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REVIEW

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Machine assisted instrumentation for preparation of primary teeth: an umbrella review

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Abstract

Maintaining primary teeth in optimal anatomical and functional condition until physiological exfoliation is crucial for the healthy development of permanent dentition. Trauma and extensive carious lesions may result in pulp involvement, necessitating endodontic treatment. Various techniques for the instrumentation of root canals in primary teeth, including both manual and rotary instruments, are potential treatment options. This study aims to evaluate, through an umbrella review, the feasibility of rotary instrumentation of root canals in primary teeth for clinical practice. The work is grounded in Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines and seeks to address the following PICO question: In primary teeth undergoing endodontic treatment (P), is it feasible (O) to perform rotary instrumentation (I) compared to the conventional (manual) root canal preparation technique (C)? The data sources utilized were PubMed, Web of Science and Scopus, supplemented by manual search. The methodological quality of the included studies was assessed using the A Measurement Tool to Assess Systematic Reviews (AMSTAR-2) tool, while the risk of bias was evaluated with the Risk of bias (ROBIS) tool. Two reviewers independently conducted the quality assessment and risk of bias analyses. The search identified several potentially relevant references, resulting in a total of 39 publications. However, after applying the eligibility criteria, only three articles were ultimately included in the review. Regarding the principal findings, no systematic review provided a defiNi-Tive conclusion concerning the optimal method of root canal instrumentation in primary teeth. However, empirical data have shown that rotary canal preparation in rotary root canal preparation in primary teeth reduces clinical working time and, due to its various kinematics and instrument designs, facilitates the filling process. Nevertheless, we cannot defiNi-Tively assert that this method yields superior benefits for treatment outcomes.

Keywords

Endodontic treatment; Rotary instrumentation; Primary teeth; Pediatric dentistry

1. Introduction

Primary teeth play a crucial role in the overall health and development of a child, contributing to aesthetic appearance, phonetics, mastication and occlusal function, as well as facilitating the proper development of the permanent dentition and stomatognathic system [1]. However, dental trauma and caries can compromise pulp vitality, potentially leading to conditions such as irreversible pulpitis. In such instances, endodontic treatment (ET) becomes necessary to prevent premature tooth loss [1].

Endodontic treatment in primary teeth can be categorized into two main types: conservative and radical. Conservative treatment is applicable when the pulp is still vital, as seen in cases of pulp hyperaemia or acute reversible pulpitis. Techniques such as indirect pulp capping, selective caries removal, direct capping or pulpotomy may be warranted. Conversely, radical treatment is indicated when the pulp is severely compromised, as observed in irreversible pulpitis, chronic degenerative pulpitis, and pulp necrosis [1–3]. Numerous studies support the efficacy of ET in cases of pulp necrosis, with or without associated radiographic lesions, and in chronic degenerative pulpitis, as long as the tooth is deemed restorable and there is adequate periodontal support, without any contraindicating health factors [4–8].

Over the years, technologies developed for permanent teeth have increasingly been adapted for use in primary teeth. For example, a meta-analysis conducted by Ahmad *et al.* [9] indicates that electronic foraminal locators provide an adequate level of precision for assessing root canal morphology in primary teeth.

Endodontic treatment may utilise manual or rotary instru-

mentation systems, employing either stainless steel or nickel-titanium (Ni-Ti) files in both deciduous and permanent dentitions [8, 10–13]. Rotary systems tend to be more efficient, reducing clinical time and the physical strain on practitioners. Moreover, advancements in kinematics and instrument design have enhanced disinfection and shaping abilities [4, 13]. The automation of root canal preparation in primary teeth has increasingly involved the use of rotary or reciprocating systems equipped with Ni-Ti files of various designs [6]. The introduction of rotary instruments with Ni-Ti files addressed the limitations associated with stainless-steel hand files, yielding positive outcomes in terms of root canal cleanliness and preservation of the original anatomy. Over the years, rotary Ni-Ti systems have evolved, presenting a diverse range of designs and techniques that facilitate rapid preparation while maintaining the original morphology of even curved canals [13, 14].

Despite the higher acquisition costs associated with rotary instruments, they offer comparable canal cleaning and shaping outcomes to traditional instrumentation, while significantly reducing operational time [8, 11]. When choosing an instrumentation technique, it is essential to consider the unique anatomical features of primary teeth, including reduced dentin wall thickness, particularly in molars, shorter root lengths, and the potential for rhizolysis [2, 12, 13]. The primary objectives during ET for deciduous teeth are to maintain the tooth until natural exfoliation occurs and to ensure optimal development of the successor tooth bud [5, 14].

In summary, the evolution of endodontic techniques applied to permanent dentition continues to be informed by evidence-based knowledge, and there is a growing interest in their application to primary teeth.

Despite the proliferation of studies examining the efficacy and safety of rotary instrumentation in paediatric dentistry, the results can vary significantly due to differences in methodologies, sample sizes, and specific instruments used.

The integration of findings from multiple systematic reviews enhances the generalisability of conclusions drawn about rotary instrumentation. Considering the diversity in patient populations and the varying contexts of clinical practice, an umbrella review will allow for the extrapolation of findings that can be applicable across different settings. This broad applicability is vital in ensuring that the recommendations made are relevant to a wide range of practitioners and patient cohorts. Conducting an umbrella systematic review on rotary instrumentation for primary teeth holds considerable significance. It not only provides a comprehensive synthesis of the existing evidence but also enhances the potential for improved clinical outcomes, identifies research gaps, critiques current methodologies, and broadens the applicability of findings. Studies concerning rotary instrumentation in primary teeth often yield contradictory findings, which can complicate clinical decision-making. Some reviews indicate that rotary instruments may enhance the quality of canal preparation by improving the efficacy of cleaning and shaping procedures, while others report no significant advantage over traditional hand instrumentation concerning outcomes such as postoperative pain and treatment success rates.

Being so, this review aims to evaluate the efficacy and feasibility of employing rotary instrumentation in the endodontic treatment of primary teeth root canals, particularly as performed by paediatric dentists or practitioners who manage paediatric dental care.

2. Materials and methods

2.1 Research question

This umbrella review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, and the study has been registered on the OSF Platform (registered report) at https://osf.io/3pg6y/. Moreover, this investigation sought to address the following specific research question framed in the PICO (Population, Intervention, Comparison, Outcomes) format: In primary teeth undergoing endodontic treatment (P), is it feasible (O) to employ rotary instrumentation (I) in comparison to the conventional manual preparation technique for the root canal system (C)?

2.2 Study search and selection strategy

Primarily, this umbrella review involved a comprehensive bibliographical search, conducted across selected databases namely Medline/PubMed, Web of Science and Scopus to identify published articles. Initially, titles and abstracts of the retrieved articles were screened for relevance. A full-text review of the shortlisted articles was conducted to ensure they met the defined inclusion criteria.

The search strategy defined for each database was the following:

- Medline/PubMed

((“primary teeth” OR “primary tooth”) AND (“pulpectomy” OR “endodontic treatment” OR “pulp treatment” OR “pulp therapy”) AND (“root canal instrumentation” OR “hand instrumentation” OR “rotatory instrumentation” OR “reciprocating instrumentation”) AND (“systematic review” OR “Syst Rev” OR overview OR re-view))

- Web of Science database

TS = ((“primary teeth” OR “primary tooth”) AND (“pulpectomy” OR “endodontic treatment” OR “pulp treatment” OR “pulp therapy”) AND (“systematic review” OR “Syst Rev” OR overview OR review))

- Scopus database

TITLE-ABS-KEY = ((“primary teeth” OR “primary tooth”) AND (“pulpectomy” OR “endodontic treatment” OR “pulp treatment” OR “pulp therapy”) AND (“root canal instrumentation” OR “hand instrumentation” OR “rotatory instrumentation” OR “reciprocating instrumentation”) AND (“systematic review” OR “Syst Rev” OR over-view OR review))

2.3 Eligibility, inclusion and exclusion criteria

All titles and abstracts of the selected studies were evaluated by two independent reviewers (ACVMM and MPD), with a third reviewer (PC) intervening in cases of discrepancies. The selection process adhered to the following inclusion criteria: (1) the study employed a systematic review methodology; (2)

it focused on endodontic instrumentation in primary teeth; (3) it constituted a systematic review of randomised clinical trials. Following the iNi-Tial screening, articles that fulfilled the inclusion criteria were selected for comprehensive full-text analysis. Conversely, those articles that met any of the subsequent exclusion criteria were discarded: (1) absence of a systematic review of clinical trials; (2) lack of comparative analyses between instrumentation techniques for primary teeth; and (3) classification as critical reviews, narrative reviews, letters to the editor, or guidelines.

2.4 Data extraction

Initially, data were extracted from the articles and systematically organised into an Excel spreadsheet. The following parameters were collected: authors and year of publication, protocol registration, total number of included articles, databases accessed, search date, number of reviewers involved, language of the articles, outcomes measured, type of root canal instrumentation employed, additional variables investigated, comparison groups, follow-up period, quality assessment, and risk of bias (including the questionnaires utilised), as well as the findings from the meta-analysis. A qualitative analysis was subsequently conducted.

2.5 Methodological evaluation of articles included by the AMSTAR-2 and ROBIS tool

The methodological quality of this umbrella review was evaluated using the A Measurement Tool to Assess Systematic Reviews (AMSTAR-2) tool [15], while the risk of bias was assessed utilizing the ROBIS framework [16]. Two reviewers (ACVMM and MPD) independently conducted the quality and risk of bias analyses. Any uncertainties and discrepancies were discussed, and a consensus was reached.

3. Results

3.1 Studies selection

The initial systematic review of the literature identified 39 potentially relevant references. A total of 17 publications were sourced from PubMed, 9 from Scopus, and 13 from Web of Science. Within the PubMed database, 10 articles were excluded as they were not systematic reviews, and 6 additional articles were excluded because they did not compare different instrumentation techniques, resulting in a total of one article meeting the criteria (Chugh *et al*. [17], 2020). In the Scopus database, seven articles were excluded for failing to compare various instrumentation techniques, and one duplicate article was identified, ultimately, leaving one article (Manchanda *et al*. [18], 2020). Within the Web of Science, 11 articles were excluded for not comparing instrumentation techniques, and two articles were excluded as they pertained exclusively to permanent teeth, leaving no remaining articles from this source. The search strategy was supplemented by a manual review, which successfully identified one additional article [19]. The remaining articles underwent comprehensive analysis for detailed information. Ultimately, three publications met the eligibility criteria and were included in this umbrella review. The study selection process is illustrated in Fig. 1.

3.2 Characteristics of the studies

Table 1 (Ref. [17–19]) presents the characteristics of the studies included in this systematic review. All articles, with the exception of one (Faghihian *et al*. [19], 2021), adhered to a registration protocol. Each article posed a specific research question framed within the PICO format and conducted a meta-analysis. The number of articles included in the systematic reviews varied, ranging from 7 to 13. Most studies employed multiple databases as sources for research. It was noted that the article selection process was conducted independently by two reviewers, with a third reviewer being consulted when necessary. All articles specified the inclusion and exclusion criteria used in their selection process. In terms of assessing the risk of bias among the included studies, all utilised various tools for this analysis. The selected studies included a quality analysis and encompassed articles published in English. Notably, no systematic review reached a defiNi-Tive conclusion regarding the optimal method of root canal instrumentation in primary teeth. However, a reduction in operating time was identified as a clinically beneficial outcome.

3.3 Assessment of methodological quality

Table 2 (Ref. [17–19]) presents the criteria employed for the methodological qualitative analysis of studies utilizing the AMSTAR-2 tool, along with the corresponding findings. The criteria under analysis, including data extraction, selection of duplicate studies, comprehensive literature searches, characteristics of the included studies, scientific quality of conclusions, appropriate methods for synthesizing results, and declarations of conflicts of interest, received positive evaluations for all included articles [17–19].

Conversely, the “a priori” design criterion was rated negatively for all included articles. None of the articles provided a comprehensive list of included and excluded studies. The scientific quality of the included studies was assessed and reported in just one article (Chugh *et al*. [17], 2020).

3.4 Assessment of risk of bias

The criteria employed for the risk of bias analysis of the included studies, assessed using the ROBIS tool, as well as the corresponding results, are detailed in Table 3 (Ref. [17–19]). The study by Chugh *et al*. [17] was found to meet all evaluated criteria positively. Similarly, the studies by Manchanda *et al*. [18] and Faghihian *et al*. [19], published in 2020 and 2021 respectively, demonstrated a low risk of bias; however, their evaluations for the criterion concerning data collection and study evaluation were inconclusive.

4. Discussion

In recent years, rotary instrumentation for root canal treatment in primary teeth has garnered considerable attention, leading to an increasing number of studies in this area. Several systematic reviews have been published on this topic, highlighting the importance of conducting an umbrella review. Understanding

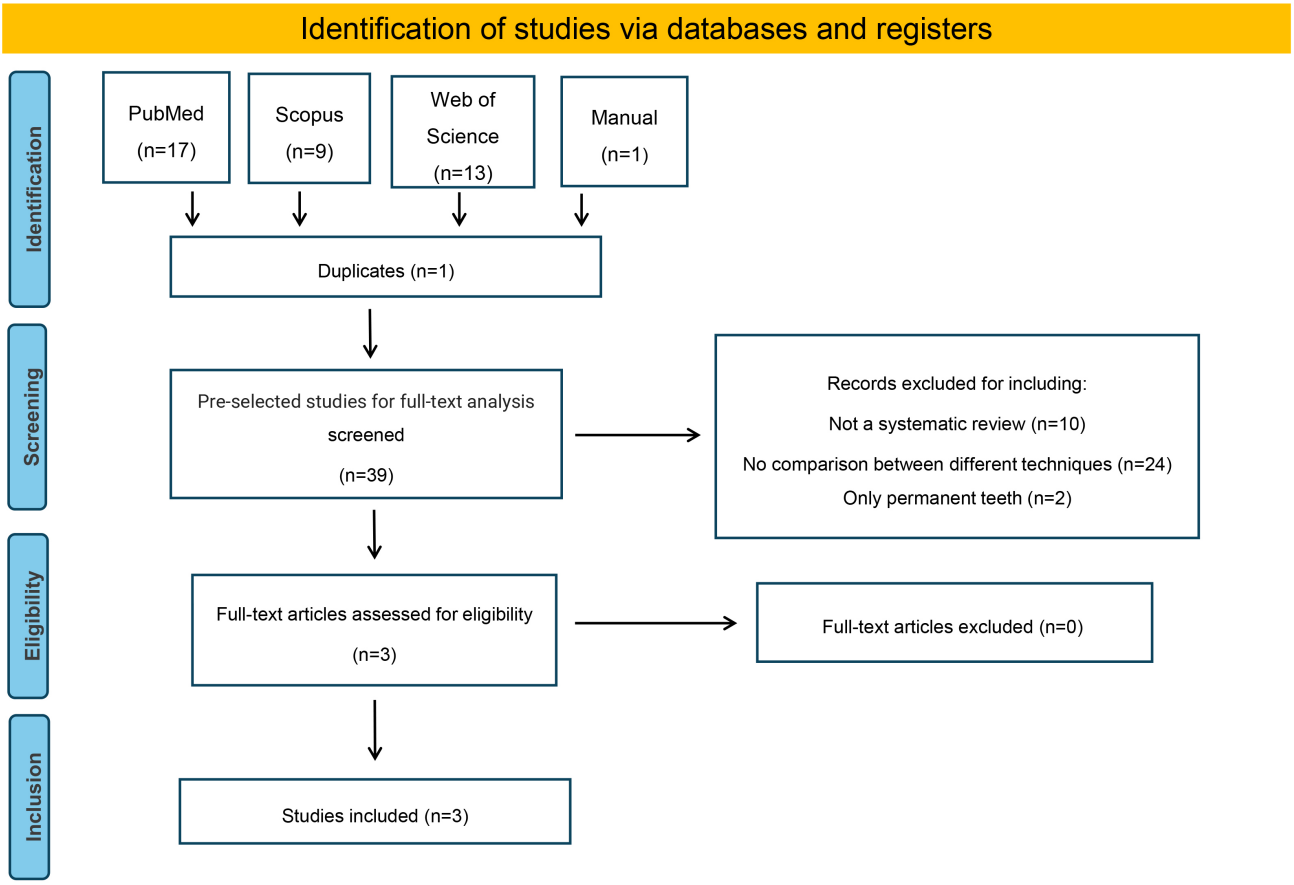

FIGURE 1. Overview of the article selection procedure according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

the level of scientific evidence is crucial for making informed clinical decisions regarding this preparation technique in primary teeth. Consequently, the objective of this review was to evaluate the feasibility of rotary instrumentation of root canals in primary teeth within the clinical practice of paediatric dentistry and among clinicians who provide care for children.

This study adhered to the PRISMA guidelines. A registration was completed on the OSF Platform, and a specific research question was formulated using the PICO (Population, Intervention, Control, Outcomes) framework: In primary teeth undergoing endodontic treatment (P), is it feasible (O) to perform rotary instrumentation (I) compared to the conventional (manual) root canal preparation technique (C)? A search strategy was developed to identify studies based on predefined inclusion and exclusion criteria. Data were extracted from the included studies, followed by a descriptive analysis and an assessment of methodological quality and risk of bias. All studies formulated a specific question using the PICO format, conducted meta-analyses, and employed multiple databases as sources of research. They also established eligibility, inclusion and exclusion criteria. The three included studies focused on comparing different techniques—manual and rotary—for root instrumentation in primary teeth.

Among the three selected articles, clinical operating time, cleaning and shaping efficacy, and clinical success rates were compared and analyzed. Chugh *et al.* [17] (2020) evaluated the time taken for instrumentation and root filling, along with the quality of the filling and both clinical and radiographic success. This study demonstrated a significant reduction in instrumentation and filling times, with the rotary technique notably enhancing both instrumentation duration and filling quality. However, no significant differences in clinical and radiographic success were observed between the techniques assessed. Similarly, Manchanda *et al.* [18] (2020) examined clinical and radiographic success rates, instrumentation and filling times, root cleaning efficiency, filling quality, and post-operative pain, reporting comparable success rates for both manual and rotary techniques. Faghihian *et al.* [19] (2021) conducted an evaluation of instrumentation times and the quality of dental fillings. Their findings indicate that, although the rotary technique significantly reduced instrumentation time and enhanced the quality of root canal preparation in primary teeth, it did not mitigate the risk of underfilling or overfilling when compared to the manual technique.

The conventional manual instrumentation of primary teeth remains widely accepted as the standard technique in paediatric dentistry. However, rotary endodontic methods offer several advantages, including reduced treatment duration and a lower incidence of operator-induced iatrogenic complications, such as ledges and root perforations [4, 5].

TABLE 1. Characteristics of the studies included.

Author Year	Title	Registered protocol	Articles included	Inclusion criteria	Studied groups	Outcomes evaluated	Results
Chugh *et al.* [17] 2020	Clinical differences of hand and rotary instrumentations during biomechanical preparation in primary teeth—a systematic review and meta-analysis	Yes	11	Participants with less than 10 years, with irreversible pulpitis, necrotic pulps, and teeth with minimal or no resorption.	Manual *vs.* rotary	Instrumentation time, quality of obturation, obturation time, clinical and radiographic success.	Significant decrease in instrumentation and obturation time with rotary devices. Optimal quality of filling in significantly number of teeth with rotary instrumentation. Both techniques showed similar clinical and radiographic success.
Manchanda *et al.* [18] 2020	A systematic review and meta-analysis of randomized clinical trials comparing rotary canal instrumentation techniques with manual instrumentation techniques in primary teeth	Yes	13	Root Canal Treatment with different types of rotary instrumentation techniques were compared to manual techniques.	Manual *vs.* rotary	Instrumentation time, quality of obturation, obturation time, clinical and radiographic success, postoperative pain, cleaning effectiveness.	Rotary instrumentation had a similar clinical and radiographic success rate, less postoperative pain (at 6 and 48 h) and took less instrumentation time compared to manual instrumentation techniques.
Faghihian *et al.* [19] 2021	Rotary versus manual instrumentation for root canal preparation in primary teeth: a systematic review and meta-analysis of clinical trials	No	7	Studies that investigate effectiveness of Rotary Instrumentation for pulpectomy of primary teeth compared to manual file.	Manual *vs.* rotary	Assessed instrumentation time, obturation time, and obturation quality.	Rotary instrumentation decreases instrumentation time and increase the rates of optimally filled canals in primary teeth. However, rotary instrumentation does not decrease the risk of underfilling and overfilling compared to manual files.

RCT: Randomized Clinical Trial; RI: Rotary instrumentation.

TABLE 2. Criteria adapted for the analysis of the methodological quality of the studies and their respective responses, according to AMSTAR-2 tool.

Author/Year \ Criteria	Was an "a priori" design provided?	Was there duplicate study selection and data extraction?	Was a comprehensive literature search performed?	Was the status of publication?	Was a list of studies?	Were the characteristics of the included studies provided?	Was the scientific quality of the included studies assessed and documented?	Was the scientific quality of the included studies used appropriately in formulating conclusions?	Were the methods used to combine the findings of studies appropriate?	Was the likelihood of publication bias assessed?	Was the conflict of interest stated?
Chugh *et al.* [17] 2020	NO	YES	YES	YES	NO	YES	YES	YES	YES	YES	YES
Manchanda *et al.* [18] 2020	NO	YES	YES	NO	NO	YES	NO	YES	YES	YES	YES
Faghihian *et al.* [19] 2021	NO	YES	YES	NO	NO	YES	NO	YES	YES	YES	YES

TABLE 3. HR and incidence rates for MACEs among male patients with different types of SD (subgroup analysis).

Author/Year \ Criteria	1. Study eligibility criteria	2. Identification and selection of studies	3. Data collection and study appraisal	4. Synthesis and findings	5. Risk of bias in the review
1. Chugh *et al.* [17] 2020	☺	☺	☺	☺	☺
2. Manchanda *et al.* [18] 2020	☺	☺	?	☺	☺
3. Faghihian *et al.* [19] 2022	☺	☺	?	☺	☺

☺ = *low risk; ? = unclear risk.*

To effectively manage the delicate anatomy of primary teeth, the materials and design of files must meet specific criteria: they should be constructed from flexible and resilient alloys and exhibit appropriate kinematics for shaping tapered root canals [4, 6]. The development of rotary nickel-titanium (Ni-Ti) alloys has significantly advanced, with current iterations showing improvements in gauge, taper and length [11, 12]. The materials used for file manufacture must possess specific characteristics, including enhanced flexibility, to better accommodate the anatomy of primary teeth's root canals, thereby significantly diminishing the risk of complications such as steps or perforations [13].

Endodontic treatment in deciduous teeth comprises several stages, one of which is the preparation of root canals, typically performed with manual instruments [1, 4, 6]. Notably, the instrumentation and filling times associated with rotary techniques were significantly shorter across all studies, which may contribute to reduced postoperative pain. While clinical and radiographic outcomes exhibited comparable success rates for both preparation techniques, it is essential to note that these findings cannot be deemed conclusive due to various confounding factors, including operator skill, patient cooperation, choice of irrigants, filling techniques, and filling materials. Longitudinal studies are warranted to further investigate these variables [18]. Nevertheless, a reduction in chairside time is anticipated to enhance patient cooperation and, concurrently, alleviate fatigue for both the patient and the dental professional.

The iNi-Tial pulpal condition—acute inflammation with or without necrosis—alongside the status of the periodontal tissue, the presence of a translucent radiographic lesion, the thickness of the dentinal wall removed, the choice between single or multiple instrumentation systems, and the degree of apical debris extrusion represent critical factors that warrant thorough investigation to establish robust scientific evidence supporting the use of rotary instrumentation in primary teeth [20, 21].

The decrease in clinical time associated with rotary instrumentation is well-documented in the literature. In essence, the use of rotary instruments significantly reduces clinical time requirements [22]. Nonetheless, additional factors, which have been minimally considered in existing studies, require further exploration. Notably, the relationship between the anatomy of root canals in primary teeth and various kinematic movements, as well as instrument designs, is of particular interest [22]. It is well established that the risk of perforations is heightened due to the thin and shorter nature of deciduous roots anatomy compared to that of permanent teeth. Furthermore, the challenge of achieving optimal disinfection in uninstrumented areas of the root canal system during preparation remains inadequately addressed, especially in irregular anatomical zones (*e.g.*, isthmus), particularly in cases of existing root resorption, where the risk of compromising adjacent periodontal tissues is elevated. The disinfection process should continue until the conditions necessary to achieve its intended purpose are established. The duration of time spent on instrumentation is not thoroughly detailed in the studies included in this review.

By investigating these issues, pediatric dentists and clinicians who work with children will be able to access clinical guidelines on optimal approaches for treating the root canals of primary teeth. These guidelines will consider various factors, including cost, feasibility, time efficiency, and success rates, among others [23, 24]. It is essential to note that these recommendations are predicated upon adherence to manufacturer standards, recogNi-Tion of the inherent learning curve associated with new techniques, and an appreciation for the unique considerations of pediatric dentistry.

Indeed, there are currently available peadiatric instruments on the market, such as Prime Pedo™ and Kedo-SG Blue™, which are rotary file systems specifically developed for use in primary teeth that show promising potential [25, 26]. Furthermore, it has been observed that dentinal microcracks can occur with both hand and rotary file systems when performing endodontic procedures on primary teeth [27]. This undesirable phenomenon must be taken always into consideration when undertaking the instrumentation of the root canal system.

Consequently, it is imperative for clinicians to critically evaluate the available evidence and consider individual case factors when selecting instrumentation techniques for endodontic treatment in primary teeth.

5. Conclusions

This umbrella review concludes that:

- Rotary root canal preparation in primary teeth reduces clinical operative time, which represents a significant advantage for pediatric patients.

- Long-term clinical and radiographic success rates of endodontic treatment in primary teeth are comparable between manual and rotary instrumentation techniques.

- Rotary root canal preparation, including the cleaning and shaping of root canals, is a viable technique for administering endodontic treatment in primary teeth.

- Further well-controlled randomized clinical studies, employing rigorous randomization criteria and predefined target variables, are necessary to enhance the evidence base for such challenging procedures in pediatric dentistry.

AVAILABILITY OF DATA AND MATERIALS

The data are contained within this article.

AUTHOR CONTRIBUTIONS

MD—collected and processed the data. PCL—processed the data and drafted the manuscript. AMT—drafted the manuscript. NV—revised the final document. PC—collected and processed the data and revised the final document. ACMM—designed the study, collected and processed the data and revised the final document.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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