ORIGINAL RESEARCH

Comparative Evaluation of Chlorhexidine Polymer Scaffold, 3Mixtatin, and Formocresol for Vital Primary Pulp Therapy: A Randomized 6-month Clinical Study

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Abstract

Introduction: The study was performed to evaluate and compare the clinical and radiographic efficacy of chlorhexidine (CHX) polymer scaffold, 3Mixtatin, and formocresol for vital primary pulp therapy—a randomized clinical study.

Materials and methods: A total of 120 primary molars were included from children aged between 6 and 8 years in this randomized clinical study based on inclusion and exclusion criteria and were randomly allocated into three groups (group I—CHX polymer scaffold, group II—3Mixtatin, and group III—formocresol. Pulpotomy was performed in a vital cariously exposed primary tooth with healthy periodontium where their retention is more beneficial than extraction. Subjects were followed up at 1, 3, and 6 months for clinical and radiographic evaluations.

Results: At 6 months of follow-up, the overall success rate of pulpotomy in groups I, II, and III was 56.41, 71.05, and 60.52% in each group, respectively. Nonsignificant difference ($p > 0.05$) was seen during intergroup comparison.

Conclusion: However, among the three materials used in this study, 3mixtatin comparatively had better results.

Keywords: Periodontal ligament widening, Root canal treatment, Stainless steel crown.

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Introduction

Pulp therapies in pediatric patients alleviate pain, pulpal infection, and associated symptoms. It also preserves and maintains the tooth's developmental, aesthetic, and functional capabilities. In terms of maintaining space for permanent successors, primary teeth are best described as "The Best Space Maintainer."[1–3]

It is increasingly recognized that pulp therapy is a conservative approach to the management of teeth with inflamed. An appropriate and conservative approach for the management of inflamed vital pulp includes pulpotomy.

The ideal properties of pulpotomy medicaments are excellent sealing ability, biocompatibility, bioinductive properties, bactericidal, nontoxic to neighboring structures, and promote radicular pulp tissue healing.[4,5] Traditionally used materials are formocresol, ferric sulfate, glutaraldehyde, formaldehyde, and beechwood cresol. Recently Kalyan et al. in 2019[6–8] evaluated chlorhexidine (CHX) polymer scaffold as pulpotomy material and showed clinical and radiographic success rates of 95, 90, and 90% after follow-ups of 6, 12, and 24 months, respectively. In vital pulp therapy, it has become increasingly important to use biomaterials that possess antimicrobial activity in polymeric scaffolds.[9] Local delivery systems having antimicrobial agents either suppress or eliminate pathogenic microbes. In the local drug delivery system polymeric scaffold increases the drug dissolution rate along with the surface area of the drug carrier. CHX possesses substantivity properties along with antimicrobial action against a wide range of microorganisms with significantly high bactericidal and bacteriostatic action.[9,10–14]

A better understanding of pulp biology and the curative and regenerative properties of the inflamed pulp has encouraged the dental practice to shift toward a more conservative approach and acceptance of pulpotomy in properly selected cases.[11,12] Still, there is a lot of controversy regarding the appropriate medicament for pulpotomy especially in pediatric patients. The clinical and radiographic prognosis depends upon their judicious use as indicated. However, there is a scarcity of literature available regarding the use of CHX scaffold polymer as pulpotomy material. Therefore, the present study evaluates the clinical and radiographic efficacy of CHX polymer scaffold, 3Mixtatin as a pulp dressing medicament in comparison with formocresol (control) at different time intervals.

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Materials and Methods

This randomized control study was conducted in the Department of Pedodontics & Preventive Dentistry, Post Graduate Institute of Dental Sciences, Rohtak, Haryana, India. Cariously primary molars of children aged 6–8 years without any underlying systemic illness having healthy periodontium, no spontaneous pain history, and absence of any abscess, fistula, sinus, swelling, or pathological

mobility were included in the study. Teeth that were nonvital, positive for spontaneous pain, tender on percussion, unsuccessful hemorrhage control and radiographically presenting with furcation radiolucency, periodontal ligament (PDL) widening, interradicular bone loss, periapical radiolucency, and root resorption were excluded. Ethical clearance was taken from Institutional Ethical Committee for Human Research prior to the commencement of research (PGIDS/IEC/2019/24).

Sample Size

The sample size was calculated considering the previous study by Jamali et al. 2018[4] who assessed the success rate of pulpotomy with 3Mixtatin with mineral trioxide aggregate and formocresol as 90.5, 88.1, and 78.9%, respectively. As per 80% age power analysis and accepted α error of 5% ages, a total of 36 teeth were required in each group. For estimated dropout, four subjects per sample were added for each group (10% dropouts).[14] Henceforth, a total of 40 teeth per group were included in the study. A total of 120 primary molars fulfilling the inclusion criteria were taken for the study. Informed written consent was obtained from all parents or legal guardians of the patient. A total of 120 primary molars were allocated randomly for pulpotomy into three groups depending on the materials used group I—CHX polymer scaffold, group II—3Mixtatin, and group III—formocresol.

Preparation of CHX Scaffold

A CHX polymer scaffold was prepared using a CHX solution of 2%, polyvinyl alcohol, and distilled water. The solution was then placed in a digital centrifugation machine for homogenous mixing and a CHX polymer scaffold was prepared. Scaffold was collected in aluminum foil and stored in an ultraviolet chamber for 12 hours. Then the scaffold was cut into 1 × 1 cm and stored in disposable vials for single use.[8]

Preparation of 3Mixtatin

Aminabadi et al. described a technique for the preparation of 3Mixtatin.[13] A total of 100 mg ciprofloxacin, 100 mg metronidazole, and 100 mg cefixime were mixed in a ratio of 1:1:1. The drugs were taken in pure form. Around 2 mg of simvastatin was added and blended to form 3Mixtatin.

Clinical Procedure

Local analgesia using 2% lidocaine with 0.005 mg epinephrine (Lox 2% adrenaline injection, neon laboratories Ltd) was administered followed by isolation of the tooth using a rubber dam. Caries were removed and the coronal pulp tissue was removed with a sterile spoon excavator or a sterile slow-speed round bur (#6 or #8) under continuous saline irrigation. The moist cotton pellet was placed on the radicular pulp stumps for 5 minutes for hemostasis. After hemostasis, the tooth was randomly allocated into groups following the lottery method of simple random sampling technique and CHX polymer scaffold, 3Mixtatin, and formocresol (control) were placed on the radicular pulp stumps, respectively. The cases were excluded in which hemostasis was not achieved even after 5 minutes of pressure with moistened cotton pellet. Restorative glass ionomer cement (3M Espe) was used to restore access cavities after the procedure. The procedures were performed in one sitting and periapical radiographs were taken immediately after treatment. The patient was assessed postoperatively and was recalled at 1, 3, and 6 months. On follow-up, patients were examined and evaluated clinically for pain, swelling, sinus tract, pathological mobility, tenderness on percussion and sensitivity to percussion and radiographically for furcation radiolucency, internal resorption, external resorption, PDL widening, and interradicular radiolucency. Tooth presenting any of the signs and symptoms mentioned in the above criteria at the time of follow-up was considered a failure. The entire clinical procedure was performed by a single operator and clinical and radiographic evaluation during follow-up was performed by two experienced pediatric dentists, who were "blinded" to the applied material. The κ agreement coefficient was used to evaluate interexaminer reliability at follow-up sessions.

Statistical Analysis

All the data obtained from the study was compiled on a Microsoft Office Excel Sheet (v 2019, Microsoft Redmond Campus, Redmond, Washington, United States) and was subjected to statistical analysis using Statistical Package for the social sciences (SPSS version 26.0, IBM). Comparison of frequencies of categories of variables with groups and time was done using the Chi-squared test. Intergroup comparisons between the groups were done using a one-way analysis of variance followed by pairwise comparison using a post *hoc* test.

Results

A total of 120 carious primary molars from children aged between 6 and 8 years meeting inclusion and exclusion criteria were included in the study. Table 1 shows the success and failure in each group at 1, 3, and 6 months. Intergroup comparison of success rates among three groups has been shown in Table 2. The frequency of clinical and radiographic success have been shown in Table 3. At 1 month follow-up, four teeth out of 39 in group I (CHX polymer scaffold), one tooth out of 38 in group II (3Mixtatin), and two teeth out of 40 in group III (formocresol) failed according to the clinical and radiographic criteria. The success rate at the end of the

Table 2: Intergroup comparison of success rate among three groups

Groups	1 month	3 months	6 months	*p*-value
Chlorhexidine polymer scaffold	35/39	33/39	22/39	
3Mixtatin	37/38	33/38	27/38	
Formocresol	38/40	31/39	23/38	.352,599 at $p < 0.05$ (nonsignificant)

Table 1: Showing success and failure in each group at 1, 3, and 6 months

Groups	*CHX polymer scaffold*			*3Mixtatin*			*Formocresol*		
Follow-up	1 month ($n = 39$)	3 months ($n = 39$)	6 months ($n = 39$)	1 month ($n = 38$)	3 months ($n = 38$)	6 months ($n = 38$)	1 month ($n = 40$)	3 months ($n = 39$)	6 months ($n = 38$)
Failure	4	2	11	1	4	6	2	6	7
Success	35 (89.74%)	33 (84.61%)	22 (56.41%)	37 (97.36%)	33 (86.84%)	27 (71.05%)	38 (95%)	31 (79.48%)	23 (60.52%)

1-month follow-up in groups I, II, and III was 89.74, 97.36, and 95%, respectively. At 3 months, 39 teeth in group I, 38 teeth in group II, and 39 teeth in group III were followed. Amongst them, two cases in group I, four cases in group II, and six cases in group III showed clinical/radiographic failure. After excluding the failed cases total of 95 teeth was available for the clinical and radiographic evaluation at 6 months. Around 6 months of follow-up presented 11, six, and seven failed cases in groups I, II, and III, respectively. A total of 22 teeth in group I, 27 teeth in group II, and 23 teeth in group III were left completely asymptomatic at the end of the study. The study design is shown in Flowchart 1.

Structural and molecular differences are reflected by a higher susceptibility to tooth resorption seen in primary teeth.[15] Research found that simvastatin could accelerate bone regeneration and soft tissue healing by stimulating neovascularization and osteoblasts.[16] The clinical success of pulpotomy is attributed to proper case selection, high aseptic standards, and appropriate use of medicament.[17,18] Rubber dam isolation is important for isolation and reducing the chances of failure of pulpotomy.[19]

Table 3: Frequency of clinical and radiographics success

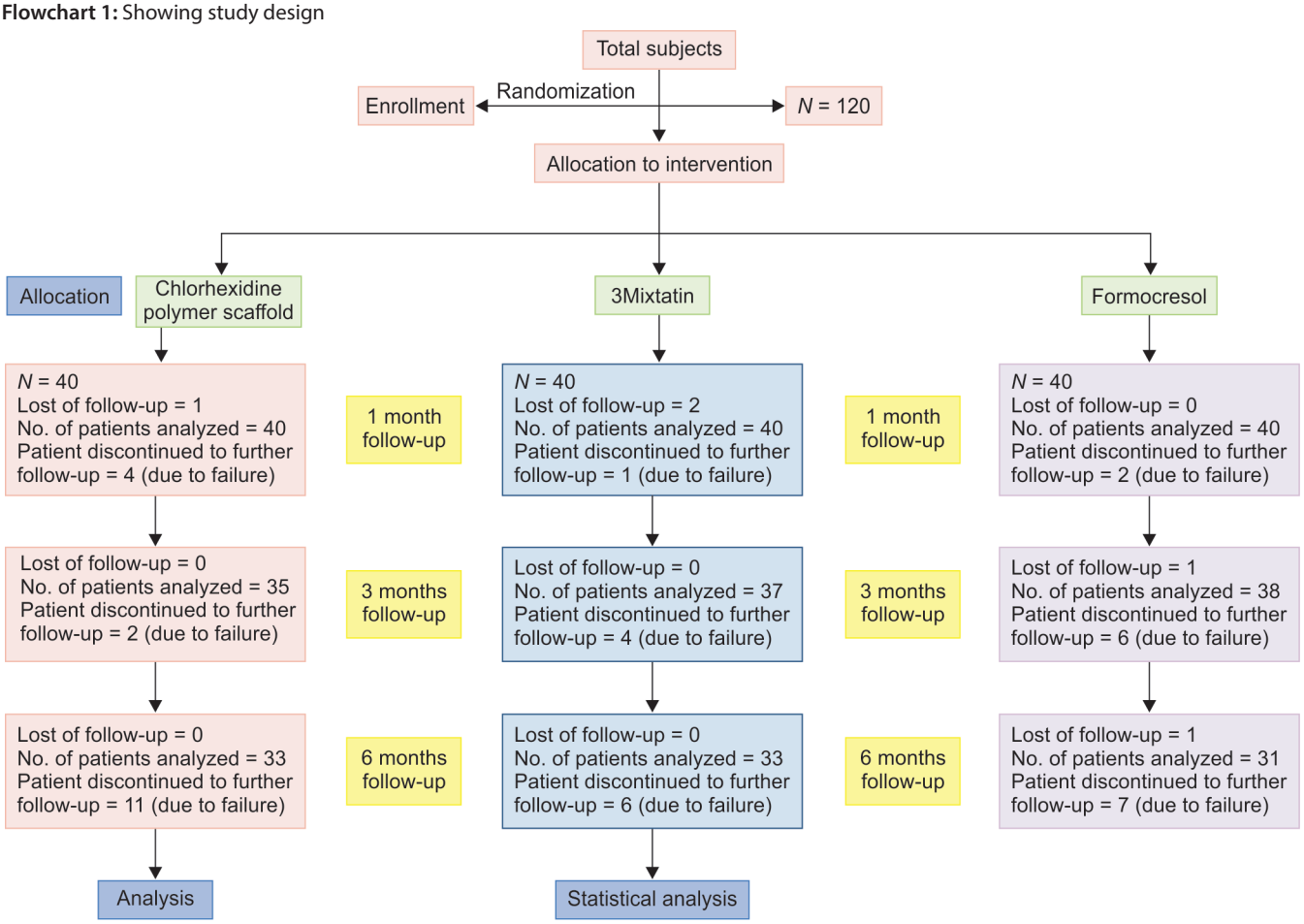
Group	*Clinical success*	*Percentage*
CHX polymer scaffold	29	74.35%
3Mixtatin	33	86.84%
Formocresol	32	84.21%
Radiographic success		
CHX polymer scaffold	21	55.2%
3Mixtatin	27	71.05%
Formocresol	23	60.52%

In the present study, more failures were observed in group I (CHX polymer scaffold). Among the clinical and radiographic evaluation criteria, pain and furcation radiolucency was the most frequent reason for failure at the follow-up. Complaint of pain and furcation radiolucency was highest in group I followed by group II and least in group III in 1 month followed highest in group I followed by group III and least in group II in 6 months. However, it was not statistically significant ($p > 0.05$). Regardless of the pulpotomy agent used, the main cause of postoperative pain is tissue ulceration which happens during the pulpotomy procedure.[20–24]

It was observed that in the long-term, the success rate of CHX polymer scaffold decreased drastically as a pulpotomy agent, this can be due to the marginal microleakage favoring bacteria entering the pulp tissue and creating infection and pulp inflammation. Teeth restored with a stainless-steel crown have a higher success rate than those restored with amalgam.[25]

Under radiographic outcomes, furcation radiolucency was seen the most, in all the groups being maximum in group I followed by group II and least in group III. PDL widening is maximum in group I followed by group III and least in group II. Nearly 18 cases (10.71%)

Flowchart 1: Showing study design



in group I showed furcation radiolucency at 6 months which might be due to the presence of micro pulpal remnants even after amputation of coronal pulp tissue. The study showed a gradual decrease in success rate from 89.74 (group I), 97.36 (group II), and 95% (group III) at 1 month to 84.61 (group I), 86.84 (group II), and 79.48 (group III) at 3 months which finally at the end of 6 months dropped out to 56.41, 71.05, and 60.52% in each group, respectively (Table 4). Failure was observed in all three groups. Nevertheless, the response was comparably better with 3Mixtatin compared to CHX polymer scaffold and formocresol. However, the results showed a statistically nonsignificant difference ($p = 0.352$ at $p < 0.05$) in the overall success rate between the groups at 6 months according to the Chi-squared test.

Discussion

Evidence from the previous literature reveals a high incidence of inadequate root fillings and a high percentage of apical periodontitis in pulpectomy with a low success rate in primary teeth. An appropriate and conservative approach for the management of inflamed vital pulp includes pulpotomy.[2,3]

In the present study, three test materials/pulpotomy medicaments were used for the evaluation of clinical and radiographic success at different time intervals.

The present study showed nonsignificant ($p = 0.352$ at $p < 0.05$) difference between the groups with an overall success rate of 56.41, 71.05, and 60.52% in group I(CHX polymer scaffold), group II (3Mixtatin), and group III (formocresol), respectively. However, various other factors influence the outcome of pulpotomy which includes proper case selection and use of antimicrobial medicaments with acceptable seal (Asgary et al.).[26,27]

Differences in the outcomes could be due to treatment modalities like study design, pulpotomy material used, type of restoration used, the skill of the operator, site of exposure, and pulpal health before treatment. One of the key factors required for pulpal healing after exposure is the absence of infection. Any remaining bacteria or leakage of new bacteria can cause failures. Rubber dam isolation was carried out as a part of the treatment protocol for each of the interventional techniques in order to maintain isolation, improved access and visibility, and reduce the burden of aerosol-born microorganisms. In a clinical study by Shafie et al.,[22] it has been reported that most of the treatment performed without rubber dam isolation showed severe coronal pulp inflammation. Subjective evaluation parameters used in our study included clinical assessment—pain, tenderness of percussion, sinus, swelling, and pathological mobility and radiographic assessment—furcation radiolucency, PDL widening, pathological root resorption, and periapical radiolucency.

Few studies recommend considering age before performing vital pulp therapy because of the better healing potential of pulp in young patients. However, it is still a controversial topic in the literature that requires further research.[28]

Table 4: Comparison of success and failure rate at 6 months follow-up at all the three groups

	Success	*Failure*
Group I	22	11
Group II	27	6
Group III	23	7
Total	72	24

In the present study, subjects were followed at 1, 3, and 6-month intervals. However, a longer follow-up may influence the long-term success rate.

Group I (CHX polymer scaffold) showed an overall success of 56.41% at the end of 6 months. Noncomparable results were seen in a randomized clinical trial, by Kalyan et al.,[8] where clinical and radiographic efficacy of 90% was found with CHX polymer scaffold in pulpotomy.

Limited success in the CHX polymer scaffold group could be because of the toxicity of CHX at concentrations higher or equal to 2%, to different cells types, including stem cells of the apical papilla, osteoblasts, and fibroblasts as reported by Alves et al.[29] Despite its antibacterial and other advantages CHX activity is pH dependent and it lacks tissue dissolving properties.[9]

Among the three groups in this study, 3Mixtatin comparatively had better outcomes, with an overall success rate of (71.05%) at the end of this study. A larger success rate of 90.5% in pulpotomy with 3Mixtatin was reported by Jamali et al., 2018.[4] 3Mixtatin has a higher success rate in comparison with CHX polymer scaffold and formocresol in this study could be attributed to the bioinductive, pleiotropic effect of simvastatin. Statin components are being used in regenerative dentistry with increasing osteoblasts function and suppress osteoclasts function.[11]

Another critical factor for the success of pulpotomy is the quality of coronal restoration. In the study glass ionomer cement was used for restoring the tooth. Better results could have been obtained if the crown was placed as a permanent restoration. The study was performed using strict inclusion criteria and randomization under absolutely aseptic conditions with prior calibration of the treatment provider still the combined success rate of pulpotomy was found to be 60.46%.

With the continued advancement and availability of bioactive pulp medicaments such as *Nigella sativa*, *Curcuma longa*, turmeric, *Thymus vulgaris*, *Allium sativum* oil, *Aloe vera*, acemannan have claimed to play a vital role so further studies using different newer materials with larger sample size, and longer follow-up period are needed to confirm the exact status of the pulp after pulpotomy.[30]

Conclusion

Within the limitations of this study, it can be concluded that pulpotomy in primary molars has favorable success and outcomes. Amongst the three materials used in the present study, 3Mixtatin showed better performance in comparison to formocresol and CHX polymer scaffold. However, further studies which larger sample sizes and a longer follow-up are required to draw a definitive conclusion.

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