of the remaining references against the eligibility criteria resulted in the remain of 103 references which were screened by their abstracts. Thirty articles made it up until to last step. The examination of the references lists of the included articles of step 2 resulted in the addition of 42 articles. Thus, 72 references were subjected to the full-text reading and 21 of them were excluded. A complementary search through Google Scholar was conducted and added no relevant reference. Accordingly, this systematic review was made of 51 articles (Figure 1). Owing to clinical and statistical heterogeneity of the included studies, meta-analysis wasn't feasible.

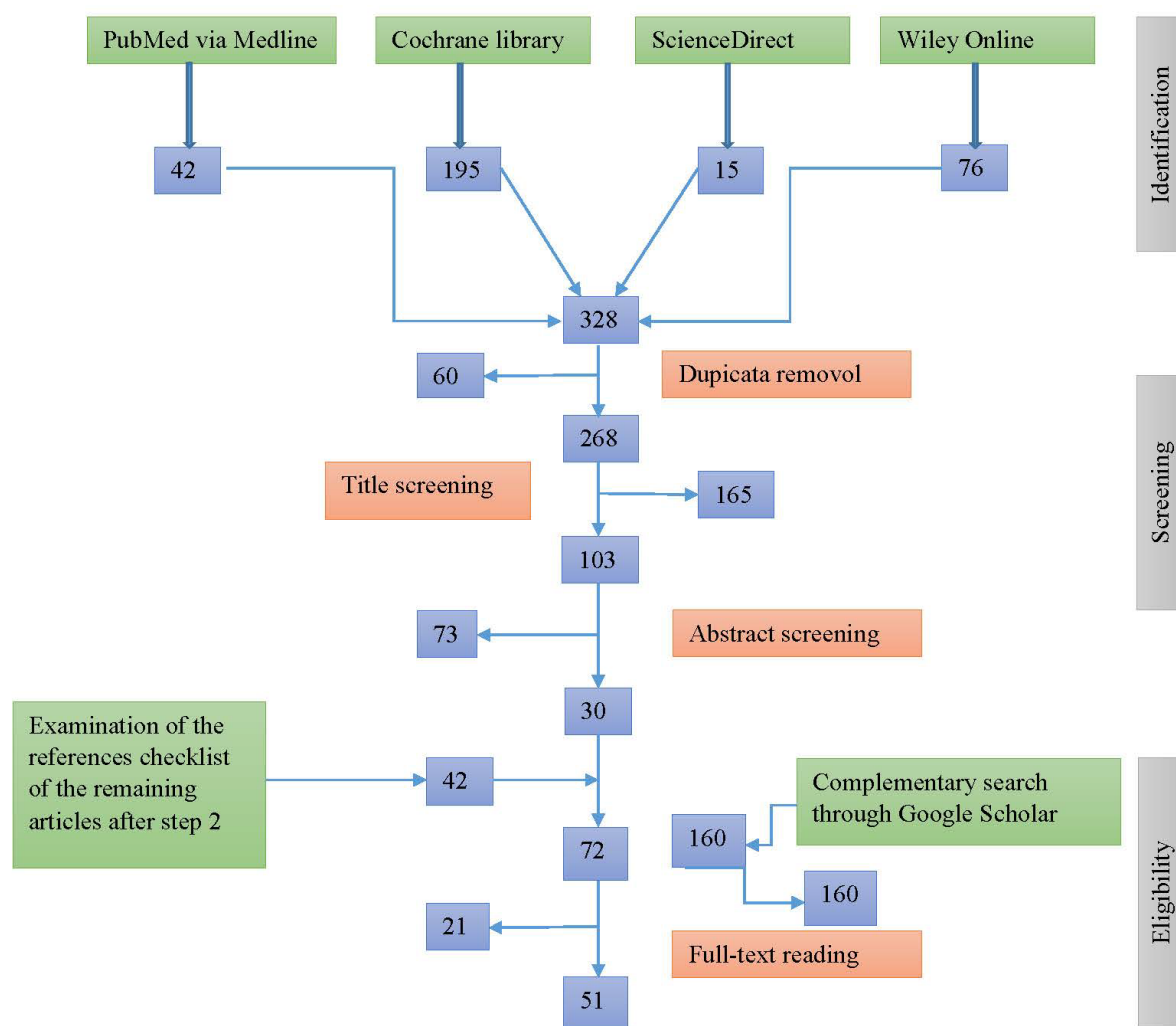


Figure 1. Search strategy chart flow

The eligibility criteria applied for this systematic review are the following :

Inclusion Criteria

- Randomized controlled trials (RCT) and clinical studies ;
- Articles published between 2014 and 2024 ;
- Articles written in English ;
- Studies performed on Human children ;
- studies performed on primary teeth ;
- Studies focusing on the efficiency of rotary systems in root canal treatment of primary teeth.

Non-Inclusion Criteria

- Systematic reviews and meta analysis, cohort studies, in vitro studies, case reports, posters and

communications sessions, books and book chapters, abstracts ;

- Studies performed on Human adults or animals ;
- Studies performed on permanent teeth ;
- Articles written in language other than English ;
- Articles published before 2014 ;
- Studies not assessing the efficiency of rotary systems in root canal treatment of primary teeth.

Cohort studies weren't included in this systematic review since the comparative evaluation of rotary pediatric systems focused on clinical parameters that essentially require immediate assessment.

RESULTS

Fifty one articles were included in the present systematic review. Based on the country where the study was performed, 36 studies were carried out in India, 4 in Egypt, 4 in Brazil, 2 in Iran, 1 in Mexico, 1 in Saudi Arabia, 1 in Syria, 1 in Turkey, and 1 in Thailand.

Regarding the year of publication, 3 studies were published in 2014, 1 in 2015, 4 in 2017, 4 in 2018, 5 in 2019, 9 in 2020, 9 in 2021, 5 in 2022, 9 in 2023 and 2 in 2024. Thus 67% of the included studies were published in the past 5 years.

Considering the type of study performed, 8 out of 51 were clinical studies while 43 were randomised controlled trials. The following primary teeth pulpectomy related factors were evaluated by the included studies : post-operative pain, mean microbial load, instrumentation and obturation times, complications during instrumentation, quality of obturation, success rate, patient's behavior, and operator's perspective.

Each included study assessed one or more of the up mentioned criteria and compared either between the manual and rotary instrumentation or between rotary file systems. The present systematic review assessed each factor apart and aimed to nominate the rotary system which demonstrates the highest efficiency considering the different evaluated criteria.

Postoperative Pain (P.O.P)

Seventeen studies assessed this factor (Table 1).

Cleaning Efficacy (C.E)

Four studies out 51 focused on this factor (Table 2).

Instrumentation Time (I.T)

Thirty five studies focused on this criteria and evocated a number of rotary file systems (Table 3).

Obturation Time (O.T)

Only 10 studies were interested in this criteria (Table 4).

Obturation Quality (O.Q)

This factor was also assessed by 35 studies (Table 5).

Complications during Instrumentation (C.I)

Only one study evaluated this parameter (Table 6).

Success Rate (S.R)

This parameter was assessed by 8 studies out of 51 (Table 7).

Child's Behavior (C.B)

Three studies highlighted this clinical factor (Table 8).

Operator's perspective (O.P)

Only one study focused on this criteria (Table 9).

Tables 10–12 show comparative summaries of manual, rotary, continuous, and reciprocating instrumentation systems according to different evaluated clinical and procedural parameters.

Risk of Bias Assessment

Cochrane risk-of-bias tool for randomized trials (RoB 2) was used for the quality assessment of the included studies (Table 13).

Table 1. Postoperative pain assessment by the included studies

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Alnassar I et al.	-Hand files ; -ProTaper Next rotary system ; -WaveOne rotary system.	- Hand instrumentation demonstrated a significantly higher postoperative pain compared to rotary instrumentation at 6, 12 and 24 H postoperatively ; - No postoperative pain difference between ProTaper Next and WaveOne rotary systems	-Difference between manual and rotary instrumentation : Significant ; -Difference between the two rotary systems : Not significant.	ProTaper Next rotary system & WaveOne rotary system
EL-Desouky SS et al.	-Hand files ; - Kedo-S Square rotary system ; - Fanta AF Baby rotary system.	- The use of hand files was associated with a significantly higher postoperative pain as compared to kedo-S Square rotary system and Fanta AF Baby rotary system.	- Difference between manual and rotary instrumentation : Significant.	Kedo-S Square rotary system & Fanta AF Baby rotary system
Govindaraju L et al. (2018)	-Hand K-files ; - Kedo-S rotary system ; - ProTaper rotary file system.	-The use of Kedo-S rotary file the pain perception was statistically lower when compared to ProTaper rotary file system and hand K-files.	-Difference between manual and rotary instrumentation : Significant ; -Difference between the two rotary systems : Significant.	Kedo-S rotary system
Moudgalya MS et al.	-Hand files ; -Kedo-S files ; -K-Flex rotary files.	-Kedo-S files and K-Flex rotary files showed a significantly less postoperative pain compard to hand files while the difference between Kedo-S system and K-Flex system in reducing post-operative pain wasn't significant.	-Difference between manual and rotary instrumentation : Significant ; -Difference between the two rotary systems : Not significant.	Kedo-S system & K-Flex system
Topçuoğlu G et al.	-Hand K files ; - Revo-S rotary file system.	-Pulpectomy with hand K files resulted in significantly higher pain intensity when compared to pulpectomy done by Revo-S rotary file system, at 6,12, 24 and 48 H postoperatively. This difference wasn't significant at 72 H and one week post-treatment.	- Difference between manual and rotary instrumentation : Significant.	Revo-S rotary file system

Table 1. Postoperative pain assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Panchal V et al (2019)	-Hand K files ; -Hand H files ; - Kedo-S rotary system.	- Instrumentation with Kedo-S rotary system was associated with significantly less post-operative pain at 6 and 12 h post-operatively, in comparison to hand K and H files ; -At 6 h, instrumentation with K- file showed significantly less post-operative pain as compared to H-file which was not significant at 12 H ; -At 24, 48 and 72 h interval there was no significant difference in the post-operative pain between Kedo-S rotary system, hand K-files and hand H-file	- Difference between manual and rotary instrumentation : Significant.	Kedo-S rotary system
Nair M et al.	- Hand k-files ; -Kedo S rotary files ; - Mtwo rotary files.	-Rotary instrumentation using Kedo S files and Mtwo files caused, at 6 H postoperatively, significantly less post-operative pain when compared to hand k-files instrumentation. This difference wasn't significant at 12, 24 and 72H postoperatively. Precisely, The least post-operative pain was recorded with Mtwo files followed by Kedo-S files followed by hand k files	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Not significant.	Mtwo rotary files ++ Kedo S rotary files +
Jeevanandan G et al. (2020)	- Manual NiTi-K flex files - Kedo-S rotary system ; - Reciprocating NiTi-K flex files	-At 6 and 12 h post-operatively, Kedo-S rotary system showed significantly the least post-operative pain followed by manual NiTi-K flex files followed by reciprocating NiTi-K flex files which demonstrated significantly the highest post-operative pain.	- Difference between manual and rotary instrumentation : Significant.	Kedo-S rotary system
Jeevanandan G et al. (2021)	-Hand K-files ; - Kedo-SH hand files -Kedo-SG Blue rotary system.	- Kedo-SG Blue rotary system showed a significantly less post-operative pain followed by hand K-files and Kedo-SH hand files.	- Difference between manual and rotary instrumentation : Significant.	Kedo-SG Blue rotary system

Table 1. Postoperative pain assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Tyagi R et al.	- Hand NiTi-K flex files ; - Pro AF Baby Gold rotary system ; - WaveOne reciprocating system.	-At 6H, hand NiTi-K flex files showed significantly the highest mean post-operative pain followed by Pro AF Baby Gold rotary system followed by WaveOne reciprocating system which demonstrated the least post-operative pain. This difference wasn't significant at 24, 72 H and one week postoperatively. -The difference between Pro AF Baby Gold and WaveOne reciprocating rotary system wasn't significant at 6, 24, 72 H and one week postoperatively	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Not significant.	WaveOne reciprocating system
Lakshmanan L et al.	-Hand K-files ; -Kedo-S rotary system ; - Kedo-S Square rotary system.	-At 6 H postoperatively, hand K-files showed significantly the highest post-operative pain followed by Kedo-S rotary system, followed by Kedo-S Square rotary system which showed the least intensity of postoperative pain. However, this difference wasn't significant at 12 and 24 H post treatment.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Not significant.	Kedo-S rotary system+ Kedo-S Square rotary system++
Divya S et al.	-Hand K-files ; -Kedo-S rotary system ; -K3 rotary file systems	-No significant difference between hand K-files, Kedo-S and K3 rotary file systems at 6, 12, 24 and 48 H postoperatively -No pain was perceived at 72 H regardless the instrumentation technique.	- Difference between manual and rotary instrumentation : Not significant ; - Difference between the two rotary systems : Not significant.	—
Marques RPS et al.	-Hand K files ; - WaveOne Gold reciprocating system.	-No differences in relation to discomfort and late postoperative pain between the manual instrumentation (hand k files) and the reciprocating rotary instrumentation (WaveOne Gold reciprocating system).	- Difference between manual and rotary instrumentation : Not significant.	—

Table 1. Postoperative pain assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Elheeny AAH et al. (2023)	- Hyflex EDM : continuous rotation motion ; - Reciproc R25 : reciprocating rotation motion.	-No statistically significant difference regarding both, postoperative pain incidence and intensity and postoperative analgesics intake between the continuous (Hyflex EDM) and reciprocating (Reciproc R25) rotation motions	- Difference between the two rotary systems (continuous vs reciprocating roation motion) : Not significant.	—
Elheeny AAH et al. (2022)	- OneShape rotary system ; - WaveOne Gold reciprocating system.	- No significant difference in the pain experience between OneShape rotary system and WaveOne Gold reciprocating system.	- Difference between the two rotary systems (continuous vs reciprocating roation motion) : Not significant.	—
Thakur B et al.	- Manual k-files ; XP-endo Shaper rotary system ; - Kedo-SG Blue rotary system.	- XP-endo Shaper rotary system was associated with significantly less postoperative pain compared to rotary pediatric Kedo-SG Blue and manual k-files at 6 and 12 H. Also, XP-endo Shaper rotary system showed no pain after 6 H post-operative and and was associated with the least percentage of patients who needed analgesics.	-Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	XP-endo Shaper rotary system
Barasuol JC et al.	- Hand K-files ; - ProDesign Logic rotary file system.	- No association was found between the type of instrumentation and post-operative pain, or analgesic medication intake after the endodontic treatment.	Difference between manual and rotary instrumentation : Not significant.	—

Table 2. Cleaning efficacy assessment by the included studies

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Jeevanandan G et al.	- Hand K files ; - Kedo S Plus ; - Kedo S Square NiTi rotary files.	-Significant reduction of the microbial amount with the use of Kedo S Plus, Kedo S Square NiTi rotary files and hand K files. Though, Kedo S plus rotary system had the best potential of bacterial reduction.	-Difference between manual and rotary instrumentation : Not significant ; -Difference between the two rotary systems : Not significant.	Kedo S plus
Subramanyam D et al.	- Kedo S rotary files ; - Hand K files	- Greater reduction of bacterial load with Kedo S rotary files in comparison to hand K files. However, the difference wasn't statistically significant.	Difference between manual and rotary instrumentation : Not significant.	Kedo S rotary files
Lakshmanan L et al. (2022)	- Hand H files ; -Hand K files ; -Kedo-S Square rotary files.	-Although the difference wasn't statistically significant, the Kedo-S Square rotary files demonstrated a better reduction of the bacterial count when compared to hand H files and hand K files.	Difference between manual and rotary instrumentation : Not significant.	Kedo-S Square rotary files
Moudgalya MS et al.	- Hand files ; - Rotary K-Flex files ; - Kedo-S files.	- Kedo-S files and rotary K-Flex files showed a significantly better efficiency in reducing bacterial load compared to hand files. Moreover, the authors found Kedo-S rotary file system was significantly more efficient compared to K-Flex rotary system.	-Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Kedo-S rotary file system

Table 3. Instrumentation time assessment by the included studies

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Morankar R et al.	- Hand K files ; - Hyflex CM NiTi rotary files.	-Pulpectomy with hand K files resulted in a significantly higher instrumentation time than Hyflex CM NiTi rotary files.	Difference between manual and rotary instrumentation : Significant.	Hyflex CM NiTi rotary system
Amorim AC et al.	- Hand K files ; - Hyflex EDM rotary files.	- Significantly longer instrumentation time with the manual instrumenration using hand K files compared to the rotary one using Hyflex EDM rotary files.	Difference between manual and rotary instrumentation : Significant.	Hyflex EDM rotary system
Kaushik M et al.	- Manual H files ; - Hyflex CM rotary system ; - Flexicon X7 rotary system.	- Instrumentation time of primary molars with Flexicon X7 rotary system was significantly less as compared to the Hyflex CM rotary system and manual H files.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Flexicon X7 rotary system
Dinesh Kumar et al.	- Hand k files ; - Kedo-S Square rotary files.	- Significantly less instrumentation time with the pediatric rotary Kedo-S Square files compared to the hand k files.	Difference between manual and rotary instrumentation : Significant.	Kedo-S Square rotary system
EL-Desouky SS et al.	- Manual k files - Fanta AF Baby rotary system ; - Kedo S-Square rotary system	- Kedo S-Square rotary system demonstrated a significantly lower instrumentation time followed by Fanta AF Baby rotary system and manual k files.	-Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Kedo S-Square rotary system
Durairaj BA et al.	- Manual k files ; - Kedo-S Square rotary files.	- Significantly less instrumentation time with Kedo-S Square files as compared to manual k files.	Difference between manual and rotary instrumentation : Significant.	Kedo-S Square rotary system

Table 3. Instrumentation time assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Jeevanandan G et al.	- Hand k files ; - Hand H files ; - Kedo-S Square rotary system.	- Kedo-S Square rotary system was associated with significantly the least instrumentation time followed by hand k files followed by hand H files.	Difference between manual and rotary instrumentation : Significant.	Kedo-S Square rotary system
Govindaraju L et al. (2018)	- Hand K-files ; - Protaper rotary file system ; - Kedo-S rotary file system.	- Instrumentation time was significantly lower with the use of Kedo-S rotary file system compared to the Protaper rotary file system and the hand K-files.	-Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Kedo-S rotary file system
Kumar A et al.	- Hand K files ; - ProTaper rotary file system.	- The mean instrumentation time was significantly less with the rotary instrumentation using ProTaper rotary file system compared to the manual instrumentation with hand K files.	Difference between manual and rotary instrumentation : Significant.	ProTaper rotary file system
Krishna DR et al.	- Hand H-files ; - Mtwo rotary files.	- The mean instrumentation time was significantly less with Mtwo files when compared with H-files.	Difference between manual and rotary instrumentation : Significant.	Mtwo rotary system
Mokhtari N et al.	- Hand K files - Mtwo rotary system.	- Mtwo rotary system showed a significantly less instrumentation time compared to the manual instrumentation using hand K files.	Difference between manual and rotary instrumentation : Significant.	Mtwo rotary system
Govindaraju L et al. (2017)	- Hand K files ; - Mtwo rotary system ; - ProTaper rotary system.	- The rotary instrumentation through the use of Mtwo and ProTaper rotary systems, resulted in a significantly lower instrumentation time compared to the manual instrumentation with hand K files. -There was no significant difference between Mtwo and Protaper rotary systems.	-Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Not significant.	Mtwo rotary system & ProTaper rotary system.

Table 3. Instrumentation time assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Govindaraju L et al. (2017)	- Hand K files - K3 rotary system ; - Protaper rotary system.	-Protaper rotary system showed a significantly less instrumentation time followed by K3 rotary system followed by hand K files.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Protaper rotary system
Babaji P et al.	-Manual K files ; -K3 rotary files.	-The K3 rotary files showed a significantly less instrumentation time compared to the manual K files.	Difference between manual and rotary instrumentation : Significant.	K3 rotary system
Vieyra JP et al.	- Hand K files ; - ProTaper rotary files ; -Light Speed LSX rotary system	-Light Speed LSX rotary system showed a significantly less instrumentation time followed by ProTaper files followed by the hand K files.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Light Speed LSX rotary system
Barasuol JC et al.	- Hand K-files ; - ProDesign Logic rotary file system.	-ProDesign Logic rotary file system showed a significantly less instrumentation time compared to hand K-files.	Difference between manual and rotary instrumentation : Significant.	ProDesign Logic rotary file system
Marques RPS et al.	- Manual K-files ; - WaveOne Gold reciprocating system.	-WaveOne Gold reciprocating system showed a significantly less instrumentation time than the manual K-files.	Difference between manual and rotary instrumentation : Significant.	WaveOne Gold reciprocating system
Boonchoo K et al.	- Hand K files ; - WaveOne Gold rotary system.	-The single reciprocating file WaveOne Gold rotary system demonstrated a significantly shorter instrumentation time than the stainless steel hand K files.	Difference between manual and rotary instrumentation : Significant.	WaveOne Gold rotary system

Table 3. Instrumentation time assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Tyagi R et al.	-Hand K-flex files ; - Pro-AF Baby Gold rotary system ; - WaveOne reciprocating system.	-Hand K-flex files was associated with a significantly higher instrumentation time when compared with Pro-AF Baby Gold rotary system and WaveOne reciprocating system. -WaveOne reciprocating system showed a less instrumentation time than Pro AF Baby Gold rotary system, but the difference between them two wasn't significant.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Not significant.	WaveOne reciprocating system
Jeepalyam S et al.	- Prime-Pedo rotary system ; - Kedo-SG Blue rotary system.	- Significantly less instrumentation time with Kedo-SG Blue rotary system compared to Prime-Pedo rotary system.	- Difference between the two rotary systems : Significant.	Kedo-SG Blue rotary system
Preethy NA et al.	- Hand K files ; - ProTaper Gold rotary system ; - Kedo-SG Blue rotary system.	- Kedo-SG Blue rotary system was associated with significantly less instrumentation time as compared to hand K files. -Instrumentation time with Kedo-SG Blue rotary system was lower than that with ProTaper Gold rotary system but the difference wasn't significant.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Not significant.	Kedo-SG Blue rotary system
Shetty B et al.	- NiTi K-flex hand files ; - Pro AF Baby Gold rotary system ; -Kedo-SG Blue rotary system	- The use of Kedo-SG blue rotary system resulted in significantly the least instrumentation time followed by the Pro AF Baby Gold followed th NiTi K-flex hand files.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Kedo-SG Blue rotary system

Table 3. Instrumentation time assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Priyadarshini P et al.	- Hand K-files ; - Kedo-SH manual files ; - Kedo-S rotary system ; - Kedo-SG Blue rotary system	- The mean instrumentation time was significantly less with the use of rotary Kedo-SG Blue file system followed by Kedo-S, Kedo-SH manual files and hand K-files.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Kedo-SG Blue rotary system
Kohli A et al.	- Prime Pedo rotary system ; - Pro-AF-Baby Gold rotary system ; - Kedo-SG Blue rotary system.	- Although the difference wasn't significant, Kedo-SG Blue rotary system showed the least instrumentation time followed by Pro-AF-Baby Gold followed by Prime Pedo rotary system.	Difference between rotary systems : Not significant.	Kedo-SG Blue rotary system
Sruthi S et al.	- Reciprocating hand K-files ; - Kedo-SH hand files ; - Kedo-SG Blue rotary system.	- Kedo-SG Blue rotary system showed a highly significant reduction in the instrumentation time followed by Kedo-SH hand files and reciprocating hand K-files.	Difference between manual and rotary instrumentation : Significant.	Kedo-SG Blue rotary system
Moudgalya MS et al.	- Hand K files ; - Rotary k-Flex files ; - Kedo-S rotary system.	- Kedo-S rotary system showed significantly the lowest instrumentation time followed by rotary k-Flex files followed by the hand K files.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Kedo-S rotary system
Panchal V et al. (2019)	- Hand K-files ; - Hand H-files ; - Kedo-S rotary system.	- Kedo-S rotary system showed the least instrumentation time compared to hand K-files and hand H-files.	Difference between manual and rotary instrumentation : Significant.	Kedo-S rotary system

Table 3. Instrumentation time assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Lakshmanan L et al. (2020)	- Hand K files ; - Reciprocating K files ; - Kedo-S rotary file system.	- Kedo-S rotary file system showed significantly the least instrumentation time compared to the reciprocating K files and hand K files, while the reciprocating K files showed significantly the highest instrumentation time when compared to the two others root canal preparation techniques.	Difference between manual and rotary instrumentation : Significant.	Kedo-S rotary file system
Jeevanandan G et al. (2018)	- Hand K-files ; - Kedo-S paediatric rotary files.	- The mean instrumentation time using Kedo-S paediatric rotary files was significantly less than that using hand K-files.	Difference between manual and rotary instrumentation : Significant.	Kedo-S rotary system
Shah HS et al.	- Hand K files ; - Pro-AF rotary files ; - Kedo-S rotary files.	-Kedo-S rotary files demonstrated significantly the least instrumentation time followed by Pro-AF rotary files followed by hand K files.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Kedo-S rotary system
Girish Babu KL et al.	- Manual K files ; - Kedo-S rotary system ; - Hero Shaper rotary file.	- Kedo-S and Hero Shaper rotary file systems showed a significantly less instrumentation time as compared to manual K files. Whereas, the difference wasn't significant between the two rotary systems.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Not significant.	Kedo-S rotary system & Hero Shaper rotary system
Juliet S et al.	- Kedo-S rotary system ; - ProTaper rotary system ; - RaCe rotary system.	- RaCe rotary file system showed significantly less instrumentation time followed by ProTaper rotary file system followed by Kedo-S rotary file system ; -The difference between the three rotary systems was significant.	Difference between rotary systems : Significant	RaCe rotary system

Table 3. Instrumentation time assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Pawar BA et al.	- Hand K files ; - Kedo-S rotary system ; - XP-endo Shaper rotary system.	- XP-endo Shaper rotary system was associated with a significantly shorter instrumentation time compared to Kedo-S rotary system and hand K files which resulted in the longest time for root canal preparation.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	XP-endo Shaper rotary system
Makarem A et al.	- Hand H files ; - FM (FlexMaster) rotary system.	- FM (FlexMaster) rotary system showed a significantly less instrumentation time compared to hand H files.	Difference between manual and rotary instrumentation : Significant.	FM (FlexMaster) rotary system
Lakshmanan L et al. (2023)	- Manual K-files ; - Kedo-S file system ; - Kedo-S Square file system.	- Kedo-S Square file system showed significantly the least instrumentation time followed by Kedo-S file system followed by manual K-files.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Kedo-S Square file system
Gomes G et al.	- Hand K files ; - ProTaper rotary system.	- There was no significant difference regarding the instrumentation time between hand (hand K files) and rotary (ProTaper rotary system) instrumentation techniques.	Difference between manual and rotary instrumentation : Not significant.	—

Table 4. Obturation time assessment by the included studies

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Morankar R et al.	- Hand K files ; - Hyflex CM NiTi rotary files.	- The difference wasn't significant between the manual (hand K files) and the rotary (Hyflex CM NiTi rotary files) instrumentation, considering the filling time.	Difference between manual and rotary instrumentation : Not significant.	—
Boonchoo K et al.	- Hand K files ; - WaveOne Gold rotary system.	- There was no significant difference between hand K files and WaveOne Gold rotary system regarding obturation time.	Difference between manual and rotary instrumentation : Not significant.	—
Gomes G et al.	- Hand K files ; - ProTaper rotary system.	- The difference wasn't significant between ProTaper rotary system and hand K files, regarding the obturation time.	Difference between manual and rotary instrumentation : Not significant.	—
Makarem A et al.	- H hand files ; - FlexMaster rotary files.	- No significant difference between the FlexMaster rotary files and H hand files in terms of obturation time.	Difference between manual and rotary instrumentation : Not significant.	—
Kumar A et al.	- Hand K files ; - ProTaper rotary file system.	- Although the difference wasn't statistically significant, the mean obturation time was found to be less in the rotary instrumentation (ProTaper rotary file system) compared to the manual instrumentation (hand K files).	Difference between manual and rotary instrumentation : Not significant.	ProTaper rotary file system
Babaji P et al.	- Manual K files ; - K3 rotary files.	- The difference was significant when manual K files were compared to K3 rotary files.	Difference between manual and rotary instrumentation : Significant.	K3 rotary system
Jeepalyam S et al.	- Prime-Pedo rotary system ; - Kedo-SG Blue rotary system.	- Kedo-SG Blue rotary system showed a significantly less obturation time compared to Prime-Pedo rotary system.	Difference between the two rotary systems : Significant.	Kedo-SG Blue rotary system

Table 4. Obturation time assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Shah HS et al.	- Manual K files ; - Kedo-S rotary system ; -Pro AF Baby Gold rotary file system.	- Kedo-S and Pro AF Baby Gold rotary file systems showed significantly less obturation time compared to manual K files. - Although the least timing taken for obturation was the following instrumentation using Pro-AF rotary system, the difference with Kedo-S rotary system wasn't significant.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Not significant.	Pro AF Baby Gold rotary file system.
Girish Babu KL et al.	- Manual K files ; - Kedo-S rotary system ; - Hero Shaper rotary system.	- Kedo-S and Hero Shaper rotary file systems showed a significantly less obturation time as compared to manual K files. - Hero Shaper rotary file system showed less obturation time than Kedo-S rotary file system but the difference wasn't significant.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Not significant.	Hero Shaper rotary file system
Tyagi R et al.	- Hand K-flex files ; - WaveOne rotary sytem ; - Pro-AF Baby Gold reciprocating rotary system	- Significantly higher obturation time with the use of hand K-flex files as compared to WaveOne and Pro-AF Baby Gold rotary systems. - WaveOne reciprocating rotary system showed a less obturation time than Pro AF Baby Gold rotary system. Though, the difference wasn't significant.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Not significant.	WaveOne reciprocating rotary sytem

Table 5. Obturation quality assessment by the included studies

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Morankar R et al.	- Hand K files ; - Hyflex CM NiTi rotary files.	- No significant difference regarding the filling quality between the manual (hand K files) and rotary instrumentation (Hyflex CM NiTi rotary files).	Difference between manual and rotary instrumentation : Not significant.	—
Amorim AC et al.	- Manual K files ; - Hyflex EDM rotary files.	- No significant difference between the manual K files and rotary instrumentation (Hyflex EDM rotary files) in terms of quality of root filling.	Difference between manual and rotary instrumentation : Not significant.	—
Kaushik M et al.	- Manual H files ; - Flexicon X7 and Hyflex CM rotary files.	- No significant difference regarding the quality of obturation was found between manual H files and Flexicon X7 and Hyflex CM rotary files	Difference between manual and rotary instrumentation : Not significant.	—
Barasuol JC et al.	- Hand K files ; - ProDesign Logic rotary file system.	- No difference regarding the apical limit of the obturation, was observed between hand K files and ProDesign Logic rotary file system.	Difference between manual and rotary instrumentation : Not significant.	—
Durairaj BA et al.	- Manual K files - Kedo-S Square rotary files.	- No significant difference between the Kedo-S Square files and the manual K files based on the quality of obturation.	Difference between manual and rotary instrumentation : Not significant.	—
Govindaraju L et al.	- Hand K-files ; - ProTaper rotary system ; - Kedo-S rotary file systems.	- No statistically significant difference considering the quality of obturation between hand k-files, ProTaper, and Kedo-S rotary file systems.	- Difference between manual and rotary instrumentation : Not significant ; - Difference between the two rotary systems : Not significant.	—
Preethy NA et al.	- Manual K files ; - ProTaper Gold rotary files ; - Kedo-SG blue rotary files.	- There was no statistically significant difference in terms of obturation quality between manual K files, ProTaper Gold rotary files, and Kedo-SG blue rotary files.	- Difference between manual and rotary instrumentation : Not significant ; - Difference between the two rotary systems : Not significant.	—

Table 5. Obturation quality assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Sruthi S et al.	- Kedo-SH hand files ; - Reciprocating hand K-files ; - Kedo-SG Blue rotary system.	- No significant differences were noted between Kedo-SG Blue rotary system, Kedo-SH hand files and reciprocating hand K-files.	Difference between manual and rotary instrumentation : Not significant.	—
Marques RPS et al.	- Hand K files ; - WaveOne Gold rotary system.	- No differences were observed in relation to quality of root canal filling between hand instrumentation with K files and reciprocating rotary instrumentation using WaveOne Gold rotary system.	Difference between manual and rotary instrumentation : Not significant.	—
Mokhtari N et al.	- Manual K files ; - Mtwo rotary system.	- No differences were observed in relation to quality of root canal filling between manual K files and Mtwo rotary files.	Difference between manual and rotary instrumentation : Not significant.	—
Govindaraju L et al. (2017)	- Hand K files ; - Mtwo rotary system ; - Protaper rotary system.	- No significant difference between hand K files, Mtwo and Protaper rotary files.	Difference between manual and rotary instrumentation : Not significant.	—
Kumar A et al.	- Hand K files ; - ProTaper rotary system.	- Hand K files and ProTaper rotary files showed a similar percentage of optimally filled canals. Whereas, under fills were more noticed in manual instrumentaion and over fills were more observed in rotary instrumentation.	Difference between manual and rotary instrumentation : Not significant.	—

Table 5. Obturation quality assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
EL-Desouky SS et al.	- Manual K files - Fanta AF Baby rotary system ; - Kedo-S Square rotary system.	- Kedo-S Square rotary system was associated with a significantly greater number of optimally filled teeth followed by Fanta AF Baby rotary system and manual k files.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Kedo-S Square rotary system
Denish Kumar et al.	- Manual K files - Kedo-S Square rotary system.	- Significantly better obturation quality with the rotary Kedo-S Square files compared to hand k files.	Difference between the two rotary systems : Significant.	Kedo-S Square rotary system
Jeevanandan G et al. (2020)	- Hand K files ; - Hand H files ; - Kedo-S Square rotary file system.	- Kedo-S Square rotary file system showed significantly the highest number of optimally filled canals compared to hand K and H files. - Kedo-S Square rotary system was associated with significantly the highest number of overfilled canals.	Difference between manual and rotary instrumentation : Significant.	Kedo-S Square rotary file system
Lakshmanan L et al. (2023)	- Hand K files ; - Kedo-S file system ; - Kedo-S Square file system.	- Kedo-S Square file system demonstrated the highest percentage of optimally filled canals followed by Kedo-S file system followed by hand K files, but the difference wasn't significant. As well, regarding the presence of voids, the difference wasn't significant.	Difference between manual and rotary instrumentation : Not significant ; - Difference between the two rotary systems : Not significant.	Kedo-S Square file system
Panchal V et al.	- Hand K-files ; - Hand H-files ; - Kedo-S rotary system.	- Significantly higher number of optimally filled canals with Kedo-S rotary system compared to hand K-files and hand H-files.	Difference between manual and rotary instrumentation : Significant.	Kedo-S rotary system
Jeevanandan G et al. (2018)	- Hand K files ; - Kedo-S rotary file system.	-Kedo-S rotary file system showed a significantly higher number of optimally filled canals and lower number of under and over filled canals as compared to hand K files.	Difference between manual and rotary instrumentation : Significant.	Kedo-S rotary system

Table 5. Obturation quality assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Divya S et al.	- Hand K-file ; - K3 rotary file system ; - Kedo-S rotary sytem.	- Kedo-S file showed significantly the least underfilled canals and had, but not significantly, the highest percentage of optimally filled canals compared to hand K files and K3 rotary system.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Kedo-S rotary sytem
Moudgalya MS et al.	- Hand files ; - Rotary K-Flex files ; - Kedo-S rotary system.	- Regarding the apical seal, Kedo-S and rotary K-Flex files showed similar efficiency and they were significantly more efficient in obtaining apical seal than hand files. As well, Kedo-S files showed significantly the least scores of voids, followed by rotary K-Flex files, whereas, hand K files showed significantly the highest number of canals with voids.	- Difference between manual and rotary instrumentation : Significant ; - Difference between the two rotary systems : Significant.	Kedo-S rotary system
Lakshmanan L et al. (2020)	- Hand K files ; - Reciprocating K files ; -Kedo-S files.	- Although the difference wasn't significant, the highest optimal fillings were noted with Kedo-S files followed by hand K files followed by reciprocating K files. However, Kedo-S showed the highest over fills while reciprocating K files showed the highest percentage of under fills.	Difference between manual and rotary instrumentation : Not significant.	Kedo-S rotary system
Juliet S et al.	- ProTaper rotary file system ; - RaCe rotary file system ; - Kedo-S rotary file system.	- Kedo-S rotary file system showed a better obturation quality with a maximal number of optimal fills and minimal percentage of under fills and over fills followed by ProTaper rotary file system followed by RaCe rotary file system.	Difference between the rotary systems : Not significant.	Kedo-S rotary system

Table 5. Obturation quality assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Girish Babu KL et al.	- Manual K files ; - Kedo-S rotary system ; - Hero Shaper rotary file system.	- Kedo-S and Hero Shaper rotary file systems showed a significantly better obturation quality as compared to manual K files. Also, when compared to Kedo-S rotary file system, Hero Shaper rotary file system showed more optimal fills, less under fills but more over fills. Though, the difference wasn't significant.	-Difference between manual and rotary instrumentation : Not significant ; -Difference between the two rotary systems : Not significant.	Hero Shaper rotary file system
Jeepalyam S et al.	- Prime-Pedo rotary system ; - Kedo-SG Blue rotary system.	- Although the difference wasn't significant, Kedo-SG Blue rotary system demonstrated a higher number of optimally filled canals compared to Prime-Pedo rotary system.	Difference between the two rotary systems : Not significant.	Kedo-SG Blue rotary system
Kohli A et al.	- Pro-AF-Baby Gold rotary system ; - Prime Pedo rotary system. - Kedo-SG Blue rotary system.	- Kedo-SG Blue rotary system showed, but not significantly, the highest number of optimally filled canals and the lowest number of underfilled canals as compared to Pro-AF-Baby Gold rotary system and Prime Pedo rotary system.	Difference between the rotary systems : Not significant.	Kedo-SG Blue rotary system
Katge F et al.	- Hand H files ; - Protaper Universal rotary system ; - Prime Pedo rotary system.	- Prime Pedo rotary system showed significantly higher number of optimally filled canals as compared to Protaper Universal rotary system and H files in mesial canals. Regarding voids, the authors reported that Prime Pedo and Protaper Universal rotary files displayed significantly less number of voids in obturation as compared to hand H files.	-Difference between manual and rotary instrumentation : Significant ; -Difference between the two rotary systems : Significant.	Prime Pedo rotary system

Table 5. Obturation quality assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Shah HS et al.	- Hand K files ; - Kedo-S rotary files ; - Pro-AF Baby Gold rotary files.	- Pro-AF Baby Gold files showed, but not significantly, the maximum number of optimal obturations with the least number of voids followed by Kedo-S rotary files followed by hand K files.	-Difference between manual and rotary instrumentation : Not significant ; -Difference between the two rotary systems : Not significant.	Pro-AF Baby Gold rotary system
Govindaraju L et al. (2017)	- Hand K files ; -Protaper rotary system ; - K3 rotary file system.	- Despite the difference wasn't significant, the highest number of optimally filled canals were noticed with the K3 rotary file system followed Protaper rotary system followed by hand K files.	-Difference between manual and rotary instrumentation : Not significant ; -Difference between the two rotary systems : Not significant.	K3 rotary file system
Babaji P et al.	- Hand K files ; -K3 rotary system.	- K3 rotary system was associated with significantly higher percentage of optimally filled canals and lower percentage of under and over fills compared to hand K files.	Difference between manual and rotary instrumentation : Significant.	K3 rotary system
Shetty B et al.	- Hand K-files ; -Pro AF Baby Gold rotary system ; -Kedo-SG blue rotary system.	-Although the difference wasn't significant, Kedo-SG blue was associated with the highest number of optimally filled canals followed by hand K-files followed by Pro AF Baby Gold rotary system. -Hand K-files showed the highest number of overfilled canals. Regarding voids, Pro AF Baby Gold demonstrated the least amount of voids followed by hand k-files within the use of Kedo-SG blue was associated with the highest number of voids.	-Difference between manual and rotary instrumentation : Not significant ; -Difference between the two rotary systems : Not significant.	Kedo-SG blue rotary system & Pro AF Baby Gold rotary system

Table 5. Obturation quality assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Priyadarshini P et al.	- Kedo-SH manual files ; - Hand K-files ; - Kedo-S rotary system ; - Kedo-SG Blue file system.	- Kedo-SG Blue file system demonstrated a high statistically significant level of optimal quality of obturation followed by Kedo-SH manual files, Kedo-S rotary system, and hand K-files.	-Difference between manual and rotary instrumentation : Significant ; -Difference between the two rotary systems : Significant.	Kedo-SG Blue file system
Jeevanandan G et al. (2021)	- Hand K-files ; - Kedo-SH hand files ; - Kedo-SG Blue pediatric rotary system.	- Kedo-SG Blue pediatric rotary system showed a significantly better obturation quality followed by Kedo-SH hand files followed by hand K-files.	Difference between manual and rotary instrumentation : Significant.	Kedo-SG Blue rotary system
Boonchoo K et al.	- Hand K files ; - WaveOne Gold rotary system.	- In mesial canals, WaveOne Gold rotary system showed a significantly higher percentage of overfilled canals compared to hand K files which showed a significantly higher percentage of under fills. - There was no significant difference between them in distal canals	Difference between manual and rotary instrumentation : Significant.	—
Pawar BA et al.	- Hand K files ; - Kedo-S rotary system ; - XP-endo Shaper rotary system.	- XP-endo Shaper rotary system showed a significantly higher number of optimally filled canals and lower number of under and overfilled canals compared to Kedo-S rotary system and hand K files.	-Difference between manual and rotary instrumentation : Significant ; -Difference between the two rotary systems : Significant.	XP-endo Shaper rotary system
Makarem A et al.	- Hand H files ; - FlexMaster rotary system.	- FlexMaster rotary system showed a significantly better obturation quality in terms of both obturation extent and form in comparison to the hand H files.	Difference between manual and rotary instrumentation : Significant.	FlexMaster rotary system

Table 6. Complication during instrumentation assessment by the included studies

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Morankar R et al.	- Hand K files - Hyflex CM NiTi rotary file system.	-There were two cases of instrumental fracture encountered with Hyflex CM NiTi rotary file system versus none observed with hand K files. Though, the difference wasn't significant.	Difference between manual and rotary instrumentation : Not significant.	Hand K files

Table 7. Success rate assessment by the included studies

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Morankar R et al.	- Hand K files ; - Hyflex CM NiTi rotary file system.	-Although the difference wasn't significant, the clinical success rate was higher with hand K files as compared to Hyflex CM NiTi rotary file system. -Radiographic success rate was higher, but not significantly, with Hyflex CM NiTi rotary file system	Difference between manual and rotary instrumentation : Not significant.	— —
Kumar A et al.	- Hand K files ; - ProTaper rotary file system.	- Manual instrumentation with hand K files demonstrated a better clinical success rate than the rotary instrumentation with ProTaper rotary file system, but the difference wasn't significant.	Difference between manual and rotary instrumentation : Not significant.	Hand K files
Elheeny AA et al. (2015)	- Manual K files ; - RaCe rotary system.	- RaCe rotary system exhibited higher success rate percentage over ProTaper rotary system and manual K files. Though, the difference wasn't significant.	Difference between manual and rotary instrumentation : Not significant.	RaCe rotary system
Girish Babu KL et al.	- Manual K files - Hero Shaper rotary file system ; - Kedo-S rotary file system.	- Clinical success rate was considered as 100% for Kedo-S rotary file system, Hero Shaper rotary file system and manual K files. Whereas, the highest radiographic success was observed with Hero Shaper rotary file system, followed by Kedo-S rotary file system followed by manual K files. - The two- year-follow up revealed no significant difference between these three instrumental techniques.	Difference between manual and rotary instrumentation : Not significant ; - Difference between the two rotary systems : Not significant	Hero Shaper rotary file system
Amorim AC et al.	- Hand K files ; - Hyflex EDM rotary files.	- No difference between the manual technique using hand K files and the rotary technique using Hyflex EDM rotary files in terms of both clinical and radiographic success.	Difference between manual and rotary instrumentation : Not significant.	—

Table 7. Success rate assessment by the included studies (continued)

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Marques RPS et al.	- Hand K files ; - WaveOne Gold reciprocating system.	-Similar success rate was observed for both manual (hand K files) and reciprocating (WaveOne Gold reciprocating system) techniques.	Difference between manual and rotary instrumentation : Not significant.	—
Boonchoo K et al.	- Hand K files ; - WaveOne Gold rotary system.	- No significant difference between hand K files and WaveOne Gold rotary system at 6 and 12 months post operatively regarding both clinical and radiographic success rate.	Difference between manual and rotary instrumentation : Not significant.	—
Vieyra JP et al.	- Hand K files ; - Light Speed LSX rotary system ; - ProTaper file rotary system.	- No difference was found between the rotary (Light Speed LSX and ProTaper file rotary systems) and manual (hand K files) instrumentation considering both clinical and radiographic success rate.	-Difference between manual and rotary instrumentation : Not significant ; -Difference between the two rotary systems : Not significant.	—

Table 8. Child's behavior assessment by the included studies

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Krishna DR et al.	- Manual H files ; - Mtwo rotary files.	- Young patients significantly preferred manual H files over Mtwo rotary files.	Difference between manual and rotary instrumentation : Significant.	Manual H files
Barasuol JC et al.	- Hand K files ; - ProDesign Logic rotary file system.	- There was no association between the type of instrumentation and participant behavior when compared hand K files to ProDesign Logic rotary file system.	Difference between manual and rotary instrumentation : Not significant.	—
Tyagi R et al.	- Hand NiTi-K flex ; - Pro AF Baby Gold rotary system ; - WaveOne reciprocating system.	- No statistically significant difference between pre-operative and post-operative child's behavior was noticed when comparing hand NiTi-K flex, Pro AF Baby Gold rotary system and WaveOne reciprocating system.	-Difference between manual and rotary instrumentation : Not significant ; -Difference between the two rotary systems : Not significant.	—

Table 9. Operator's perspective assessment by the included studies

Study	Compared instruments	Findings	Significance	Effective rotary instrument
Krishna DR et al.	- Manual H-files ; - Mtwo rotary files.	- Operators preferred Mtwo rotary files over manual H-files. However, the difference wasn't significant.	Difference between manual and rotary instrumentation : Not significant.	Mtwo rotary system

Table 10. Recapitulative table demonstrating the comparison between manual instrumentation and rotary instrumentation based on the different evaluating parameters

	P.O.P	C.E	I.T	O.T	O.Q	S.R	C.I	O.P	C.B
Rotary instrumentation	+	+	+	+	+	=	-	+	-
Hand Instrumentation	-	-	-	-	-	=	+	-	+

* + : Effective ; - : Not effective ; = : Equally effective ; _ : Not mentioned

Table 11. Recapitulative table demonstrating the comparison between rotary systems based on the different evaluating parameters

	P.O.P	C.E	I.T	O.T	O.Q	S.R	C.I	O.P	C.B
Kedo-S plus	_	++	_	_	_	_	_	_	_
Kedo-S	++	+	++	_	++	_	_	_	_
Square									
Kedo-SG	+	_	++	++	++	_	_	_	_
Blue									
Kedo-S	+	++	+	+	+	+	_	_	_
ProDesign	_	_	+	_	-		_	_	=
Logic									
WaveOne	++	_	++	+	-	-	_	_	=
Gold									
Light Speed	_	_	++	_	_	-	_	_	_
LSX									
Pro AF Baby	+	_	+	+	+	_	_	_	=
Gold									
Fanta AF	+	_	+	_	-	_	_	_	_
Baby rotary									
Mtwo	+	_	+	_	-		_	+	-
Hyflex CM	_	_	+	-	-	-	-	_	_
NiTi									

* ++ : Most effective ; + : Effective ; - : Not effective ; = : Equally effective ; _ : Not mentioned

Table 11. Recaputlative table demonstrating the comparison between rotary systems based on the differents evaluating parameters (continued)

	P.O.P	C.E	I.T	O.T	O.Q	S.R	C.I	O.P	C.B
Hyflex EDM	+	—	+	—	-	-	—	—	—
FlexMaster	—	—	+	-	+		—	—	—
Hero Shaper	—	—	+	+	+	++	—	—	—
K3	-	—	+	+	+	—	—	—	—
Prime Pedo	—	—	-	-	+	—	—	—	—
ProTaper	+	—	+	-	-	-	—	—	—
Flexicon X7	—	—	++	—	-	—	—	—	—
K-Flex	+	+	-	—	+	—	—	—	—
XP-endo	++	—	++	—	++	—	—	—	—
Shaper									
Revo-S	+	—	—	—	—	—	—	—	—
Reciproc R25	+	—	—	—	—	—	—	—	—
OneShape	+	—	—	—	—	—	—	—	—
RaCe rotary	—	—	+	—	-	++	—	—	—
system									

* ++ : Most effective ; + : Effective ; - : Not effective ; = : Equally effective ; _ : Not mentioned

Table 12. Recaputlative table showing the comparison between continuous and reciprocating motion used in rotary instrumentation

	P.O.P	C.E	I.T	O.T	O.Q	S.R	C.I	O.P	C.B
Continuous motion	=	—	-	-	—	—	—	—	=
Reciprocating motion	=	—	+	+	—	—	—	—	=

* + : Effective ; - : Not effective ; = : Equally effective ; _ : Not mentioned

Table 13. Quality assessment of the included studies based on the RoB 2 tool

	D1	D2	D3	D4	D5	Overall	Explanation
Morankar R et al.							—
Jeevanandan G et al. (2023)							The significance of difference in bacterial load reduction between rotary files wasn't assessed.
Dinesh kumar et al.							The quality of obturation assessment was only based on the extent of fill while the presence of voids wasn't reported.
Alnassar I et al.							The pain assessment was performed by parents.
Amorim AC et al.							The randomization process wasn't clearly described. The quality of obturation assessment was only based on the extent of fill and the presence of voids wasn't reported. Small sample size.
Subramanyam D et al.							Small sample size.
EL-Desouky SS et al.							The quality of obturation assessment was only based on the extent of fill and the presence of voids wasn't reported. The evaluator of postoperative pain wasn't mentioned.
Jeepalyam S et al.							The quality of obturation assessment was only based on the extent of fill and the presence of voids wasn't reported. Small sample size.
Durairaj BA et al.							Small sample size.
Lakshmanan L et al. (2022)							Small sample size.
Elheeny AAH et al. (2023)							—
Kaushik M et al.							The assessor of the quality of obturation wasn't blinded to the instrumentation technique. The presence of voids wasn't evaluated.

Table 13. Quality assessment of the included studies based on the RoB 2 tool (continued)

	D1	D2	D3	D4	D5	Overall	Explanation
Krishna DR et al.							Small sample size. The evaluator of the main outcome wasn't blinded.
Panchal V, Jeevanandan G, and Subramanian EM (2019)							The evaluation of instrumentation time wasn't blinded. The presence of voids wasn't evaluated.
Divya S et al.							The assessment of postoperative pain wasn't blinded. The presence of voids wasn't evaluated. Small sample size.
Jeevanandan G et al. (2020)							Small sample size. The presence of voids wasn't evaluated.
Govindaraju L et al. (2018)							The presence of voids wasn't evaluated.
Preethy NA et al.							Small sample size. The presence of voids wasn't evaluated.
Shetty B et al.							Small sample size. The measurement tool of the instrumentation time wasn't mentioned.
Moudgalya MS et al.							The assessors of results weren't mentioned. Postoperative pain was evaluated by parents.
Barasuol JC et al.							—
Elheeny AAH et al. (2022)							—
Marques RPS et al.							—
Mokhtari N et al.							The objectives and results of the trial weren't well-defined. The measurement tools of all the parameters weren't mentioned. The assessors of parameters weren't mentioned.

Table 13. Quality assessment of the included studies based on the RoB 2 tool (continued)

	D1	D2	D3	D4	D5	Overall	Explanation
Thakur B et al.							—
Topçuoğlu G et al.							—
Kumar A et al.							Small sample size. The presence of voids wasn't evaluated. The assessers of parameters weren't mentioned.
Boonchoo K et al.							The measurement tools of parameters weren't mentioned The presence of voids wasn't reported. Small sample size.
Panchal V et al. (2019)							Postoperative pain assessment by phone calls.
Priyadarshini P et al.							The presence of voids wasn't evaluated
Kohli A et al.							The presence of voids wasn't reported.
Sruthi S et al.							The presence of voids wasn't reported.
Govindaraju L et al. (2017)							Small sample size. Small sample size. The presence of voids wasn't reported.
Nair M et al.							The pain assessment wasn't blinded.
Lakshmanan L et al. (2020)							Small sample size. The presence of voids wasn't reported.
Lakshmanan L et al. (2023)							Small sample size.
Katge F et al.							Small sample size.

Table 13. Quality assessment of the included studies based on the RoB 2 tool (continued)

	D1	D2	D3	D4	D5	Overall	Explanation
Gomes G et al.							Very small sample size (8 primary teeth).
Pawar BA et al.							The presence of voids wasn't evaluated. The instrumentation time assessment wasn't blinded. Significance difference between instrumentation techniques wasn't reported.
Jeevanandan G et al. (2018)							The presence of voids wasn't evaluated.
Makarem et al.							Small sample size. The evaluator of chair side time wasn't mentioned.
Govindaraju L et al. (2017)							The presence of voids wasn't evaluated.
Babaji P et al.							Small sample size. The evaluators of the parameters weren't mentioned. The measurement tools of all parameters weren't mentioned. The presence of voids wasn't evaluated.
Vieyra JP et al.							The evaluation of parameters wasn't blinded.
Shah HS et al.							Small sample size. The evaluator of instrumentation and obturation time wasn't mentioned.
Elheeny A et al. (2015)							The evaluator of success rate wasn't mentioned.
Girish Babu KL et al.							The presence of voids wasn't evaluated.
Juliet S et al.							Small sample size. The presence of voids wasn't evaluated.

Table 13. Quality assessment of the included studies based on the RoB 2 tool (continued)

	D1	D2	D3	D4	D5	Overall	Explanation
Jeevanandan G et al. (2020)							—
Jeevanandan G et al. (2021)							Small sample size. The presence of voids wasn't evaluated.
Tyagi R et al.							The evaluator of postoperative pain wasn't mentioned. The measurement tool of instrumentation time wasn't mentioned.
Domains						Judgement	
D1: Bias arising from the randomization process							Low risk
D2: Bias due to deviations from intended interventions							Some concerns
D3: Bias due to missing outcome data							High risk
D4: Bias in measurement of the outcome							
D5: Bias in selection of the reported result							

DISCUSSION

Pulpectomy is considered the treatment of choice for primary teeth with severe pulpal involvement, as it aims to preserve deciduous teeth until their physiological exfoliation. This ensures the maintenance of essential oral functions, including mastication and phonation, preserves esthetics, and prevents the development of deleterious oral habits. The introduction of nickel–titanium (NiTi) alloys enabled the use of rotary instrumentation in pulpally involved teeth, first reported by Barr et al. in 2000. Since then, numerous rotary systems have been developed specifically for pulpectomy in primary teeth.⁶⁰

This systematic review aimed to compare different rotary file systems used for pulpectomy in primary teeth and to identify the most reliable system for clinical use. The evaluation focused on key clinical parameters, including postoperative pain, cleaning efficacy, instrumentation time, obturation time and quality, success rate, practitioner’s preference, child behavior, and

intraoperative complications. An efficient rotary system should minimize postoperative pain and analgesic intake, reduce chairside time to enhance patient cooperation, prevent instrument fracture, provide optimal cleaning and shaping, achieve high-quality obturation, ensure a high success rate, and be preferred by both clinicians and patients.

Postoperative pain is a critical outcome in pediatric endodontics, as it can significantly influence a child’s future dental behavior.⁵⁷ Pain was assessed using a four-point pain intensity scale categorizing pain as none, slight, moderate, or severe.¹⁶ The findings of this systematic review indicate that rotary instrumentation is more effective than manual instrumentation in reducing postoperative pain, in agreement with the umbrella review conducted by Swaminathan et al.⁶¹ Among the rotary systems evaluated, Kedo-S Square, WaveOne Gold, and XP-Endo Shaper demonstrated superior performance in minimizing postoperative pain.¹⁶⁻²⁴⁻³⁷⁻³⁰ When comparing continuous rotation and reciprocating motion, no

significant difference in pain reduction was observed.²⁸

The primary objective of pulpectomy in primary teeth is the elimination of intracanal microorganisms to prevent reinfection and promote periradicular tissue healing, thereby reducing postoperative discomfort.³³ Rotary instrumentation demonstrated superior cleaning efficacy compared to hand files. When rotary systems were compared with each other, Kedo-S Plus and Kedo-S showed the most favorable cleaning outcomes.⁹⁻³²⁻¹⁸

Chairside time, defined as the duration required for canal preparation and obturation, is a crucial factor in pediatric dentistry. Reducing treatment time helps alleviate anxiety, improves cooperation, and decreases operator fatigue, particularly when managing uncooperative children.⁴³⁻¹⁸ The present review demonstrated that rotary instrumentation significantly reduced chairside time compared to manual techniques, consistent with the findings of Faghihian et al.⁶² Rotary systems such as Kedo-S Square, Kedo-SG Blue, WaveOne Gold, LightSpeed LSX, Flexicon X7, and XP-Endo Shaper were associated with short treatment times.³⁵⁻¹⁶⁻³⁶⁻⁴⁻³⁷⁻²⁶⁻²⁴⁻⁴⁴⁻⁴⁵⁻⁴⁶⁻⁴⁷⁻¹⁻³⁻⁵⁴⁻²⁵ Furthermore, reciprocating motion resulted in shorter chairside time than continuous rotation.²⁴

Obturation quality is a decisive factor in the success of root canal treatment.³⁵ Rotary instrumentation was associated with superior obturation quality, a finding also supported by Faghihian et al.⁶² and Swaminathan et al.⁶¹ In this context, Kedo-S Square, Kedo-SG Blue and XP-Endo Shaper exhibited superior obturation quality.⁵⁴⁻⁴⁻³⁷⁻²⁵⁻⁴⁴⁻¹⁻⁴⁶⁻⁴⁷⁻²³

Regarding overall success rates, most studies reported comparable outcomes between hand and rotary instrumentation.²⁻³⁴⁻²⁷⁻⁴³⁻²⁶ However, when comparing rotary systems, RaCe and Hero Shaper demonstrated higher success rates.⁵⁹⁻⁵² Success was evaluated both clinically and radiographically.

Clinically, success was defined by the absence of pain, tenderness to percussion, gingival swelling, sinus tract formation, or abnormal mobility.² Radiographic success was characterized by the absence of increased or new radiolucencies and the absence of pathological internal or external root resorption.²

Instrument fracture was the most commonly reported complication associated with rotary instrumentation, although it was noted in only one study.² Instrument separation is multifactorial and may be minimized by limiting instrument reuse and ensuring adequate operator experience.²

From the practitioner's perspective, rotary instrumentation was generally preferred, with the Mtwo rotary system favored over hand files.³⁴ Regarding child behavior, one study³⁸ reported a preference for manual instrumentation, whereas two others³¹⁻²⁴ found no association between behavior and instrumentation type. Continuous and reciprocating motions showed comparable behavioral outcomes.²⁴

This systematic review has several strengths. It is the first to compare not only manual and rotary pulpectomy techniques in primary teeth but also a wide range of currently available rotary systems. Additionally, it included a substantial number of high-quality clinical studies evaluating multiple clinical parameters.

However, several limitations must be acknowledged. The heterogeneity of the included studies prevented the performance of a meta-analysis, as individual studies evaluated different outcomes and rotary systems. In addition, a considerable proportion of the included studies were characterized by small sample sizes, which may adversely affect the statistical power and overall reliability of their findings. Another limitation of the present review is that most of the included studies evaluated variants of the Kedo-S rotary system, potentially leading to an overrepresentation of its performance and

introducing the risk of performance overestimation. Furthermore, the review focused exclusively on clinical parameters related to pulpectomy procedures. Some of these outcomes are inherently subjective, being dependent on either practitioner assessment or patient-reported measures, while others reflect only short-term follow-up periods. Collectively, these factors preclude the formulation of definitive conclusions.

Additionally, the quality assessment identified a moderate risk of bias across the included studies, raising further concerns regarding the reliability and internal validity of the reported outcomes.

Moreover, a large proportion of the included studies (36 out of 51) were conducted in India, emphasizing the need for multicentric research. Future studies should aim to include a broader range of rotary systems and evaluate a wider array of clinical parameters. Finally, the exclusion of in vitro studies limited the assessment of additional objective variables such as apical debris extrusion and the ability of rotary systems to maintain the original canal anatomy during instrumentation.

CONCLUSIONS

Considering the heterogeneity of the included studies and the lack of standardized and objective assessment of pulpectomy parameters, identifying a single pediatric rotary file system that consistently fulfilled all evaluated criteria was not feasible. Nevertheless, this systematic review emphasizes the need for future multicentric studies with standardized methodologies that simultaneously evaluate a broader range of rotary systems. Such studies should integrate both clinical and in vitro parameters to provide more robust and comprehensive evidence to guide clinical decision-making in pediatric endodontics.

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