RESEARCH

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A CLINICAL AND RADIOGRAPHIC ASSESSMENT OF THE EFFICACY OF THE LESION STERILIZATION AND TISSUE REPAIR TECHNIQUE (LSTR) IN PRIMARY TEETH

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ABSTRACT

Introduction: *Pulp infection in primary teeth is a frequent case found in the clinic and requires endodontic treatment. Root canal preparation of primary teeth is quite difficult because of the anatomic variations of the roots and the need to manage children's behaviour during the treatment. The short and non-invasive treatment that is preferable for pediatric patients is lesion sterilization and tissue repair (LSTR) technique.* ***Aim:*** *This article aims to evaluate the efficacy of LSTR treatment in deciduous teeth.* ***Methods:*** *Electronic databases including PubMed and Google scholar were searched using PICO keywords. Relevant articles only in the English language and full text (in vivo studies and case reports) published from Januari 2013 to Juny 2023 were selected.* ***Result:*** *According to the collected information there were thirteen articles included in the inclusion criteria. LSTR technique in primary teeth has shown excellent rates of clinical success and good radiographic results.* ***Conclusion:*** *LSTR can be considered as a treatment option for pulpally involved primary teeth.*

Keywords: *antibiotic paste; lesion sterilization and tissue repair; primary teeth; tooth infection*

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INTRODUCTION

Initial dental visits by paediatric patients in developing countries are predominantly curative in nature, whereas cases frequently encountered in these clinics are deciduous teeth infected with pulp necrosis. It is also not uncommon for patients to present with chronic abscesses. The rate at which pulp infection develops in deciduous teeth is greater compared to permanent teeth, due to the distinct morphological and structural differences between the two. The thinner enamel and dentin layers of deciduous teeth, higher pulp horns, larger pulp chambers and more intricate radicular systems, in comparison to permanent teeth, result in a heightened tendency for infection to spread rapidly.[1,2]

It is generally accepted that there are significant benefits to retaining deciduous teeth until the permanent teeth erupt normally; as such, paediatric dentists are more likely to perform endodontic procedures such as pulpectomy than extractions. However, there are several factors that complicate conventional endodontic treatment in children. Cooperation from both the child and their parent is required due to the time-consuming

nature of the procedure, particularly in cases of abscessed teeth. Abscess treatment frequently requires multiple visits, and sometimes systemic antibiotics are necessary to eradicate the infection.[2,3]

In the provision of paediatric dental care, consideration should be given to both deciduous tooth morphology and the management of children's behaviour.[2,3] Lesion Sterilization and Tissue Repair (LSTR) is a suitable method for dealing with these issues, due to the fact that the procedure is relatively uncomplicated, does not require specialised equipment, and can reduce visit time. LSTR endodontic treatment, also known as non-instrumental endodontic treatment (NIET), is a promising biological approach in the management of carious lesions, with or without pulp and periapical involvement, utilising polyantibiotics.[3,4] The LSTR method aims to treat carious teeth by sterilizing dentin tissue, pulp, and periapical lesions using a combination of several anti-bacterial drugs.[5]

The LSTR procedure, as outlined by Takushige et al., involves the initiation of the procedure with the opening of the pulp chamber. This is followed by the enlargement of the orifice for the placement of the polyantibiotic paste, otherwise referred to as the medication cavity. Subsequent to the irrigation process, the paste is meticulously positioned within the bottom of the cavity. This is then sealed with glass ionomer cement. It is recommended that the tooth is subsequently restored with a stainless-steel crown (SSC).[6] The efficacy of LSTR treatment may be influenced by variations in antibiotic type, solvent properties, restorative technique, and the initial condition of the tooth.[7,8,9]

The present article aims to evaluate the efficacy of LSTR treatment in deciduous teeth. The evaluation was carried out clinically and radiologically at least three months after treatment. The therapy is considered successful if both clinical signs and symptoms improve and radiographic images show a reduction in the lesions and the absence of pathological signs.

METHODS

This review employs a scoping review approach to identify in-depth and comprehensive articles obtained from various sources using a range of research methods and related to the research topic.The review was organised based on the Arskey and O'Malley framework, which consists of five stages. The first stage involves the formulation of research questions, which are tailored to the objectives of the study. The second stage involves the identification of relevant literature sources through various sources. The third stage involves the selection of literature that has been obtained in accordance with the research topic. The fourth stage involves the mapping and collection of the literature used. The fifth stage involves the compilation and reporting of the results of analysing the selected literature.[10]

The initial step in the research process was to identify research questions that would function as a guide for the subsequent article searches.The research questions were then organised according to the PICO (Patient/ Intervention, Comparison/ Outcome) format. This was done in order to limit the scope of research that is relevant to the topic and to reduce the number of articles that were not in accordance with the objectives of this paper.The research question was as follows: What is the success rate of pulp treatment in deciduous teeth

using the LSTR method based on clinical and radiographic evaluation?

The second step in the research process involved the identification of relevant literature sources. This was achieved by conducting electronic searches in MEDLINE using the PubMed and Google Scholar databases from January 2013 until May 2023. The search strategy employed multiple keywords utilising the PICO framework, namely P (primary teeth OR deciduous teeth), I (LSTR OR "Lesion Sterilization and Tissue Repair" OR antibiotic paste), C (-), and O (clinical success OR radiographic success OR successful treatment).

The third step of the methodology was the selection of literature, which was carried out in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) reporting guidelines. The following inclusion criteria were applied: articles had to be written in English, and the type of in vivo study or case report had to be in the form of pulp disease or necrosis of deciduous teeth treated using the LSTR method. Furthermore, articles had to include follow-up data for a minimum period of three months in order to evaluate clinical symptoms and radiographic findings. Articles that are in vitro, cross-sectional, literature reviews, or not written in English were excluded from the selection of articles.

The fourth step of the process entailed the mapping and collection of articles to be utilised. The general characteristics of each selected article, meeting the predetermined inclusion criteria, were systematically compiled into a tabular format. This approach facilitated the examination, discussion, analysis of problems, and drawing of conclusions from this scoping review. The subsequent step involved conducting an in-depth analysis and reporting of the results in the designated results and discussion sections.

RESULTS

A literature search of the PubMed database yielded 22 articles that may be relevant to the subject under discussion, whereas a similar search of Google Scholar yielded 16 articles. The total number of articles identified through the two databases was 38, but four articles were excluded on the basis that they were duplicates. Subsequently, a further 10 articles were excluded after examination of the abstract and title, while an additional 11 were excluded following fulltext reading due to non-compliance with the inclusion criteria (see Table 1 for details).

Table 1. Article excluded and the reason for exclusion

Author, Year	Reasons for exclusion
Agarwal et al, 2019	Systematic review
Coll et al, 2020	Systematic review
Garrocho-Rangel et al, 2021	Systematic review
Shivashankar, 2017	Did not employed the LSTR method (revascularization)
Duarte et al, 2020	Systematic review
Mittal et al, 2020	Full text is not available
Castro et al, 2023	Full text is not available
Reddy et al, 2017	Did not employed the LSTR method (pulpectomy)
Kayalvizhi et al, 2013	Literature review
Talekar et al, 2022	Did not employed the LSTR method (pulpectomy)
Schmoeckel et al, 2017	Did not employed the LSTR method (revascularization)
Karunakaran et al, 2017	Treatment in permanent tooth
Asnani et al, 2019	Survey cross sectional
Afsari, 2021	Literature review
Santra et al, 2022	in vitro study
Doneria et al, 2017	No follow up
Villanueva and Mendoza, 2020	Article is not in english
Paulindraraj et al, 2023	Did not employed the LSTR method (pulpotomy)
Arenas and Veronica, 2020	Article is not in english

Thirteen articles satisfied the inclusion criteria, and the full text of this scoping review is

presented below. It should be noted that all articles were in English and published between 2013 and 2021.The overall screening process is described in Figure 1, and a summary of the general characteristics of each article is provided in Table 2. The discussion section describes clinical information related to the purpose of this article.

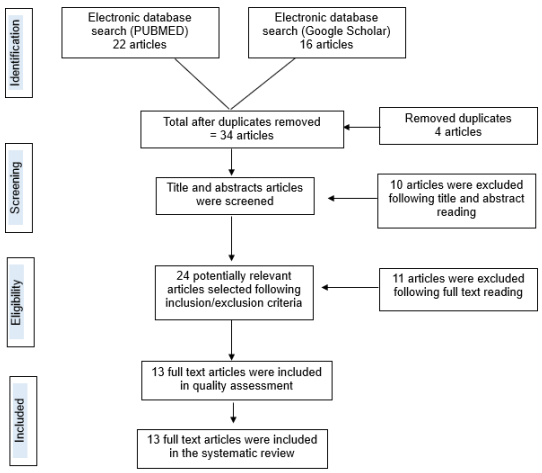

Figure 1. Flow chart of the literature search

DISCUSSION

Lesion Sterilization and Tissue Repair (LSTR) is an endodontic treatment procedure involving minimal removal of pulp tissue and minimal use of equipment, and is therefore referred to as Non-instrumentation Endodontic Treatment (NIET).[18] The LSTR method may result in the retention of infected tooth tissue, as there is no requirement for root canal preparation. However, this is not considered to be a concern, due to the efficacy of polyantibiotics in eradicating bacteria in dentinal tubules and root canals. This assertion is substantiated by the findings of Lakod et al., which demonstrated comparable outcomes in groups where pulp tissue was extracted from the root canals or left intact.[13]

A number of studies were conducted in order to establish the success rate of LSTR treatment in comparison with pulpectomy.[7,8,11,14,16] The evaluation of treatment success, both clinically and radiographically, yielded similar favourable results in both cases, with no significant differences observed. This is in accordance with the statement that a portion of the root canal remains untouched during chemomechanical preparation, regardless of the technique and equipment used. This untouched area may contain bacteria and necrotic tissue, even if the root canal filling appears adequate radiographically. Consequently, LSTR can yield comparable outcomes to pulpectomy, despite the absence of root canal preparation in the LSTR method.[19]

The fundamental principle of LSTR is predicated on the premise that the body's innate defence mechanisms are capable of effecting repairs, in addition to the sterilisation of the root canal and pulp chamber by polyantibiotics, with a view to reducing the number of bacteria. Hoshino[20] utilised a combination of three antibiotics, namely metronidazole, ciprofloxacin, and minocycline, at a ratio of 1:1:1, while Takushige[21] employed a mixture of these antibiotics at a ratio of 1:3:3. Both ratios yielded equivalent results. Subsequent to these studies, combinations of various antibiotic drugs are currently being investigated, and clinical trials have been conducted to enhance the effectiveness of the LSTR procedure.[22]

In the study conducted by Aranganal et al.[1], minocycline was substituted with doxycycline on the basis that doxycycline was more readily available, economical, and exhibited an equivalent antibacterial spectrum to minocycline. The study determined that doxycycline could be utilised in the LSTR method, owing to its high success rate.

Minocycline has been observed to result in tooth staining, antiangiogenic activity, and demineralisation.[23] Therefore, Shankar et al[2] conducted a study in which they replaced minocycline with clindamycin in Modified Triple Antibiotic Paste (MTAP) at two concentrations. The results of both pastes were satisfactory, and no significant differences were observed between them.

The 3Mix modification, which utilises cefaclor in place of minocycline and ornidazole instead of metronidazole, has been demonstrated to yield superior clinical outcomes.[24] These findings have been corroborated by Rai et al. and Lakode et al., who have shown that the paste delivers favourable clinical and radiographic results in the management of deciduous teeth, a condition that historically necessitated pulpectomy.[12,13]

Cappiello recommended the use of CTZ antibiotic paste, which consists of chloramphenicol, tetracycline, zinc oxide, and eugenol.[25] De Deus Moura et al. used the CTZ paste in the treatment of deciduous teeth using the LSTR method.[15] Evaluation of clinical and radiographic success showed that CTZ paste gave quite good results when compared with Vitapex, but MTAP paste still showed better results than CTZ paste.[13]

Parakh and Shetty utilised a polyantibiotic paste, designated as GAM paste, which comprised gentamicin, amoxicillin, and metronidazole, for the treatment of deciduous teeth employing LSTR and pulpectomy methodologies. The efficacy of both methods was comparable, exhibiting no statistically significant difference.[14] Gentamicin is recommended for the treatment of infections caused by Gram-negative bacteria, while the combination of metronidazole and amoxicillin has demonstrated efficacy in the treatment of various infections in humans.[26]

A combination of various antibiotics requires an organic solvent or intermediate medium in order to adequately penetrate the dentinal tubules. In their study, Hoshino utilized macrogol and propylene glycol to formulate a paste comprising ciprofloxacin, metronidazole, and minocycline, previously designated as 3MIX-MP paste.[21,27] However, in the preparation of this scoping review, several researchers opted for alternative materials, namely zinc oxide eugenol, simvastatin, and saline. These three materials are mixed with polyantibiotics with the purpose of helping the polyantibiotics work well in the LSTR method and provide good clinical and radiological results at 12-month follow-up.[3,8,11]

The clinical success of LSTR has been shown to exceed that of radiographic findings in several studies. In particular, the LSTR method has been reported to achieve 100% clinical success within 12 months of evaluation, with the use of various polyantibiotic pastes in each study. Nanda et al. utilized metronidazole and ornidazole in distinct antibiotic pastes, while Raslan et al. compared the use of minocycline and clindamycin. Additionally, de Deus Moura et al. conducted an evaluation up to 25–36 months after treatment using CTZ paste and still demonstrated clinical success up to 100%. The evaluation of clinical treatment success is consistent across the articles, contingent upon the inclusion criteria of each study.The assessment is determined by the following criteria: the disappearance of pain, the absence of abscesses or fistulas, the resolution of swelling, and the absence of pathological tooth mobility.[9,15,17]

The morphology of deciduous teeth has been demonstrated to exert a significant influence on the efficacy of LSTR treatment. The presence of accessory canals, as well as the porosity and permeability of the pulp base in deciduous teeth, has been shown to facilitate the absorption of polyantibiotics from the pulp to the periodontal tissue. This, in turn, has been observed to enhance the ability of the drug to carry out tissue repair.[9] The use of solvents, such as propylene glycol and macrogol, has been identified as a crucial factor in facilitating the penetration of the drug into the dentinal tubules.[27]

The study conducted by Thakur et al. provided the lowest clinical and radiological treatment success evaluation data from the previous literature, both in group II LSTR procedures (clinical: 73.9% and radiographic: 60.9%) and pulpectomy (clinical: 52.4% and radiographic: 42.9%). The observed discrepancy in outcomes can be attributed to variations in the combinations and dosages of medications utilized, with this study employing cefixime in contrast to minocycline. In the group I LSTR procedure, the incorporation of simvastatin into the antibiotic paste mixture yielded favorable results in both clinical and radiographic assessments.[8] Simvastatin functions as an anti-inflammatory and bioinductive agent, capable of inhibiting bone resorption while promoting osteoblast proliferation and differentiation.[28]

The radiographic success evaluation of the articles did not reach a success rate of 100%. The highest success rate was 94.44%, which was achieved by Raslan et al. using a procedure that involved the use of 3Mix polyantibiotic paste mixed with propylene glycol and macrogol, following a formula previously popularized by Hoshino.[17] In contrast, Sijini et al. used saline as a solvent instead of propylene glycol and macrogol, resulting in a radiological success rate of 72.73%.[7]

Radiologic evaluation of treatment efficacy in the articles of this review is predicated on the observation of radiolucent areas that undergo shrinkage or disappearance, as well as internal or external resorption, in the absence of new pathological lesions. Increases in radiolucency within the periapical region of deciduous teeth may be indicative of both physiologic and pathologic resorption. However, the absence of a general classification for the various types of tooth resorption has led to confusion among practitioners, resulting in inaccurate diagnoses.[29] The presence of radiolucent areas in the periapical region of deciduous teeth was included in the criteria for failed treatment, even This may be related to physiological resorption, where the destruction of mineral and organic components of the bone matrix occurs.[1] Meanwhile, in the repair phase, new bone formation begins, but it takes up to 12 months to reach the maximum amount of minerals in the bone matrix.[30]

A retrospective study conducted by Duanduan et al. found failures in the Vitapex and 3Mix MP groups that showed leakage of temporary fillings at the second visit, as well as leakage of permanent restorations that were done with composite resin and glass ionomer cement. These factors can lead to bacterial penetration[16], which is a significant concern in endodontic treatment. Restoration failure can affect the success of endodontic treatment, especially in proximal caries.[31] The type of restoration and the time between temporary and permanent restorations greatly influence treatment success.

SSCs are the restoration of choice as they have good marginal adaptation.[16]

A high evaluation success rate has been demonstrated both clinically and radiographically with the LSTR method. This analysis of a scoping review indicates that the success rate of the LSTR method is equivalent to that of pulpectomy. The success of the LSTR method is contingent upon the type of polyantigen, the solvent utilized, the type of restoration, and the patient's initial condition. The LSTR method has been employed in the treatment of deciduous teeth afflicted with various conditions, including, but not limited to, pulpitis, necrosis, abscess/fistula, root resorption, periapical abnormalities, and cases that are deemed to have a poor prognosis.

Coll et al. stated that deciduous teeth with resorbed roots can be maintained using the LSTR method until the replacement teeth erupt normally. The LSTR method is an alternative treatment option besides pulpectomy in cases of deciduous teeth that must be maintained for up to 12 months. If the deciduous teeth must be maintained for a longer time, periodic control is recommended at least once a year for clinical and radiographic examinations.[32]

It is important to note that evaluations carried out more than 12 months can provide different results in clinical and radiographic images. Root resorption of deciduous teeth involving the alveolar bone will cause tooth mobility, resulting in a decreased clinical success rate. Meanwhile, the bone remineralization process will produce areas that are more radiopaque on X-rays so that the radiological success rate will increase. This finding aligns with the research conducted by Trairatvorakul and Detsomboonrat, which demonstrated that the LSTR procedure yielded superior outcomes following a 24-month radiological evaluation.[33]

CONCLUSION

The efficacy of LSTR treatment is influenced by various factors, including the type of antibiotic, the solvent utilized, the restoration method employed, and the condition of the tooth in question. LSTR is a less complex alternative to pulpectomy, particularly advantageous for uncooperative children and resource-constrained settings due to its minimal equipment requirements and brief duration. The clinical evidence indicates that LSTR promotes tooth function retention, with the majority of cases reporting no complications for a period of 12 months following treatment, thereby contributing to a reduction in premature extractions. The polyantibiotic combination (Ciprofloxacin, Metronidazole, Minocycline) with solvents (Macrogol, propylene glycol) that was reviewed yielded favorable outcomes. Nevertheless, the necessity of larger, long-term studies is crucial to assess bacterial resistance and periapical tissue responses.

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Table 2. Summary of articles included in the systematic review

Author(s) (Year)	Type of article	Cases on deciduous teeth	Applied materials	Procedures/ Final restoration	Evaluation of the treatment success		Conclusion
					Clinical	Radiography	
Moura et al. (2021) [11]	In Vivo Study - Randomized Controlled Trial	- 88 mandibular molar teeth diagnosed with pulp necrosis - History of spontaneous pain, sinus tract, and swelling - Resorption of less than two-thirds of the root, radiolucent furcation - Age 4-10 years	CTZ paste (chloramphenicol, tetracycline, zinc oxide, eugenol) (n = 44)	LSTR / SSC	12 months = 86,4% (sinus tract or swelling disappears)	12 months = 75% (Radiolucent areas disappear or decrease)	Both techniques showed no significant difference in the success rate of nonvital pulp therapy. LSTR with CTZ paste may be an alternative treatment for deciduous molars with pulp necrosis.
			ZOE paste (n = 44)	Pulpectomy / SSC	12 months = 90,9% (sinus tract or swelling disappears)	12 months = 72.7% (Radiolucent areas disappear or decrease)	
Arangannal et al (2019) [1]	In Vivo Study	- 40 teeth diagnosed with pulp necrosis - History of pain when chewing, intraoral abscesses or fistulas - Resorption of less than half of the root, furcation involvement that does not affect the permanent tooth seeds - Age 3-10 years	Ciprofloxacin, metronidazole, doxycycline, and propylene glycol (n = 40)	LSTR / SSC	12 months = 100% (Abscess and pain resolve)	12 months = 80% (Radiolucent areas disappear or decrease)	LSTR can be an alternative treatment option for nonvital primary teeth. Doxycycline can be used in combination with drugs other than minocycline as it provides good treatment success.
Shankar et al (2021) [2]	In Vivo - Interventional Randomized Clinical Trial	- 64 irreversible pulpitis molars with periapical lesions - Age 4-10 years	MTAP (Ciprofloxacin, metronidazole, clindamycin, macrogol, propylene glycol) 1 mg/mL in concentration (n = 32)	LSTR / SSC	3 months = 84,4% (No pain and no swelling)	3 months = 78,1% (No periapical lesion)	There was no significant difference between low and high concentrations of 3MixMP. This polyantibiotic can be efficiently used in the LSTR of primary molar teeth
			MTAP (Ciprofloxacin, metronidazole, clindamycin, macrogol, propylene glycol) 1 g/mL in concentration (n = 32)	LSTR / SSC	3 months = 90,6 (No pain and no swelling)	3 months = 90,6% (No periapical lesion)	

Rai et al (2019) [12]	In Vivo Study - Randomized Controlled Trial	- 70 non vital molar - Gingival abscess, fistula, unsuccessful pulpotomy procedure - Internal/ external resorption, radiolucency in apical region - Age 4-9 years	Ciprofloxacin, ornidazole, minocycline, propylene glycol (n = 35)	LSTR / SSC	6 months = 97,14% (Pain, swelling, and fistula were absent. No pathological tooth mobility)	6 months = 77,14% (No furcation and periapical radiolucency. No external resorption)	There was no significant difference in clinical success, however, there was a significant difference in radiographic success, where vitapex with pulpectomy method gave better results.
			Vitapex (n = 35)	Pulpectomy / SSC	6 months = 100% (Pain, swelling, and fistula were absent. No pathological tooth mobility)	6 months = 97,14% (No furcation and periapical radiolucency. No external resorption)	
Lokade et al (2019) [13]	In Vivo Study - Randomized Controlled Trial	- 63 molar teeth - History of spontaneous pain, deep caries with exposed pulp, abscess, uncontrolled bleeding after pulp removal - Resorption of less than a half of the root, disrupted lamina dura - Age 4-8 years	Ciprofloxacin, ornidazole, cefaclor, macrogol, propylene glycol (n = 20)	LSTR / SSC (No medication cavity preparation)	12 months = 90% (Pain, swelling, and fistula were absent. No pathological tooth mobility)	12 months = 75% (No increase in interradicular radiolucency, internal and external resorption)	There was no significant difference between the 3 groups, but 3Mix modified paste showed better results than CTZ paste. The use of 3Mix modified paste using the LSTR method with or without pulp tissue removal and the use of CTZ paste can be used as an alternative dental treatment option that requires pulpectomy treatment.
			Ciprofloxacin, ornidazole, cefaclor, macrogol, propylene glycol (n = 21)	LSTR / SSC (With medication cavity preparation)	12 months = 90,5% (Pain, swelling, and fistula were absent. No pathological tooth mobility)	12 months = 76,2% (No increase in interradicular radiolucency, internal and external resorption)	
			CTZ paste (Tetracycline, chloramphenicol, zinc oxide, eugenol) (n = 22)	LSTR / SSC (No medication cavity preparation)	12 months = 81,8% (Pain, swelling, and fistula were absent. No pathological tooth mobility)	12 months = 63,6% (No increase in interradicular radiolucency, internal and external resorption)	
Sijini et al (2020) [7]	In Vivo Study - Non-randomized Controlled Trial	- 48 irreversible pulpitis molar, pulp necrotic - Chronic infection (spontaneous pain, fistula, percussion and pressure pain, mobility grade II) - Periapical radiolucency, pulp perforation, bone loss at the furcation area, internal/ external resorption. - Age 5-9 years	Metronidazole, minocycline, ciprofloxacin, saline (n = 28)	LSTR / SSC	12 months = 95,45% (Pain and fistula were absent. No pathological tooth mobility)	12 months = 72,73% (Periapical or furcation radiolucency were absent, no pathological root resorption)	There was no significant difference in clinical or radiographic success. Antibiotic paste and vitapex can effectively treat deciduous teeth.
			Vitapex (n = 20)	Pulpectomy / SSC	12 months = 100% (Pain and fistula were absent. No pathological tooth mobility)	12 months = 62,50% (Periapical or furcation radiolucency were absent, no pathological root resorption)	

Thakur et al (2021) [8]	In Vivo study - Randomized Controlled Trial	- 87 molar teeth - History of spontaneous pain, deep caries with open pulp, abscess, must be restorable. - Lamina dura was disrupted, there was furcation involvement, lesion involving pulp - Age 4-8 years	3Mixtatin (Ciprofloxacin, ornidazole, cefixime, simvastatin) (n = 30)	LSTR / SSC	12 months = 90,9% (Pain and swelling were absent. No pathological tooth mobility)	12 months = 90,9% (Periapical or furcation radiolucency were absent, no pathological root resorption)	3Mixtatin paste is highly effective for treating pulp in deciduous teeth using the LSTR method
			3MixMP (Ciprofloxacin, ornidazole, cefixime, macrogol, propylene glycol) (n = 29)	LSTR / SSC	12 months = 73,9% (Pain and swelling were absent. No pathological tooth mobility)	12 months = 60,9% (Periapical or furcation radiolucency were absent, no pathological root resorption)	
			Metapex (n = 28)	Pulpectomy / SSC	12 months = 52,4% (Pain and swelling were absent. No pathological tooth mobility)	12 months = 42,9% (Periapical or furcation radiolucency were absent, no pathological root resorption)	
Nanda et al (2014) [9]	In Vivo study - Randomized Controlled Trial	- 40 molar that is indicative of pulpectomy - Pain on percussion, mobility grade I/II, abscesses - Furcation radiolucency - Age 4 -10 years	Ciprofloxacin, metronidazole, minocycline, propylene glycol (n = 20)	LSTR / SSC	12 months = 100% (Pain, abscess or fistula were absent. No pathological tooth mobility)	12 months = 81% (Radiolucency reduces or disappears)	There was no significant difference in clinical or radiographic success. Both antibacterial pastes can be used effectively in the LSTR method.
			Ciprofloxacin, ornidazole, minocycline, propylene glycol (n = 20)	LSTR / SSC	12 months = 100% (Pain, abscess or fistula were absent. No pathological tooth mobility)	12 months = 92% (Radiolucency reduces or disappears)	
Parakh and Shetty (2019) [14]	In Vivo study - Randomized Controlled Trial	- 30 molar teeth with pulp infection - Deep caries with open pulp, failure pulpotomy treatment, abscess, fistula, tooth mobility - Periapical and furcation radiolucency - Age 4-8 years	GAM paste (Gentamicin, amoxicillin, metronidazole, saline) (n = 15)	LSTR / SSC	12 months = 93,33% (Pain, abscess, fistula or swelling were absent. No pathological tooth mobility)	12 months = 73,33% (Uninterrupted lamina dura, no pathological resorption)	There was no significant difference in the two procedures using GAM paste. The LSTR method using GAM paste can be an alternative treatment to pulpectomy.
			GAM paste (Gentamicin, amoxicillin, metronidazole, saline) (n = 15)	Pulpectomy / SSC	12 months = 100% (Pain, abscess, fistula or swelling were absent. No pathological tooth mobility)	12 months = 71,43% (Uninterrupted lamina dura, no pathological resorption)	

		- 30 molar teeth with pulp infection - Deep caries with open pulp, failure pulpotomy treatment, abscess, fistula, tooth mobility - No periapical and furcation radiolucency - Age 4-8 years	GAM paste (Gentamicin, amoxicillin, metronidazole, saline) (n = 15)	LSTR / SSC	12 months = 100% (Pain, abscess, fistula or swelling were absent. No pathological tooth mobility)	12 months = 86,67% (Uninterrupted lamina dura, no pathological resorption)	
			GAM paste (Gentamicin, amoxicillin, metronidazole, saline) (n = 15)	Pulpectomy / SSC	12 months = 93,33% (Pain, abscess, fistula or swelling were absent. No pathological tooth mobility)	12 months = 93,33% (Uninterrupted lamina dura, no pathological resorption)	
Parakh et al (2021) [3]	Case Series	- One mandibular molar with deep caries, pain when chewing - Lesion involving the pulp without furcation involvement - 6 years old	GAM paste (Gentamicin, amoxicillin, metronidazole, saline)	LSTR / SSC	12 months = clinical symptoms resolve	12 months = radiographic abnormality resolves	The LSTR method using GAM paste can help preserve primary teeth until the eruption of successor teeth
		- One mandibular molar - Caries involving furcation		LSTR / SSC	12 months = clinical symptoms resolve	12 months = radiographic abnormality resolves	
		- One mandibular molar - Dentin caries involving pulp		LSTR / SSC	12 months = clinical symptoms resolve	12 months = Internal resorption occurs	
de Deus Moura et al (2016) [15]	Case report	- 38 mandibular molar tooth necrosis with abscess - Age 4-10 years	CTZ paste (Chloramphenicol, tetracycline, Zinc oxide, eugenol) (n = 38)	LSTR / SSC	25 months – 36 months = 100% (No abscess and no pathological mobility)	25 months – 36 months = 93% (Radiolucent reduced or absent, no pathological resorption)	CTZ paste can be an alternative treatment for deciduous molars with pulp necrosis
Duanduan et al (2013) [16]	Retrospective Study	- 73 nonvital teeth (anterior and posterior) - Patient data from January 2005 - May 2011 post treatment with Vitapex or 3MixMP	Vitapex (n = 50)	Pulpectomy / permanent restoration	6 months – 72 months = 89,0% (No pain, swelling, and pathological tooth mobility)	6 months – 72 months = 64,6% (No new pathological lesions, no pathological resorption, reduced radiolucency)	Pulpectomy treatment with vitapex and LSTR treatment with 3MixMP are treatments with excellent success rates for deciduous teeth.

		- Age 3-10 years	3MixMP (Metronidazole, ciprofloxacin, minocycline, macrogol, propylene glicol) (n = 23)	LSTR / permanent restoration	6 months – 72 months = 84,6% (No pain, swelling, and pathological tooth mobility)	6 months – 72 months = 65,2% (No new pathological lesions, no pathological resorption, reduced radiolucency)	
Raslan et al (2017) [17]	In Vivo Study - Randomized Controlled Trial	• 42 molar teeth • Pain on percussion, abscess, fistula • Periapical radiolucency, bone resorption	3MixMP (Metronidazole, ciprofloxacin, minocycline, macrogol, propylene glicol) (n = 21)	LSTR / SSC	12 months = 100% (No pain, abscess, fistula, and no pathological tooth mobility)	12 months = 94,44% (Reduced radiolucency)	Both antibiotic paste combinations can be used as alternative options for treating deciduous teeth using the LSTR method.
			3MixMP-R (Metronidazole, ciprofloxacin, clyndamycin, macrogol, propylene glicol) (n = 21)	LSTR / SSC	12 months = 100% (No pain, abscess, fistula, and no pathological tooth mobility)	12 months = 80% (Reduced radiolucency)	