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The Role of Rotary and Reciprocating Systems in Primary Molar Pulpectomy: A Literature Review

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ABSTRACT

Pediatric dentists have begun to use NiTi motorized instruments to address the difficulties of manually instrumenting root canals in primary teeth. Increasing research shows that mechanized canal preparation reduces treatment time, post-procedure pain, and obturation variability compared with traditional hand instrumentation. This study tries to determine the efficacy, mechanical performance, and safety of different engine-driven file systems during pulpectomy procedures for primary molars. By reviewing the existing literature, the objective of this study is to develop practical criteria for the selection between dedicated pediatric rotary files and modified adult rotary files. Studies show that engine-driven instrumentation can be used very effectively in pulpectomy of primary teeth and achieves success comparable to hand K-files. It functions as an extremely efficient technique in reducing working time, which in turn boosts patient cooperation. With the help of heat treatment of the alloy and pediatric design, it is feasible to retain the curvatures of the root canal while averting any root perforations and cracks in the dentine. Yet, debris extrusion at the apex and canal transport are problems with severely curved or resorbed roots. An engine-driven pulpectomy for primary teeth is a reliable and highly efficient method for managing such cases. Expected results can be achieved when pediatric files and conservative tapers with controlled speed are applied. Engine-driven endodontics in pedodontics is one of the most rapidly developing fields that necessitates active involvement of specialists. Current innovations have great possibilities; however, more studies are needed.

Keywords: primary teeth; pulpectomy; pediatric endodontics; rotary instrumentation; reciprocating systems; NiTi files

1. INTRODUCTION

Irreversible pulpitis and root canal infection of primary molars are among the most difficult clinical cases in pediatric dentistry, requiring maintenance of the integrity of these teeth until their physiological replacement (Smaïl-Faugeron et al., 2018; Barr et al., 2000). The complicated anatomy of the primary tooth roots, as exemplified by the ribbon canals, their lateral branches, and physiological resorption, makes it difficult to achieve complete debridement of the root canal

system (Barr et al., 2000; Musale et al., 2016). The conventional method of preparing root canals with stainless steel hand K-files is laborious as well as operator-dependent, thus causing fatigue to the dentist (Kaur et al., 2025; Panchal et al., 2019). The failure of the filing technique causes a prolonged time at chairside that makes children uncooperative and anxious (Morankar et al., 2018).

While hand files have been thought to be the gold standard for treatment in pediatric endodontics, recent evidence has shown that the use of hand instruments results in a number of procedural mishaps, including canal transportation, zipping, and ledging (Jeevanandan et al., 2021; Musale et al., 2016). This problem is attributed mainly to the rigidity of stainless steel instruments during instrumentation of curved primary teeth (Barr et al., 2000). Due to their fragility, the thin walls of the root canals were considered not able to withstand the cuts caused by NiTi motors (Barr et al., 2000). Nevertheless, subsequent studies proved that flexibility and pseudoelasticity of NiTi alloys allow for the correct formation of canals without the removal of too much dentine (Ramezanali et al., 2017; Akcay et al., 2020).

Modern methods of endodontics include the development of pediatric rotary files with shortened shafts, specific tapers, and heat-treated metals (Jeevanandan, 2017; Nair et al., 2021). Additionally, a single-file reciprocating technique has been introduced in order to help with the biomechanical management of this particular category of pediatric patients (Katge et al., 2014; Elnaghy et al., 2022). The modern techniques are not only aimed at reducing the duration of the procedure, but also at protecting the developing permanent tooth germ from any apically extruded pathogens (Alhayki et al., 2025; Ozturk et al., 2020).

Pulpectomies using motor-driven systems present a very promising clinical approach, provided there are definite guidelines concerning file selection, motion kinematics, and torque generation.

The following paper discusses the impact of rotary and reciprocating preparation on pulpectomies of primary molars, a field that experiences substantial changes in contemporary pediatric dentistry. Literature analysis will allow for identifying the best file systems as well as for differentiation of appropriate clinical protocols from those that need to be treated with greater care. The main purpose of this literature review is to define clinical situations in which mechanized pulpectomy works as expected and to identify issues that require more research.

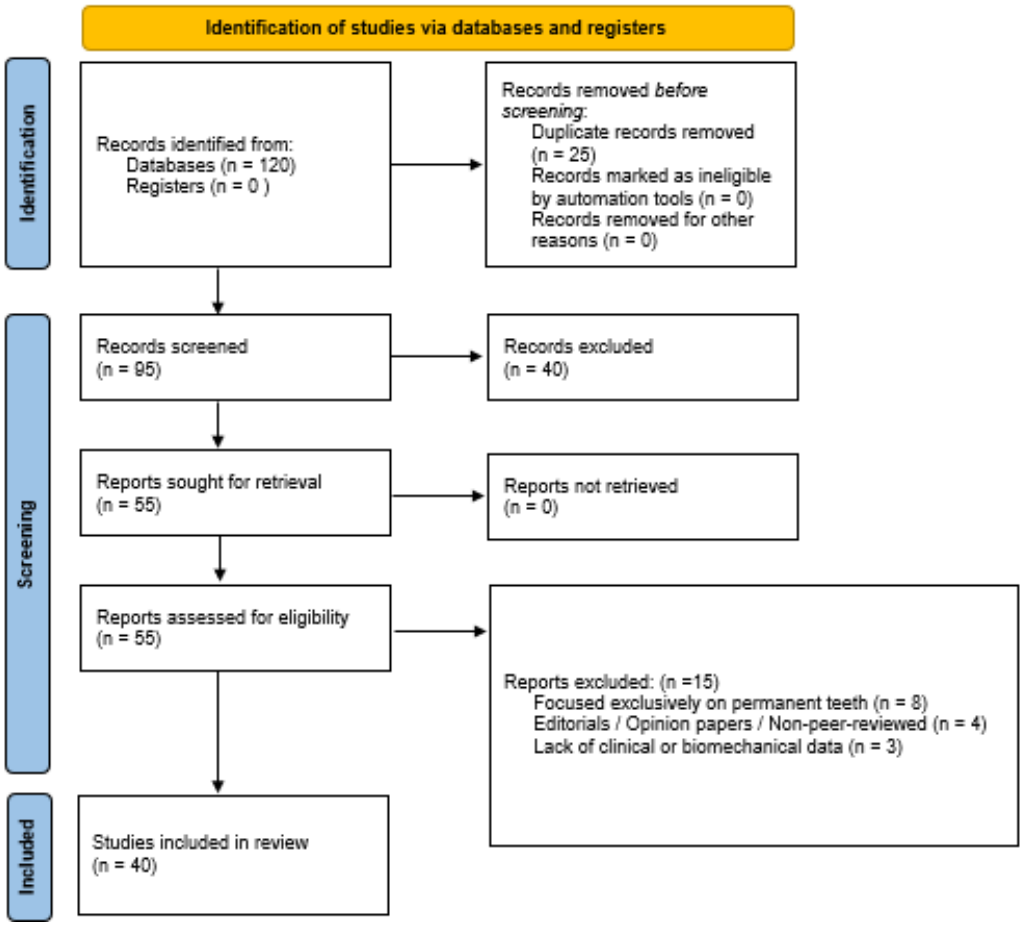

Figure 1. PRISMA Literature Screening Flowchart

2. REVIEW METHODS

This review is based on a narrative review methodology. Scientific publications were retrieved systematically by searching electronic databases such as PubMed, Scopus, and Google Scholar. The keywords used during the search were: "primary teeth", "pulpectomy", "endodontics in children", "rotary instruments", "reciprocating files", "Kedo-S", and "dentinal microcracks"

The inclusion criteria consisted of articles published in peer-reviewed journals that examined the clinical effectiveness, safety, or biomechanics of engine-driven instrumentation in primary teeth; these had to contain information related to experiments, clinical practice, or radiography. Opinion papers, editorials, and non-peer-reviewed articles that focused exclusively on permanent teeth endodontics were not included. Forty papers were finally chosen for qualitative analysis. The detailed process of literature search and selection is presented in the PRISMA flow diagram (Figure 1).

3. RESULTS AND DISCUSSION

Clinical Efficiency and Time Management in Pediatric Pulpectomy

Pediatric Endodontics needs less time in treatment in order to get the cooperation of the patient (Morankar et al., 2018). The manual instrumentation procedure consists of a cycle that takes more time during treatment (Kaur et al., 2025). More time during treatment causes behavioral problems in children (Morankar et al., 2018). Motorized instruments help in continuous or reciprocating cutting that makes the process of cleaning and shaping of the canals fast (Panchal et al., 2019; Katge et al., 2014). Proper management of treatment time is necessary for performing pulpectomy within the attention span of children (Jeevanandan et al., 2021).

Many clinicians are uncertain whether there is any clinical difference in speed between specific rotary instruments designed for pediatric use and those used by adults, or even hand K-files (Govindaraju et al., 2018). One view is that specific rotary instruments for pediatric use, like the Kedo-S instrument, complete the entire procedure much faster than hand filing (Jeevanandan et al., 2017; Prabhakar et al., 2020). In cases where the patient's behavior is difficult, faster instrumentation reduces the risk of saliva contamination.

Engine-powered tools make it possible to create even tapering in the canals that will facilitate the process of filling them (Reddy et al., 2022; Tyagi et al., 2020). It is made only by having full control over the working length and the speed of the rotation of the instrument (Sultan et al., 2023). Improper advancement of the files results in over-instrumentation or root wall perforation (Musale et al., 2016). At the same time, correct file selection requires a special diagnostic procedure in order not to over instrument thin roots (Panchal et al., 2020). Exact information about torque and speed selection is needed to avoid instrument separation in narrow canals (Barr et al., 2000). There are great differences in manufacturer recommendations about the appropriate speeds of rotation in primary teeth (Jeevanandan et al., 2017).

There is also a lack of evidence indicating that rotary continuous systems for adults have greater advantages than reciprocating single-file systems in uncooperative pediatric patients (Elnaghy et al., 2022). For an endodontic system to be recognized as the gold standard in pedodontics, it should show high clinical performance and safety in randomized clinical trials (Kaur et al., 2025; Smaïl-Faugeron et al., 2018).

Postoperative Discomfort and Apical Debris Extrusion

Post-pulpectomy pain occurs because of the contamination of the periradicular tissue through the apical foramen caused by the presence of infected dentine that has either necrotic or contaminated dentinal debris or solution (Alhayki et al., 2025; Lakshmanan and Jeevanandan, 2021). The pushing and pulling movement made during the cavity preparation is like a piston action, which pushes the debris through the resorbed apical region (Ozturk et al., 2020). Therefore, an inflammatory response will be triggered by the bacteria that have been introduced into the periapical space (Topçuoğlu and Topçuoğlu, 2017).

In pulpectomies of primary molars, apical extrusion tends to be very risky due to the closeness of the permanent successor tooth (Alhayki et al., 2025). Instruments that have flutes for conveying debris coronally have been found to decrease apically extruded material (Ozturk et al., 2020). The condition is asymptomatic when it is handled properly, but improper procedure may lead to acute exacerbation postoperatively (Lakshmanan and Jeevanandan, 2021). In general, clinical observation, along with the use of pain scales (e.g., Wong-Baker FACES Pain Scale), is applied to assess the result of the treatment (Topçuoğlu and Topçuoğlu, 2017).

Another equally important element identified in recent studies is canal transportation. Canal transportation is the result of mechanical deviation of the canal axes due to straightening of the curved primary roots using rigid instruments (Musale et al., 2016). It results from aggressive instrumentation of canals and can lead to lateral root perforations and incomplete debridement of uninstrumented canal walls (Canoglu et al., 2014).

While traditional hand instruments may be used to form canals with dexterity, they cannot ensure consistent centering through curved roots (Jeevanandan et al., 2021). The limitation has facilitated the immense use of flexible NiTi rotary techniques (Barr et al., 2000). Heat-treated NiTi alloys maintain the biological path of mature primary roots (Nair et al., 2021).

It has been reported that engine-driven instrumentation works well in reducing post-operative pain in patients (Table 1) (Lakshmanan and Jeevanandan, 2021). In a comprehensive study performed through micro-CT analysis, it was found that the use of rotary files kept canals centered and minimized dentin gouging in most cases (Musale et al., 2016). Engine-driven filing was also associated with decreased chances of post-treatment pain when compared with hand files (Topçuoğlu and Topçuoğlu, 2017).

A systematic review has also revealed that the mechanical technique requires shorter chair time without affecting the quality of obturation (Panchal et al., 2019). Recent clinical trials have proven that single-file reciprocal techniques are safe for children (Vieira et al., 2019). Mention should be made of the application of three-dimensional imaging and nano-CT in pediatric patients (Jeevanandan et al., 2024). The diagnostic tools mentioned above are rather widespread in contemporary studies (Kishore et al., 2021).

Although the results are positive, further comparative studies are needed to be carried out (Kaur et al., 2025). Few randomized clinical trials performed in multiple centers have provided a direct comparison between specialized pediatric files and heat-treated adult files for use in primary teeth (Subramanyam and Tirupathi, 2021). The available literature includes several comparisons based on in vitro tests and model teeth (Moudgalya et al., 2022). Such studies provide mechanical strength theoretically and involve selection bias.

Other difficulties include the absence of a uniform taper for primary root canals (Kuo et al., 2006). Conservative taper (.04) is preferred by some dentists to conserve dentin, while others prefer larger tapers (.06) for simpler paste obturation (Crespo et al., 2008). Most studies have considered second primary molars; however, there is insufficient information available on first molars and incisors, especially those having a complex root form (Katge et al., 2014).

From contemporary literature, severely curved roots in primary molars have been identified as belonging to a high-risk group for making mistakes during manual file operation (Musale et al., 2016). The use of gold or blue NiTi wire after heat treatment has been suggested as a potentially promising procedure, but needs clinical validation (Nair et al., 2021). The use of pediatric rotary files can be a game changer, although it needs to be validated (Jeevanandan and Govindaraju, 2021).

Table 1. Selected Instrumentation Systems and Clinical Risk Factors in Primary Pulpectomy

System / File Type	Kinematics & Taper	Clinical Chair Time	Risk of Canal Transportation	Apical Debris Extrusion
Manual Stainless Steel K-Files	Hand filing / .02 Taper	High (15–25 mins)	High	High
Kedo-S / Kedo-SG Blue	Continuous Rotation / Varied Pediatric Taper	Very Low (3–6 mins)	Minimal	Low
ProTaper Gold (Adapted)	Continuous Rotation / Variable Taper	Moderate (6–10 mins)	Moderate	Low to Moderate
WaveOne Gold (Adapted)	Reciprocation / Regressive Taper	Low (4–7 mins)	Minimal	Moderate

Kinematics, Heat-Treated Alloys, and Biomechanical Safety

Continuous or reciprocation is an important issue in children's endodontic research (Katge et al., 2014). Motion parameters have an influence on the efficiency of cutting, cyclic fatigue, and stresses of the instruments while working inside the primary canal system (Akcay et al., 2020). Control of mechanical parameters is important to avoid breaking the instrument during its work in narrow ribbon-like canals (Ramezanali et al., 2017).

A key determinant of success is the structural flexibility of the alloy (Nair et al., 2021). Historically, it was feared that engine-driven instruments would cause dentinal microcracks or root fractures in thin primary dentin (Azar et al., 2019). However, modern metallurgical advancements—such as Controlled Memory (CM) wire, gold, and blue heat treatments—have created instruments with superior flexibility and reduced shape memory (Ramezanali et al., 2017; Akcay et al., 2020). These heat-treated files conform readily to root curvatures, reducing lateral stress on canal walls (Ramezanali et al., 2017).

The use of multi-file technique procedures is no longer recommended by recent studies in pediatric endodontics (Vieira et al., 2019). This method of canal shaping through single-file techniques can be done through rotary or reciprocating movements (Elnaghy et al.,

2022; Vieira et al., 2019). The single-file technique secures better efficiency in the process with minimized risks of errors on the part of the operator and reduced expenses in terms of clinical work (Elnaghy et al., 2022). Taper control is critical for proper preparation and saving cervical dentin (Kuo et al., 2006).

The advantages of applying specific rotary instruments for pediatrics are significant compared with standard techniques (Table 2) (Jeevanandan, 2017; Govindaraju et al., 2018; 2024). Depending exclusively on conventional procedures results in prolonged treatment time and irregularity in canal taper (Panchal et al., 2019). Specific pediatric files (Kedo-S, for example), which have shorter working lengths (16 mm) and differently shaped handles that fit pediatric handpieces and pediatric mouths, are used instead (Jeevanandan, 2017). A successful pulpectomy makes certain that periapical tissue is healthy and supports supporting the functionality of the tooth until its natural exfoliation. The success of a treatment is evident from the healing of bone in radiographs along with the lack of any signs and symptoms (Subramanyam and Tirupathi, 2021).

The case reports indicate that the dedicated pediatric rotary systems offer an efficient means for avoiding the necessity of manual instrumentation (Prabhakar et al., 2020; Prabhakar and Nagarathna, 2022). Early reservations about using rotary instruments in children were associated with concerns about file breakage and the absence of tactile sensation (Barr et al., 2000). This problem may be avoided by following appropriate speed and torque values, yet ongoing clinical education is required. Until 2015, there were no dedicated pediatric file systems; however, in recent years, some progress in this area has been made (Jeevanandan, 2017; Panchal et al., 2020). Currently, engine-driven pulpectomy is recognized as an efficient procedure in pediatric dentistry.

Table 2. Comparison of Instrumentation Approaches in Primary Molar Pulpectomy

Parameter	Manual K-Files	Adapted Adult Rotary Systems	Dedicated Pediatric Rotary (e.g., Kedo-S)
Working Length & Design	Standard 21–25 mm lengths	Long shaft; requires manual depth adjustment	Shortened shaft (16–18 mm) tailored for children
Flexibility & Metallurgy	Rigid Stainless Steel	Conventional or Heat-Treated NiTi	Advanced Heat-Treated NiTi (Blue/Gold Wire)
Obturation Quality	Variable density; risk of voids	High density; risk of over-extension	High density; controlled taper prevents over-filling
Child Behavior Impact	Lower cooperation due to extended time	Improved cooperation	Optimal cooperation due to rapid completion

Obturation Quality, Long-Term Radiographic Success, and Clinical Considerations

A hermetic and voidless obturation of the primary root canals is very important to avoid further infection and to secure longevity of the procedure (Bahrololoomi and Ahlstedt, 2014; Selvakumar and Jeevanandan, 2023). Absorbable paste types are used by clinicians in order to obturate the root canals, for example, zinc oxide-eugenol, iodoform, or calcium hydroxide pastes (Metapex, Endoflas) (Reddy et al., 2022). Only a few prospective studies have examined the connection between the preparation procedure and obturation density in primary teeth (Subramanyam and Tirupathi, 2021; Tyagi et al., 2020).

Fewer still have compared the resorbability of filling materials between those made in canals prepared using rotary files versus hand files (Selvakumar and Jeevanandan, 2023). In one recent study, it was shown that smooth and tapering canals created using rotary files aid in easy insertion of paste material, thus limiting any voids internally. It was observed that in cases where there is a funnel preparation, paste insertion can be done deeply without trapping any air (Bahrololoomi and Ahlstedt, 2014). Other researchers reported variable filling densities depending on the operator's filling technique.

An observational study on the effectiveness of pulpectomy using pediatric rotary files was done by Subramanyam and Tirupathi in 2021. During two years of observation, the success rate for rotary-filed teeth was found to be more than 90%, which was similar to or even higher than that of hand-filed controls.

The complications observed throughout the various studies were attributed to poor coronal seal or physiological root resorption that existed before treatment, not the type of files used (Subramanyam and Tirupathi, 2021; Smaïl-Faugeron et al., 2018). This finding indicates that mechanized preparation is the solid foundation for the retention of primary teeth. Before biomechanical preparation, it is important for dentists to measure root length and physiologic resorption from preoperative X-rays (Musale et al., 2016). Root canal

instrumentation should always be confined to the anatomic root canal without damaging the permanent tooth germ underneath (Alhayki et al., 2025).

Use of unheated and heavy rotary instruments is not recommended in patients with high root curvature to prevent future perforations (Ramezanali et al., 2017). Clinical and radiographic monitoring is important in ensuring healing of the periapical area and root resorption (Elheeny and Abdelkarim, 2020). Pediatric dentists are supposed to detect any symptoms of non-cooperation in early stages and apply the right single-file technique where appropriate (Makarem and Ghasemi, 2014). Parents are supposed to receive proper education about the pulpectomy process before the treatment (Smaïl-Faugeron et al., 2018; Marais et al., 2023).

4. CONCLUSION

Though there have been major gains in understanding the use of rotary instruments for pulpectomy in primary molars, clinical application still requires appropriate system selection. Present-day literature offers sufficient proof for certain protocols, whereas others need to be investigated clinically. The research concludes that the following treatment approaches are ideal for children who undergo pulpectomy: using pediatric rotary files with altered shafts and conservatively tapered files, using heat-treated nickel titanium alloys via curved canals, and using single-file continuous or reciprocal preparations to reduce treatment time. Complementary innovations comprise heat-treated Blue and Gold wires that provide a flexible and safe way to preserve the existing shape of the canals during biomechanical preparation.

In the current state of knowledge, it is possible to differentiate between definite clinical indications and cases that need more caution. Teeth with pronounced physiological root resorption (more than one-third of the root length) need more caution because active mechanical instrumentation could result in periapical damage in such situations. Another indication for more caution includes severely curved roots with thin dentin walls because they can easily get perforated by adult taper files. Preparation of root canals without proper torque control and working length determination is beyond the scope of safety in pediatric endodontics. There is great potential in the use of a single-file reciprocating system in primary teeth in the long term. However, the area needs more clinical multi-center trials to determine standard protocols.

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Informed consent

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Ethical approval

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Conflict of interest
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Data and materials availability
All data associated with this study will be available based on the reasonable request to corresponding author.

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