

Pulp therapy in primary teeth with irreversible pulpitis or necrosis: a literature review

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Abstract: For many professionals, pulpectomy in primary teeth is a challenging procedure due to the technical difficulty and complexity of the root canals. In addition, there is a wide variety of techniques and materials available. This review aims to summarize and compare the scientific evidence on pulpectomy in primary teeth. The bibliographic search was performed in the PubMed database in August 2022 and updated in June 2023. Two reviewers independently assessed studies according to the following inclusion criteria: systematic reviews with or without meta-analysis, published in the last 10 years. The certainty of the evidence (GRADE) was taken from the original article. Disagreements were resolved by a third reviewer. Two hundred and thirty-six studies were retrieved. After reading, 31 studies were evaluated for eligibility and 25 systematic reviews were included. The studies were developed in 11 countries, with Brazil (n=7) and India (n=6) accounting for most studies. The year of publication varied between 2014 and 2023, with the years 2021 (n=8) and 2022 (n=5) having the largest number of studies. The certainty of the evidence of most of the studies was which moderate to very low. This review concluded that there is still insufficient evidence to determine which of the different techniques and materials are most effective, leaving it up to the clinician to choose the clinical protocol to be used.

Key words: pulpectomy, root canal therapy, deciduous tooth, review.

Terapia pulpar en dientes deciduos con pulpitis irreversible o necrosis: una revisión de la literatura

Resumen: Para muchos profesionales, la pulpectomía en dientes temporales es un procedimiento desafiante debido a la dificultad técnica y la complejidad de los conductos radiculares. Además, existe una amplia variedad de técnicas y materiales disponibles. Esta revisión tiene como objetivo resumir y comparar la evidencia científica sobre pulpectomía en dientes temporales. 10 años. La certeza de la evidencia (GRADE) fue tomada del artículo original. Los desacuerdos fueron resueltos por un tercer revisor. Se recuperaron doscientos treinta y seis estudios. Después de la lectura, se evaluó la elegibilidad de 31 estudios y se incluyeron 25 revisiones sistemáticas. Los estudios se llevaron a cabo en 11 países, siendo Brasil (n=7) e India (n=6) responsables de la mayoría de los estudios. El año de publicación varió entre 2014 y 2023, siendo los años 2021 (n=8) y 2022 (n=5) los de mayor número de estudios. La certeza de la evidencia para la mayoría de los estudios fue de moderada a muy baja. Esta revisión concluyó que aún no existe evidencia suficiente para determinar cuáles de las diferentes técnicas y materiales son más efectivos, y corresponde al profesional elegir el protocolo clínico a utilizar.

Palabras clave: pulpectomía, tratamiento del conducto radicular, diente deciduo, revisión.

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Terapia pulpar em dentes decíduos com pulpite irreversível ou necrose: uma revisão de literatura

Resumo: Para muitos profissionais, a pulpectomia em dentes decíduos é um procedimento desafiador devido à dificuldade técnica e complexidade dos canais radiculares. Além disso, existe uma grande variedade de técnicas e materiais disponíveis. Esta revisão tem como objetivo resumir e comparar as evidências científicas sobre pulpectomia em dentes decíduos. A busca bibliográfica foi realizada na base de dados PubMed em agosto de 2022 e atualizada em junho de 2023. Dois revisores avaliaram de forma independente os estudos de acordo com os seguintes critérios de inclusão: revisões sistemáticas com ou sem meta-análise, publicadas nos últimos 10 anos. A certeza de evidência (GRADE) foi retirada do artigo original. As divergências foram resolvidas por um terceiro revisor. Duzentos e trinta e seis estudos foram recuperados. Após a leitura, 31 estudos foram avaliados quanto à elegibilidade e 25 revisões sistemáticas foram incluídas. Os estudos foram desenvolvidos em 11 países, sendo o Brasil (n=7) e a Índia (n=6) responsáveis pela maioria dos estudos. O ano de publicação variou entre 2014 e 2023, sendo os anos de 2021 (n=8) e 2022 (n=5) os de maior número de estudos. A certeza de evidência da maioria dos estudos foi de moderada a muito baixa. Esta revisão concluiu que ainda não há evidências suficientes para determinar quais das diferentes técnicas e materiais são mais eficazes, cabendo ao profissional a escolha do protocolo clínico a ser utilizado.

Palavras-chave: pulpectomia, tratamento pulpar do canal radicular, dente decíduo, revisão.

Introduction

Primary teeth remain in the oral cavity for a shorter duration than permanent teeth; nevertheless, they fulfill several important functions. They contribute to chewing and swallowing, maintain the space necessary for the eruption of permanent teeth, and play a significant aesthetic role^{1, 2}. Given these functions, preserving primary teeth in functional condition is essential to prevent negative impacts on a child's quality of life^{3, 4}.

Pulp therapy is necessary in certain cases of dental trauma and extensive carious lesions. The choice of treatment—pulp protection, indirect or direct pulp capping, pulpotomy, or pulpectomy—depends on the health status of the pulp tissue^{3, 5}. For primary teeth exhibiting signs or symptoms of irreversible pulpitis or pulp necrosis, pulpectomy is recommended to preserve the integrity and health of the tooth and supporting tissues, allowing them to maintain their functions in the oral cavity until the eruption of the permanent tooth⁵.

Pulpectomy in primary teeth is a complex and challenging procedure, often causing apprehension and insecurity among professionals. It involves anesthesia, rubber dam isolation, and child behavior management, requiring a thorough understanding of the anatomical complexity of the primary root canal system^{3, 5}. Additionally, a wide range of instrumentation techniques, irrigants, materials, and filling methods are available⁵⁻⁷.

However, a consensus on the most recommended materials and protocols for clinical use remains lacking. This uncertainty in pediatric endodontic treatment often leads professionals to make choices based primarily on their familiarity with a particular technique or material^{1, 5, 8}. While contemporary dentistry prioritizes evidence-based practice, it also acknowledges the importance of clinical experience in therapeutic decision-making; both factors must be considered together. Therefore, it is essential for professionals to critically evaluate the effectiveness of available materials and techniques⁶.

Thus, this literature review aimed to summarize and compare the best available scientific evidence on pulpectomy in primary teeth.

Materials and methods

Search strategy and study selection:

The search was conducted in August 2022 and updated in June 2023 using a search strategy specific to the PubMed database (Table 1). Boolean operators OR/AND were employed to develop the search strategy by combining terms related to the topic and their synonyms, extracted from the Medical Subject Headings (MeSH) database: “pulp therap*”, “pulpal therap*”, “tissue pulpal”, “endodontic”, “nonvital pulp treatment”, “irreversible pulpitis”, “necrotic pulp”, “pulpectomy”, “lesion sterilization tissue repair”, “dental pulp”, “root canal preparation”, “root canal irrigants”, “root canal medicaments”, “root canal obturation”, “deciduous teeth”, “primary teeth”, “deciduous tooth” and “primary dentition.” Alternative keywords were tested but did not yield additional studies on pulpectomy in primary teeth. The following filters were

applied: systematic review, meta-analysis, and publication within the last 10 years.

Inclusion criteria:

- 1. Systematic reviews, with or without meta-analysis.
- 2. Studies published within the last 10 years.

Exclusion criteria:

- 1. Studies that diverged from the topic of interest.
- 2. Case reports, case series, animal studies, clinical trials, in vitro and ex vivo studies, non-systematic reviews, and guidelines.
- 3. Studies focusing on permanent teeth.

Two reviewers (M.E.O.G. and R.C.J.) independently assessed study titles and abstracts to determine eligibility. If the title and abstract did not provide sufficient information for decision-making, the full text was evaluated. All eligible studies were retrieved directly from the database or through direct

Table 1 - Search strategy applied in the PubMed database.

Database	Search strategy
PubMed	(pulp therap*[Title/Abstract] OR pulpal therap*[Title/Abstract] OR tissue pulpal[Title/Abstract] OR Endodontic*[Title/Abstract] OR nonvital pulp treatment[Title/Abstract] OR irreversible pulpitis[Title/Abstract] OR necrotic pulp[Title/Abstract] OR pulpectomy[Title/Abstract] OR lesion sterilization tissue repair[Title/Abstract] OR Dental pulp[Title/Abstract] OR preparation, root canal[MeSH Terms] OR irrigants, root canal[MeSH Terms] OR medicaments, root canal[MeSH Terms] OR obturation, root canal[MeSH Terms]) AND (deciduous teeth[Title/Abstract] OR primary teeth[Title/Abstract] OR deciduous tooth[Title/Abstract]OR primary dentition[Title/Abstract] OR primary dentition[MeSH Terms])

contact with the authors. Studies that could not be obtained after five e-mail attempts to contact the author were excluded. A third researcher (N.R.B.) was consulted in cases of disagreement. When multiple versions of the same eligible systematic review were identified, the most recent version was included.

Data extraction

Using a data extraction spreadsheet, two reviewers (M.E.O.G. and R.C.J.) independently collected data from the selected studies. Extracted data included the author, year of study, country, journal of publication, study purpose, clinical protocol, results, considerations, conclusion, and certainty of evidence (GRADE). If any necessary data were missing, the corresponding authors were contacted by e-mail. Cases of disagreement were discussed among the evaluators until a consensus was reached.

Regarding clinical protocols, the assessments included the method of working length (WL) determination during the pulpectomy procedure, canal instrumentation method, irrigating solutions, filling materials, filling method, number of sessions, and medications used between sessions.

Results

Initially, 236 studies were identified in the searched database. After evaluation, 205 were excluded for the following reasons: in vitro or animal studies (n=8), studies on

permanent teeth (n=4), studies whose full text could not be obtained after five e-mail attempts to contact the author (n=2), and studies that diverged from the topic of interest (n=191). Thirty-one studies were deemed eligible, but six were excluded as they fell into the categories of guidelines (n=1), letter to the readership (n=2), narrative review (n=1), or scoping review (n=2). Hence, 25 systematic reviews were included in this literature review. A bibliographic search flowchart is presented in Figure 1.

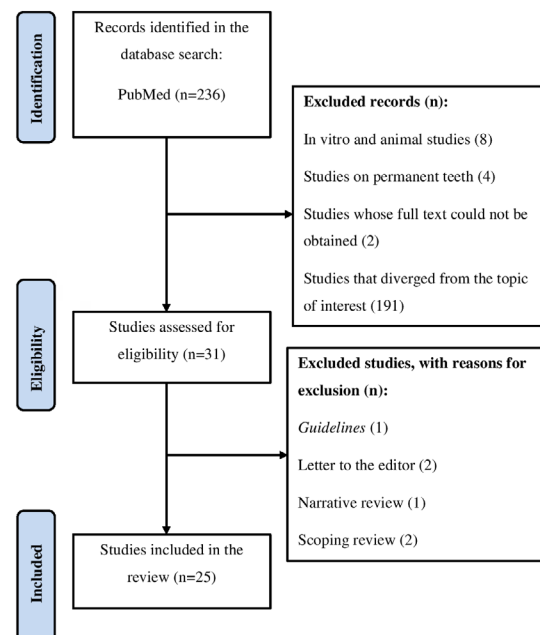


Figure 1. Flowchart depicting the bibliographic search process conducted in the study.

Characteristics of the studies:

Of the 25 systematic reviews selected, seven were conducted in Brazil^{2, 6, 9-13}, six in India¹⁴⁻¹⁹, two in Saudi Arabia^{20, 21}, two in China^{22, 23}, two in the United States^{8, 24}, and one each in Germany²⁵, Spain¹, France²⁶, Italy²⁷, Mexico²⁸, and Tunisia²⁹.

The reviews were published between 2014 and 2023, with most concentrated in 2021 (n=8) and 2022 (n=5). Twelve were published in general, non-area-specific journals^{1,2, 6, 10, 15, 16, 19, 21, 23, 24, 26, 29}, nine in pediatric dentistry journals^{8, 9, 12, 13, 14, 17, 18, 25, 28}, and four in endodontic journals^{11, 20, 22, 27}. The International Endodontic Journal (n=3) and the International Journal of Pediatric Dentistry (n=3) accounted for the highest number of publications on pulpectomy in primary teeth.

Three systematic reviews examined methods for determining working length^{11, 20, 27}; nine focused on instrumentation

methods^{1, 2, 10, 14, 16, 17, 19, 22, 24}; two, analyzed irrigation^{12, 28}; seven evaluated filling materials^{6, 13, 15, 21, 25, 26, 29}; one investigated filling methods⁹; two addressed the number of sessions and medication used between sessions^{18, 23}, and one covered all these topics⁸.

Only eight^{2, 6, 8, 10, 11, 14, 22, 26} of the included reviews assessed the certainty of evidence, which ranged from moderate to very low. A description of the objectives, number of studies included, conclusions, and certainty of evidence (GRADE) data of the selected reviews is presented in Table 2.

Table 2. Description of the included studies.

Author /Year	Number of studies	Purpose	Conclusion	Certainty of evidence (GRADE)
Agarwal <i>et al.</i> (2019) ¹⁹	3	To gather all literature comparing Vitapex with non-instrumental endodontic treatment in primary teeth with pulp involvement and to evaluate success rates based on clinical and radiographic outcomes.	There was no difference between non-instrumental endodontic treatment and Vitapex in terms of the associated success rates following treatment of primary teeth with pulp involvement. Non-instrumental endodontic treatment can be considered a treatment option for primary molars with pulp involvement.	Not evaluated.
Ahmad and Pani (2014) ²⁰	19	To conduct a meta-analysis on the accuracy of electronic apex locators in determining working length in human primary teeth.	Electronic apex locators demonstrated an acceptable level of accuracy in measuring root canal length in primary teeth. This, combined with the documented need to minimize radiation exposure in children, constitutes a compelling argument for their use for working length determination in primary teeth.	Not evaluated.
Arduim <i>et al.</i> (2021) ⁹	3	To evaluate the quality of root canal fillings in primary teeth performed using a Lentulo spiral compared to those obtained with other instruments.	There is insufficient scientific evidence to demonstrate the superiority of the Lentulo spiral for filling root canals in primary teeth. Given the limited level of evidence, professionals may select the instrument based on their preferences.	Not evaluated.

Table 2. Description of the included studies (cont.).

Author /Year	Number of studies	Purpose	Conclusion	Certainty of evidence (GRADE)
Boutsiouki et al. (2021) ²⁵	75	To evaluate the clinical outcomes of partial pulpotomy, pulpotomy, and pulpectomy for the treatment of primary teeth with normal pulp, infected pulp, or irreversible pulpitis.	The conditions, procedures and evaluation of pulpectomy were not well defined in the studies. However, there is evidence for the use of calcium hydroxide, zinc oxide and eugenol paste, or iodoform-based pastes as filling materials for nonvital molars.	Not evaluated.
Casaña Ruiz et al. (2022) ¹	11	To update information on the different rotary systems currently available and the results of their use in the endodontic treatment of primary teeth.	Rotary systems that adapt to the root anatomy of primary teeth and enable quick and straightforward instrumentation without causing excessive debris extrusion at the root apex yielded the best results in primary teeth.	Not evaluated.
Chouchene et al. (2021) ²⁹	5	To compare the effectiveness of different antibiotic mixtures used in non-instrumental endodontic treatment of primary teeth.	Based on overall success rates, the ciprofloxacin/minocycline/ornidazole mixture was more effective than the 3-Mix mixture, which, in turn, was more effective than the ciprofloxacin/tinidazole/minocycline and ciprofloxacin/metronidazole/clindamycin mixtures. However, given the limitations of the currently available evidence, it was not possible to determine the superiority of any specific mixture.	Not evaluated.
Chugh et al. (2021) ¹⁴	11	To ascertain the clinical differences between manual and rotary instrumentation in primary teeth.	Evidence indicates a significant reduction in instrumentation time (by 5 minutes) with rotary instrumentation.	Moderate.
Coll et al. (2020) ⁸	79	After a minimum of six months of follow-up, to determine the overall clinical and radiographic success of treatment options for nonvital primary teeth with extensive caries or trauma affecting the pulp and to evaluate the in vivo and in vitro factors that may have influenced outcomes.	For nonvital teeth, pulpectomy is recommended for long-term success (exceeding 24 months) in teeth without root resorption. Non-instrumental endodontic treatment is preferable to pulpectomy in nonvital teeth with root resorption when the tooth must be maintained in the arch for 12 months or less. The obturation method, number of treatment sessions, working length determination method, and irrigating solutions did not influence pulpectomy success rates.	Moderate to very low.

Table 2. Description of the included studies (cont.).

Author /Year	Number of studies	Purpose	Conclusion	Certainty of evidence (GRADE)
Duarte <i>et al.</i> (2020) ¹⁰	6	To evaluate whether the lesion sterilization and tissue repair technique achieves clinical and radiographic outcomes comparable to those of pulpectomy in primary teeth.	Of the six studies included in this systematic review, three found that conventional endodontic treatment of primary teeth was statistically more favorable based on radiographic criteria. However, the meta-analysis did not demonstrate a significant difference between treatments, regardless of follow-up period (6, 12, or 18 months) or type of assessment (clinical or radiographic).	Moderate to very low.
Elicherla <i>et al.</i> (2022) ¹⁵	8	To evaluate the clinical and radiographic outcomes associated with Endoflas® paste as a filling material for primary teeth.	Endoflas® paste is suitable as a root canal filling material for treating primary teeth with furcation radiolucency.	Not evaluated.
Jia <i>et al.</i> (2019) ²³	16	To analyze the effectiveness of calcium hydroxide compared to formocresol and camphorated phenol in disinfecting root canals of primary teeth.	The efficacy of calcium hydroxide in disinfecting the root canals of primary teeth was superior to that of traditional formocresol and camphorated phenol.	Not evaluated.
Junior <i>et al.</i> (2022) ⁶	21	To compare the effectiveness of iodoform-based and non-iodoform-based filling materials in the endodontic treatment of primary teeth.	Iodoform-based filling materials demonstrated superior clinical and radiographic performance in the short term and comparable performance in the long term.	Low to very low.
Khouqeer <i>et al.</i> (2021) ²⁴	13	To compare the effectiveness of manual and rotary instrumentation techniques in primary teeth.	The use of rotary instruments is more time-efficient, which may be particularly beneficial for treating apprehensive pediatric patients.	Not evaluated.
Lakshmanan <i>et al.</i> (2021) ¹⁶	3	To compare different instrumentation methods in terms of the incidence and intensity of post-pulpectomy pain in primary teeth.	Rotary instrumentation contributed to a lower incidence and intensity of postoperative pain compared to manual instrumentation.	Not evaluated.
Manchanda <i>et al.</i> (2020) ²²	11	To compare the effectiveness of rotary and manual instrumentation techniques for endodontic treatment in primary teeth.	Rotary instrumentation demonstrated similar clinical and radiographic success rates, lower postoperative pain (at 6 and 48 hours), and reduced instrumentation time compared to manual techniques.	Moderate.

Table 2. Description of the included studies (cont.).

Author /Year	Number of studies	Purpose	Conclusion	Certainty of evidence (GRADE)
Najjar <i>et al.</i> (2019) ²¹	15	To compare the success rate of pulpectomy using calcium hydroxide/iodoform versus zinc oxide-eugenol based on clinical and radiographic criteria.	Due to its resorbable property, calcium hydroxide/iodoform was the best filling material for pulpectomy in primary teeth in the exfoliation phase. However, zinc oxide and eugenol performed better in primary teeth far from exfoliation.	Not evaluated.
Natchiyar <i>et al.</i> (2021) ¹⁷	3	To compare the clinical and radiographic success rates of pulpectomy in primary molars using a rotary system and a manual file system.	Both manual and rotary instrumentation were effective in terms of treatment outcomes, with no clear superiority in clinical or radiographic success. Rotary systems offered an advantage over manual systems only in reducing instrumentation time.	Not evaluated.
Paradiso <i>et al.</i> (2022) ²⁷	14	To describe the methods used to determine working length in pulpectomies of primary teeth and compare their reliability.	The electronic apex locator, conventional radiography, and digital radiography were comparable in determining the working length in primary teeth.	Not evaluated.
Pedrotti <i>et al.</i> (2023) ¹³	7	To investigate the effect of different filling materials in reversing the failure of endodontic treatment in primary teeth with necrosis.	There is no scientific evidence supporting the superiority of any filling material for endodontic treatment of primary teeth with necrosis.	Not evaluated.
Pintor <i>et al.</i> (2016) ¹²	2	To determine whether the smear layer removal procedure influences the outcome of endodontic treatment.	Within the limitations of the few studies included, it can be concluded that the smear layer removal procedure may improve the outcome of endodontic treatment for primary teeth with initial clinical signs and symptoms of pulp necrosis.	Not evaluated.
Pozos-Guillen <i>et al.</i> (2016) ²⁸	7	To evaluate the clinical efficacy of intracanal irrigants used during pulpectomy in primary teeth.	Further high-quality studies, including comprehensive reports with summary measures of response variables and effect size, are needed to determine the most effective irrigating agents for use in pulpectomies.	Not evaluated.
Smaïl-faugeron <i>et al.</i> (2018) ²⁶	87	To evaluate the effects of different pulp treatment techniques and associated medications in the management of extensive caries lesions in primary teeth.	Regarding pulpectomy, there is no conclusive evidence indicating that one medication or technique is superior to another; therefore, the choice of medication remains at the discretion of the professional.	Moderate to very low.

Table 2. Description of the included studies (cont.).

Author /Year	Number of studies	Purpose	Conclusion	Certainty of evidence (GRADE)
Tedesco <i>et al.</i> (2021) ²	9	To determine the best treatment for extensive caries lesions with or without pulp involvement in primary teeth.	For pulp necrosis or irreversible pulpitis, no difference was observed between pulpectomy and non-instrumental endodontic treatment; therefore, there is no evidence supporting the superiority of one treatment over the other for irreversible pulpitis or pulp necrosis.	Moderate to very low.
Tirupathi <i>et al.</i> (2019) ¹⁸	4	To compare the efficacy of single-session versus multiple-session pulpectomy in infected primary teeth.	More evidence is needed to establish a pulpectomy protocol for primary teeth, whether single or multiple sessions. The single-visit protocol may be recommended for primary teeth, as the multiple-visit protocol requires more sessions, additional pain control, and repeated radiation exposure.	Not evaluated.
Vitali <i>et al.</i> (2022) ¹¹	29	To evaluate the accuracy of the electronic apex locator in determining the working length during pulpectomies of primary teeth.	Although the results suggest acceptable accuracy of the electronic apex locator in determining working length during pulpectomies of primary teeth, the low quality of the included studies and the very low quality of the associated evidence warrant caution in interpreting these results..	Very low.

Discussion

It is important to highlight that most systematic reviews did not assess the certainty of evidence, and when they did, the certainty ranged from moderate to very low. Few were able to perform meta-analyses due to the heterogeneity of the studies, which also hindered comparisons between reviews. Considering this, we gathered the relevant data that emerged from the analysis of the systematic reviews but were unable to conclude that robust data with high certainty of evidence exist on the topic, making it difficult to demonstrate the superiority of any technique or material over the others evaluated.

Most of the studies were published in journals covering various fields of dentistry, with nine appearing in pediatric dentistry journals, which generally have lower impact factors than endodontic journals. Only four studies were published in endodontic journals, suggesting a lack of interest in the treatment of primary teeth in many countries, despite its importance for children's health, development, and quality of life.

This review showed that most studies were conducted in developing countries, which may be related to the higher prevalence of pulp involvement caused by dental caries in these countries³⁰. However, this

observation may also reflect the alarming rates of tooth extractions performed under general anesthesia (GA) in developed countries³¹. In these countries, physical restraint of the child during dental treatment is not acceptable, and care for such patients often involves GA sessions to ensure a quick resolution and a more “child-friendly” approach. Under GA, pulp therapy for primary teeth with pulp involvement is not routinely performed to avoid the potential need for retreatment and repeated GA sessions, leading to the prioritization of tooth extraction as a therapeutic approach^{4,32}. This scenario, however, raises an important issue: extraction is a definitive treatment, but it does not resolve all related problems. Early tooth loss requires a space maintainer to prevent arch space loss, which adds to the overall treatment cost—an aspect that is often not considered during initial case planning⁴.

Endodontic treatment involves several stages, including an initial radiograph of the tooth, local anesthesia using the most appropriate technique, rubber dam isolation, coronal access with spherical burs, removal of all pulp tissue, working length determination, canal instrumentation, irrigation, and finally, filling with a biocompatible obturation paste²⁶.

Different methods have been proposed to determine working length (WL), including conventional radiography, digital radiography, and electronic apex locators²⁷. Although radiographs require the child’s compliance and provide two-dimensional images with the potential overlapping of structures, they remain the most widely used method^{11, 27}. In contrast,

the use of electronic apex locators is increasing, as they offer a fast and comfortable alternative while overcoming the limitations of radiographic techniques, such as structure superimposition and radiation exposure^{11,20, 27}.

Conventional radiography, digital radiography, and electronic apex locators are equally effective in determining WL²⁷. Apex locators have an acceptable level of accuracy⁹, although discrepancies may occur between the actual root canal length and the measurement obtained by the locator²⁰. Therefore, apex locators may be recommended as they can reduce children’s exposure to radiation^{11, 20}. Coll *et al.* (2020)⁸ concluded that there are no significant differences between the radiographic method and electronic apex locators in determining WL. These authors suggest that the choice of method does not affect the success of the procedure, leaving it to the professional’s discretion. However, it is noteworthy that the certainty of evidence in this study was very low⁸.

Several techniques are available for the instrumentation of root canals in primary teeth. The findings of this study indicate that hand files were the most widely used throughout the analyzed period; however, due to their low flexibility, their use can lead to iatrogenic errors, such as alterations in the original canal shape and perforations. Consequently, the use of rotary instrumentation has increased over the last decade, aligning with the trend toward shorter dental appointments^{16,22,24}. Two studies reported that rotary instrumentation was associated with a lower incidence of postoperative pain^{16, 22}; however, it is important to note that

the certainty of evidence for this outcome was moderate²².

The time required to treat a child is an important consideration, as lengthy procedures may lead to a loss of cooperation. All systematic reviews that assessed instrumentation time^{1,14,17,22,24} concluded that rotary instrumentation shortened the procedure. However, no differences were observed in clinical and radiographic success rates between the two instrumentation methods^{17, 22}. The certainty of evidence for this finding was also moderate^{14, 22}.

Considering that primary teeth undergo physiological resorption and have a complex anatomy, irrigant solutions are currently the most effective method for eliminating debris and bacteria remaining in the root canal during instrumentation²⁸. Various irrigants have been proposed for use in primary root canals, including sodium hypochlorite, chlorhexidine, saline solution, citric acid, and MTAD, among others, making the selection of an ideal irrigating solution a challenge for professionals²⁸.

Pozos-Guillen *et al.* (2016)²⁸ conducted a systematic review of studies comparing different irrigants used during pulpectomy in primary teeth, including 1% sodium hypochlorite, water with oxidative potential, MTAD, 2% chlorhexidine, and saline solution, aiming to evaluate their clinical efficacy. However, the study was unable to determine which solution is most effective, highlighting the need for further high-quality studies. Another study found no significant differences between chlorhexidine, 1% sodium hypochlorite, 5% sodium hypochlorite, or saline/sterile water as irrigants in pulpectomy procedures⁸.

This suggests that the choice of irrigating solution may rely on the practitioner's individual clinical experience, but it is important to note that the certainty of evidence in this study was very low⁸.

Only two systematic reviews^{8, 12} evaluated the influence of smear layer removal on pulpectomy success, with inconclusive results. Pintor *et al.* (2016)¹² included only two studies that used 6% citric acid as an irrigant and concluded that smear layer removal may benefit the procedure's success, though they emphasized the need for further studies to support this conclusion. Coll *et al.* (2020)⁸ found that smear layer removal during pulpectomy in primary teeth does not affect success; however, the certainty of evidence in this study was very low⁸.

The present literature review revealed a wide variety of filling materials in use, reflecting the ongoing search for a material with improved properties. In most cases, the choice remains at the professional's discretion²¹. Najjar *et al.* (2019)²¹ recommend calcium hydroxide combined with iodoform for pulpectomy in primary teeth nearing exfoliation due to its resorbable properties, while suggesting the use of zinc oxide and eugenol for teeth still far from exfoliation. Junior *et al.* (2022)⁶ conducted a systematic review with meta-analysis and concluded that iodoform-based materials show better clinical and radiographic performance in the short term, with similar results to non-iodoform-based materials in the long term. However, the certainty of evidence in this review ranged from low to very low⁶.

When compared to other filling materials, Endoflas® paste was associated with a reduction in interradicular radiolucency

and faster resorption of extruded material, making it a promising option for the endodontic treatment of primary teeth with furcation radiolucency¹⁵. Other systematic reviews evaluating the success rates associated with different filling materials for primary root canals concluded that no material has proven superior to another, leaving the choice to the professional's discretion^{13,25,26}. The certainty of evidence ranged from moderate to very low²⁶.

In the 1990s, due to the significant anatomical complexity of primary root canals and corresponding difficulty involved in instrumenting them with manual or rotary files, a new technique emerged as an alternative to conventional pulpectomy: non-instrumental endodontic treatment². This fast and simple approach involves not performing canal instrumentation and placing a paste made from a mixture of antibiotics at the root canal entrance¹⁹. Conventional pulpectomy is recommended for non-vital teeth without root resorption, whereas non-instrumental endodontic treatment is indicated when extensive root resorption is present and/or the tooth needs to be retained for 12 months or less⁸. However, the certainty of the evidence supporting these recommendations is low⁸. In the present review, three studies found no difference between non-instrumental endodontic treatment and conventional pulpectomy regarding clinical and radiographic success^{2,10,19}. However, the certainty of evidence for this finding ranged from moderate to very low^{2,10}.

With the growing use of non-instrumental endodontic treatment, various antibiotic combinations have been proposed, including CTZ paste—composed of chloramphenicol, tetracycline, and zinc

oxide and eugenol—widely used in Latin America, and 3-Mix paste—composed of ciprofloxacin, metronidazole, and minocycline^{2,8}. There is still limited evidence on the ideal antibiotic mixture. Coll *et al.* (2020)⁸ conducted a systematic review and recommended the alternative 3-Mix paste (without tetracycline) over the original formulation, as minocycline, a tetracycline-group antibiotic, may cause adverse effects. However, the certainty of evidence supporting this conclusion was very low⁸.

Chouchene *et al.* (2021)²⁹ evaluated the efficacy of different antibiotic mixtures, including 3-Mix paste, ciprofloxacin/minocycline/ornidazole, ciprofloxacin/tinidazole/minocycline, and ciprofloxacin/metronidazole/clindamycin. They concluded that the ciprofloxacin/minocycline/ornidazole mixture was more effective than 3-Mix paste, which, in turn, was more effective than the other two combinations. However, the authors emphasized the need for future clinical trials with longer follow-up periods and larger samples to determine the optimal antibiotic mixture reliably.

Several techniques have been recommended for obturating primary root canals. Filling materials can be introduced using spiral filling techniques—such as bidirectional and Lentulo spirals—or injection filling techniques^{8,9}. One study found that the Lentulo spiral was associated with a slightly higher success rate than syringes⁸. However, the certainty of evidence in this study was very low⁸, and there is no sufficient scientific basis to confirm the superiority of the Lentulo spiral over bidirectional spirals or syringes⁹. Thus, the choice of

technique remains at the discretion of the professional⁸.

Pulpectomy can be performed in a single or multiple sessions, with no statistically significant difference favoring either approach¹⁸. Thus, the choice is at the discretion of the professional⁸. However, multiple-session pulpectomy requires repeated anesthesia and rubber dam isolation, increases patient radiation exposure, and carries the risk of dressing loss between sessions, which may lead to root canal contamination¹⁸.

Different medications can be used in multiple-session pulpectomy. Jia *et al.* (2019)²³ evaluated the efficacy of various medications for disinfecting primary root canals between appointments. They compared calcium hydroxide with camphorated phenol and formocresol—the latter no longer recommended due to its systemic cytotoxic potential²⁶—and

concluded that calcium hydroxide was more effective. However, the authors acknowledged study limitations and emphasized the need for further research using different methodologies to address them²³.

Conclusion

Based on the selected systematic reviews, it was not possible to establish the superiority of any technique or material due to the low levels of certainty of evidence associated with them. Thus, professionals should choose among techniques and materials with proven effectiveness. Non-instrumental endodontic treatment is a viable option for primary teeth with irreversible pulpitis or pulp necrosis. Its faster execution makes it preferable for cases of root resorption and uncooperative patients.

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