

Success Rates of Antibiotic Sterilization, Indirect Pulp Treatment, and Pulpotomy in the Management of Primary Teeth with Deep Carious Lesions

Deeksha Saxena¹, Nishita Garg², Lumbini Pathivada³, Harsimran Kaur⁴, Ramakrishna Yeluri⁵

ABSTRACT

Background and aim: A new concept of antibiotic sterilization has come into existence which can be used to sterilize the demineralized portion of the teeth with minimal or ultraconservative excavation of caries in deep dentinal carious lesions as an alternative for indirect pulp therapy (IPT) and pulpotomy to avoid further complications. This study was undertaken to compare the success rates of antibiotic sterilization, indirect pulp treatment, and pulpotomy in the management of primary teeth with deep carious lesion.

Materials and methods: Ninety teeth involving deep carious lesions approaching pulp in primary molars were selected and randomly divided into three groups containing 30 teeth. Group I was treated with antibiotic sterilization using 3Mix-MP paste, group II was treated with indirect pulp treatment using calcium hydroxide, and group III was treated with conventional pulpotomy using 15.5% ferric sulfate (FS) solution. Clinical and radiographic analysis of all three groups was performed at 1, 3, 6, 9, and 12 months to evaluate the success of treatment procedures using predetermined criteria. Pearson's Chi-squared test and McNemar test were used for statistical analysis.

Results: At the end of the 12-month follow-up period, the overall clinical and radiographic success was determined to be 96.3% for group I, 100% for group II, and 96.4% for group III. There were no statistically significant differences observed between the success of three groups, suggesting that either of the procedures can be adopted for the management of deep carious lesions approaching pulp in primary teeth.

Conclusion: Antibiotic sterilization can be introduced as a newer modality in the management of deep carious lesions approaching pulp in primary teeth which is ultraconservative in nature and reduces the risk of pulp exposure in comparison with indirect pulp treatment and pulpotomy procedures.

Keywords: Antibiotic sterilization, Deep caries, Indirect pulp treatment, Primary teeth, Pulpotomy, Vital pulp therapy.

International Journal of Clinical Pediatric Dentistry (2024): 10.5005/jp-journals-10005-2742

INTRODUCTION

Dental caries is one of the infectious diseases that results in inorganic and organic loss from diseased teeth, due to acids of dietary carbohydrate microbial fermentation. It has a complex etiology that confides in correlation among teeth, saliva, microbiota, and dietary habits and has become topic of interest worldwide.¹

Treatment of primary teeth with dental caries where the lesion is near to the pulp tissue needs proper understanding of endodontic treatment and its success is dependent on precise diagnosis of the pulpal health at the time of therapy; whether the pulp is reversibly or irreversibly inflamed, necrotic, or normal. For vital or reversibly inflamed, the vital pulp treatment procedures of pulpotomy or indirect pulp treatment can be opted.²

Traditionally, indirect pulp therapy (IPT) and pulpotomy are the two treatment approaches for vital deciduous teeth. Indications for IPT and pulpotomy are similar in primary teeth with deep caries where the vitality of the pulp is decided clinically or radiographically.³ Altogether none of techniques are available to accurately assess how much carious dentin is to be removed or the amount of caries that has to be left behind which is darker and firmer by clinical judgement.⁴ The dissimilarity occurs during caries excavation method where IPT helps to prevent pulp exposure by partial caries removal while pulpotomy is performed when pulp exposure has occurred. Although IPT has shown greater success rates than any pulpotomy technique, but still the controversy

^{1,4}Department of Pedodontics & Preventive Dentistry, Teerthanker Mahaveer Dental College & Research Centre, Moradabad, Uttar Pradesh, India

²Department of Pedodontics & Preventive Dentistry, Dental Institute, Rajendra Institute of Medical Sciences, Ranchi, Jharkhand, India

³Department of Pediatric & Preventive Dentistry, Rungta College of Dental Sciences & Research, Bhilai, Chhattisgarh, India

⁵Department of Pediatric & Preventive Dentistry, Sharad Pawar Dental College & Hospital, Datta Meghe Institute of Higher Education & Research, Wardha, Maharashtra, India

Corresponding Author: Nishita Garg, Department of Pedodontics & Preventive Dentistry, Dental Institute, Rajendra Institute of Medical Sciences, Ranchi, Jharkhand, India, Phone: +91 7060774863, e-mail: doctornish2210@gmail.com

How to cite this article: Saxena D, Garg N, Pathivada L, *et al.* Success Rates of Antibiotic Sterilization, Indirect Pulp Treatment, and Pulpotomy in the Management of Primary Teeth with Deep Carious Lesions. *Int J Clin Pediatr Dent* 2024;17(3):237–242.

Source of support: Nil

Conflict of interest: None

persists which procedure is superior in managing vital pulp therapy.³

Unnecessary endodontic treatment should not be promoted in primary tooth roots at the time of formation or resorption.

Recommendations have been made that sterilization can be achieved by topical application of antibacterial drugs *in vivo*^{5,6} when the decay process is left behind in permanent teeth. If it is possible in permanent teeth then antibacterial drugs can be useful in avoiding unexpected endodontic treatment in deciduous teeth by leaving the soft dentin on the cavity floor.

Trairatvorakul et al.⁷ in 2014 concluded that similar results were found between the treatment success rates of IPT using calcium hydroxide and antibiotic sterilization using 3Mix-MP (triple antibiotic paste) done in lower deciduous molars having carious lesions approaching the pulp at 6–11 month or 12–29-month follow-up period. Vidya et al.⁸ in 2015 designed a study to assess and compare calcium hydroxide IPT and pulpotomy using mineral trioxide aggregate (MTA). The success of the two treatment groups was assessed both clinically and radiographically. They concluded that while the indications were same for both procedures, IPT furnished several advantages over pulpotomy including lesser possible side effects, less chairside time, better cooperation from the patient, noninvasiveness, and cost-effectiveness.

The treatment modalities of vital pulp therapy are keeping a balance between both procedures whether to perform IPT or pulpotomy as several studies have supported both procedures, although there have been a lot of studies but still the controversy exists or is questionable. Hence, in order to overcome such dilemma a new concept of antibiotic sterilization⁷ has come into existence which can be used to sterilize the demineralized portion of the teeth with minimal or ultraconservative excavation of caries in deep dentinal carious lesions as an alternative for IPT and pulpotomy to avoid further complications.

Limited data is available in the literature evaluating the success of antibiotic sterilization, IPT, and pulpotomy with deep carious lesions in deciduous teeth. Hence, this study was undertaken to compare the success rates of antibiotic sterilization, indirect pulp treatment, and pulpotomy in the management of primary teeth with deep carious lesions.

MATERIALS AND METHODS

Before the start of the study, the experiment protocol was approved by the Institutional Ethics Committee. Keeping the power at 85%, the sample size was estimated. Ninety teeth with extensive carious lesions nearing the pulp in primary molars were selected from the outpatient Department of Pediatrics and Preventive Dentistry and randomly divided into three groups containing 30 teeth. Based on clinical/radiographic criteria, the inclusion criteria were deep carious lesions approximating but not involving the pulp of primary molars, carious primary molars that could be restored with a stainless-steel crown, and radiographic evidence of carious lesions approximating/ involving the pulp, with at least second/third of root length present. Patients with extraoral swelling/sinus, grossly carious tooth less favorable for placement of stainless crowns, mobility, furcation radiolucency, periapical/periradicular radiolucency, and internal resorption/external resorption were excluded from the study. Antibiotic sterilization using 3Mix-MP paste treatment was done in group I patients. For group II, treatment was indirect pulp treatment using calcium hydroxide, and group III was treated with conventional pulpotomy using 15.5% ferric sulfate (FS) solution. To evaluate the success of treatment procedures at 1, 3, 6, 9, and 12 months, clinical and radiographic analysis of all three groups was performed using predetermined criteria.

Clinical Procedure of Antibiotic Sterilization

After the administration of local anesthesia (Lignox, 2% Adrenaline, Indoco Remedies Ltd, Mumbai, India) isolation of the selected tooth was done using rubber dam.⁷ In this group, only caries on the lateral walls were excavated with a sharp spoon excavator, and the remaining soft dentin at the cavity floor was left behind. Ethylene diamine tetraacetic acid (Ammdent, Mohali, India) was employed on the peripheral walls of the cavity with a sterile cotton pellet for 1 minute to achieve clean cavity walls and patent dentinal tubules in order to allow penetration of antibiotics into them, and that the cavity was made moisture free. Subsequently, the left part of the cavity was applied with a combination of antibiotics which included metronidazole (Metrogyl 400 mg, Ankleshvar, India), ciprofloxacin (Ciplox 500 mg, Sikkim, India), and minocycline (Minolox 100 mg, Hosur, India) with Macrogol 400 mw and Propylene glycol 600 mw [CDH(P) Ltd, New Delhi, India]. Permanent restoration was done using resin-modified glass ionomer cement (type I) on the floor of the cavity and preparing the tooth for a stainless steel crown (Hu-Friedy, Rockwell St Chicago, United States). Crown cementation was done with luting glass ionomer cement (GC Corporation, Itabashi-ku, Tokyo, Japan).

Clinical Procedure of Indirect Pulp Treatment

After the administration of local anesthesia (Lignox, 2% Adrenaline, Indoco Remedies Ltd, Mumbai, India.) isolation of the selected tooth was done using rubber dam.⁷ Caries was completely excavated with a slow speed number 557 round bur from surrounding cavity walls and the dentin enamel junction. As the removal of the outer demineralized dentin was complete, excavation was kept on until pulpal exposure was predicted on further caries removal. Thereafter, some part of soft carious dentin on the cavity floor was left behind. Then the cavity was cleaned and made moisture free followed by application of hard-setting calcium hydroxide (Dycal, Densply, Milford, United States). The rest of the cavity was filled with an intermediate restorative material. In the subsequent appointment, crown cutting was done for receiving a stainless-steel crown (Hu-Friedy, Rockwell St Chicago, United States).

Clinical Procedure for Pulpotomy

After the administration of local anesthesia (Lignox, 2% Adrenaline, Indoco Remedies Ltd, Mumbai, India.) isolation of the selected tooth was done using rubber dam.⁹ A standard access cavity was prepared by using a high-speed sterile bur. After de-roofing the pulp chamber amputation of the coronal pulp was performed with the help of a sterilized spoon excavator. Then cavity was washed with normal saline and hemostasis was achieved with 15.5% FS (Ultradent, South Jordan, Utah, United States) solution applied using a sterilized cotton pellet for 15 seconds. After hemostasis, the access cavity was sealed with an intermediate restorative material. In the subsequent appointment, crown cutting was done to receive stainless steel crown (Hu-Friedy, Rockwell St Chicago, United States).

Clinical and Radiographic Evaluation

Clinical and radiographic evaluation was carried out at 1, 3, 6, 9, and 12 months intervals to evaluate the success of all three treatment procedures based on the following criteria described by Fuks et al.¹⁰ in 2005. Existence of healthy teeth with normal periodontium and lamina dura was considered successful treatment whereas finding of pain, tenderness, swelling/abscess/sinus/or pathological mobility were considered clinical failures. Periodontal ligament space

widening, radiolucency in the furcation, and internal or external root resorption were indicative of radiographic failure.

Statistical Analysis

The data thus obtained was analyzed statistically with the help of Statistical Package for Social Sciences (SPSS) (SPSS Inc, Chicago, Illinois) software version "17" for Windows. The significance level for all the statistical tests utilized in the study was predetermined at $p < 0.05$. Pearson's Chi-squared test and McNemar test were utilized to collate the favorable outcomes of all three treatment procedures.

RESULTS

The average age of the patients who participated in this study was observed to be 6.56 ± 1.33 years. Distribution of teeth accessible at different follow-up intervals, that is, at 1, 3, 6, 9, and 12 months, respectively is illustrated in Figure 1. Table 1 shows clinical and radiographic success or failure at various follow-up periods. At 6th month follow-up (Fig. 2), one clinical failure as tenderness and radiographic failure as periodontal ligament space enlargement, periapical radiolucency, and internal and external root resorption were reported in group I. In group III at 9th month follow-up (Fig. 3), one clinical failure as tenderness and radiographic failure as periodontal ligament space enlargement, periapical radiolucency, and internal root resorption were observed. Table 2 represents comprehensive success rate (clinical and radiographic in %) observed among group I (antibiotic sterilization), group II (Indirect pulp treatment), and group III (pulpotomy). Out of ninety teeth,

26 teeth in group I, 27 teeth in group II, and group III were available for evaluation on completion of the follow-up period of 12 months. The overall success based on clinical and radiographic criteria was determined to be 96.3% for group I, 100% for group II, and 96.4% for group III. No statistically significant differences were observed between the success of three groups suggesting that either of the procedures can be adopted for the treatment of deep caries approaching pulp in deciduous teeth.

DISCUSSION

Treatment of the grossly decayed deciduous molar is a frequent condition but can prove to be a demanding aspect of dental management of young children. Hence, every effort should be made to preserve the vitality of the pulp until its natural exfoliation time as it leads to more favorable treatment outcomes.¹¹ Vital pulp treatment encompasses two therapy approaches—IPT and pulpotomy in cases of deep dentinal caries. IPT is the commonly accepted vital pulp technique in restorative dentistry nowadays due to better knowledge of pulp biology with the introduction of newer biocompatible materials.¹²

Dorfman et al.¹³ concluded that demineralization of dentin precedes the progression of bacterial invasion into dentin. IPT procedure is based on the process of reparative dentin formation and isolation of caries that can be achieved by excavating the superficial layer of carious dentin, which mainly consists of the microorganisms that progress with demineralization of the deeper layers of the dentin from bacterial toxins.¹⁴ A detailed study of histomorphology of deep carious lesions corroborated its importance in evaluating clinical findings observed after indirect pulp capping procedures with different materials with the aim of maintaining pulp vitality.¹⁵

A study performed by AL-Zayer et al.¹⁴ concluded that IPT can be done as a replacement for pulp therapy due to its favorable outcomes in primary posterior teeth. Gruythuysen et al.¹⁶ have also evaluated the success of IPT clinically. According to Cochrane reports, it is indicated that variation in base materials produces no change in the treatment modality of IPT.¹⁷ On the other hand, pulpotomy is the treatment of choice for deciduous primary molars having no signs of radicular pathology or clinical symptoms. A variety of materials have been used as medicaments for pulpotomy procedure.¹⁸ Pulpotomy is done with the aim to preserve pulp vitality and radicular pulp so that the tooth can be retained till the time for exfoliation.^{10,19} In 1930, formaldehyde as formocresol was used as pulpotomy medicament for the first time by Sweet with a success rate of 70–97%.²⁰ In June 2004, formaldehyde was classified as carcinogenic for humans by the International Agency for Research on Cancer. This led to the search for alternative pulpotomy agents.²¹ It has been postulated that formaldehyde causes a rare nasopharyngeal cancer in humans and limited chance of developing leukemia. Therefore, ferric chloride (FC) has been banned in few countries, mainly due to safety concerns.²¹ Hence, FS has been used as an alternative to formocresol in the present study which offers similar outcomes in primary teeth with deep caries approaching pulp. Even though comprehensive literature in the form of clinical trials and animal studies have been published on this subject, enough evidence is not available to conclude which is the most suited technique for pulpotomy in deciduous teeth.²² IPT and pulpotomy are contrary to each other hence, either of the procedures can be used but offers some advantages and disadvantages one over the other.

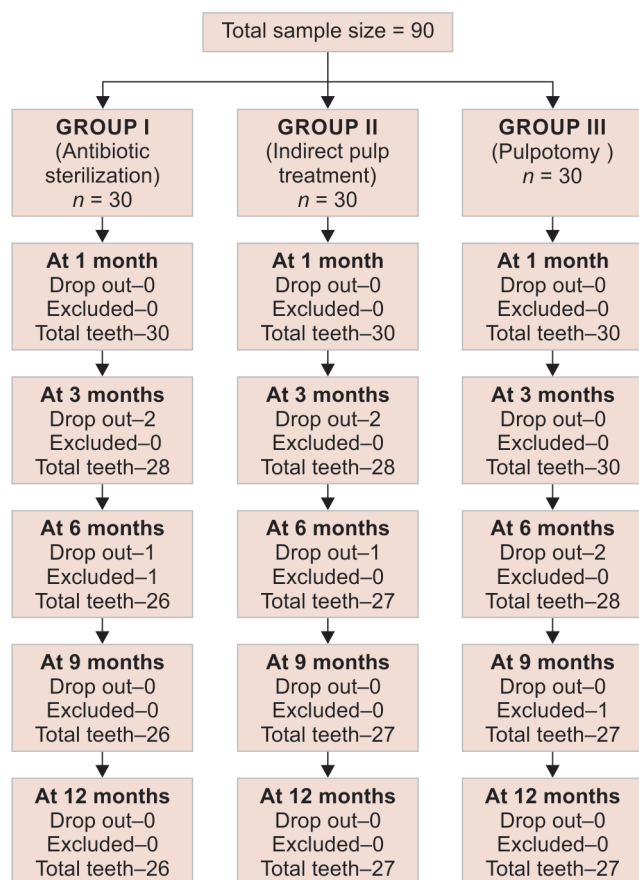
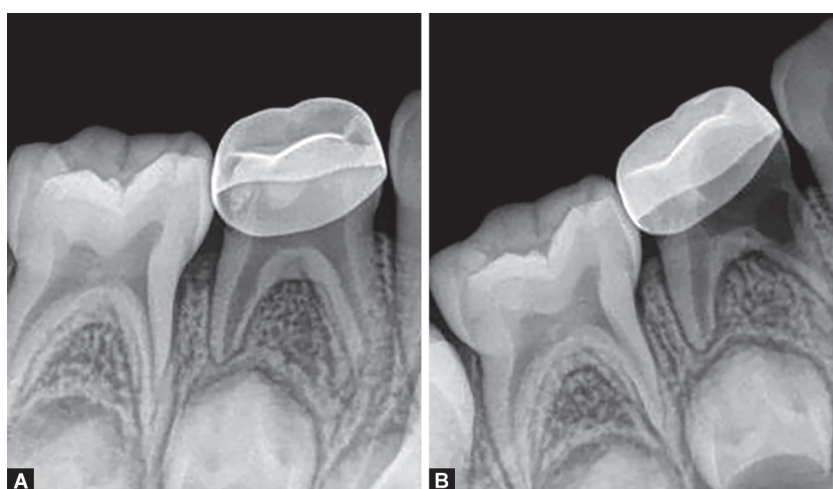


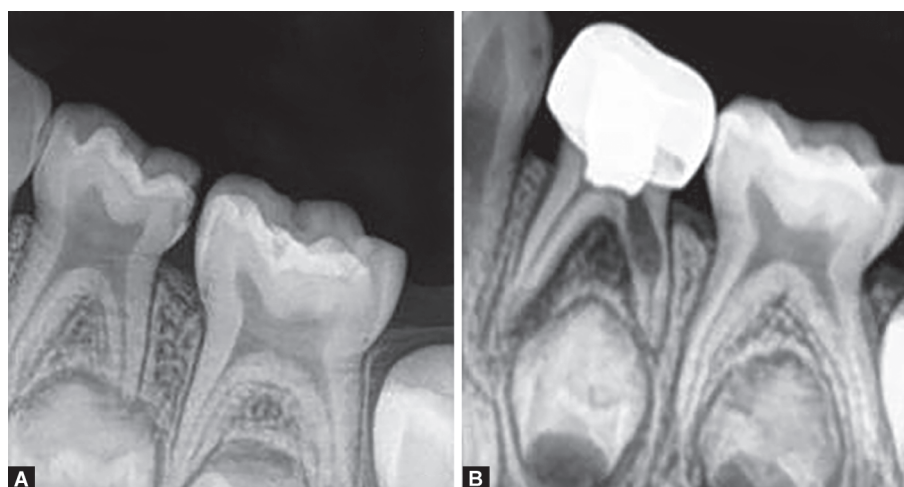
Fig. 1: Distribution of teeth available at various follow-up intervals (1, 3, 6, 9, and 12 months)

Table 1: Summary of distribution of number of teeth with clinical and radiographic success or failure at various follow-up periods (1, 3, 6, 9, and 12 months)

Time interval (in months)		Group I (antibiotic sterilization)		Group II (indirect pulp treatment)		Group III (pulpotomy)	
		Success	Failure	Success	Failure	Success	Failure
1	Clinical	30 (100%)	0 (0.0%)	30 (100%)	0 (0.0%)	30 (100%)	0 (0.0%)
	Radiographic	30 (100%)	0 (0.0%)	30 (100%)	0 (0.0%)	30 (100%)	0 (0.0%)
3	Clinical	28 (100%)	0 (0.0%)	28 (100%)	0 (0.0%)	30 (100%)	0 (0.0%)
	Radiographic	28 (100%)	0 (0.0%)	28 (100%)	0 (0.0%)	30 (100%)	0 (0.0%)
6	Clinical	26 (96.3%)	1 (3.7%)	27 (100%)	0 (0.0%)	28 (100%)	0 (0.0%)
	Radiographic	26 (96.3%)	1 (3.7%)	27 (100%)	0 (0.0%)	28 (100%)	0 (0.0%)
9	Clinical	26 (100%)	0 (0.0%)	27 (100%)	0 (0.0%)	27 (96.42%)	1 (3.7%)
	Radiographic	26 (100%)	0 (0.0%)	27 (100%)	0 (0.0%)	27 (100%)	1 (3.7%)
12	Clinical	26 (100%)	0 (0.0%)	27 (100%)	0 (0.0%)	27 (100%)	0 (0.0%)
	Radiographic	26 (100%)	0 (0.0%)	27 (100%)	0 (0.0%)	27 (100%)	0 (0.0%)



Figs 2A and B: Digital radiographic images showing (A) immediate postoperative view and (B) failure at 6 months for group I



Figs 3A and B: Digital radiographic images showing (A) preoperative view and (B) failure at 9 months for group III

Loh et al.²³ assessed and compared all available clinical trials involving FC against FS using a different clarifying system and concluded that similar clinical/radiographic success was observed for both medicaments. Farsi et al.²⁴ compared the

radiographic and clinical success rates of sodium hypochlorite (NaOCl) pulpotomy to FC and FS in decayed primary molars and concluded that three pulpotomy medicaments yielded similar outcomes. IPT and pulpotomy are contrary to each other; hence,

Table 2: Overall success rate (clinical and radiographic in %) observed between group I (antibiotic sterilization), group II (indirect pulp treatment), and group III (pulpotomy)

	Group I (antibiotic sterilization)	Group II (indirect pulp treatment)	Group III (pulpotomy)	p-value
1 month	30 (100%)	30 (100%)	30 (100%)	Not applicable (NA)
3 months	28 (100%)	28 (100%)	30 (100%)	NA
6 months	26 (96.3%)	27 (100%)	28 (100%)	0.357
9 months	26 (100%)	27 (100%)	27 (96.42%)	0.387
12 months	26 (100%)	27 (100%)	27 (100%)	NA
Overall	26 (96.3%)	27 (100%)	27 (96.4%)	0.604

either of the procedure can be used but offers some advantages and disadvantages one over the other.

Hence, a newer modality in the treatment of antibiotic sterilization in the management of deep carious lesions approaching pulp in primary teeth has been emerged as a technique that is ultraconservative, requires minimal time, less invasive, and offers minimal risk of pulp exposure.

In the present study, the groups were assigned on the basis of randomization protocol.²⁵ The teeth were divided into three groups group I (antibiotic sterilization) which consisted of triple antibiotic mixture of the three drugs, that is, ciprofloxacin, metronidazole, and minocycline mixed with propyl glycol and macrogol. Group II calcium hydroxide (indirect pulp treatment) and group III FS (pulpotomy).

In the present study at the end of 12th month study period, the overall clinical and radiographic success was determined to be 96.3% for group I, 100% for group II, and 96.4% for group III and no statistically significant differences were observed between the groups.

Lesion sterilization and tissue repair (LSTR) treatment modality which leads to disinfection of dentinal, pulpal, and periradicular lesions using a blend of antimicrobial drugs was developed at the Cariology Research Unit, School of Dentistry, Niigata University, Japan.^{26,27} Since the main purpose of endodontic therapy is to diminish the microorganisms in the root canal, the diminished microbial level achieved (up to 20–40%) with the help of antibiotics augments the traditional debridement of the root canal.^{28,29}

Since there are limited studies comparing the efficacy of all the procedures, this study was undertaken to evaluate the success of antibiotic sterilization, indirect pulp treatment, and pulpotomy in the management of primary teeth with deep carious lesions approaching pulp. There is no available literature highlighting the conceivable systemic adverse reaction such as antibiotic resistance and teeth staining from the use of 3Mix-MP.³⁰ This mixture also offers some advantages as the procedure involves partial caries removal leaving some part on the cavity floor that prevents pulp exposure in primary teeth with deep carious lesions approaching pulp. It is also ultraconservative in nature that offers more child cooperation.

Long-term studies are also needed as vital pulp therapy is an upcoming area where the intent is to achieve regeneration of the dentin complex for reproducing normal dental tissue architecture. We are still a long way from comprehending the concept of molecular mechanisms which emulate odontoblast-like cell function. Hence, future studies should also be directed toward longer duration of follow-up period and involve larger sample size to arrive at a definite conclusion. As per the observations of the present experiment, it

can be deduced that antibiotic sterilization can be an alternative treatment option for deciduous teeth with deep caries approaching the pulpal tissue which is ultraconservative, less time-taking, and more economical in nature that may replace traditional methods like indirect pulp treatment or pulpotomy which are invasive more time-consuming and increases the risk of pulp exposure or losing coronal portion of the dental pulp.

CONCLUSION

The inferences achieved from this study are:

- In the present study, no significant differences were noticed after 12 months of follow-up period within the success rates of all three procedures, that is, antibiotic sterilization, indirect pulp treatment, and pulpotomy in managing deciduous teeth with deep caries approaching pulp.
- Hence, antibiotic sterilization can be introduced as a newer modality in the management of deep carious lesions approaching pulp in primary teeth which is ultraconservative in nature and diminishes the risk of exposure of pulp in comparison with indirect pulp treatment and pulpotomy procedures.
- Further studies with long-term follow-up are recommended to evaluate the efficacy of antibiotic sterilization in pediatric dental practice.

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