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ORIGINAL RESEARCH

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Comparison of clinical outcomes between mineral trioxide aggregate and bioceramic materials in pulpotomy for treating early chronic pulpitis in deciduous teeth

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Abstract

This study aims to elucidate the clinical efficacy of Mineral Trioxide Aggregate (MTA) and Bioceramic Materials in pulpotomy procedures for early-stage chronic pulpitis in deciduous teeth. The clinical data of 100 children with early chronic pulpitis in deciduous teeth treated at our institution between January 2021 and January 2023 were included retrospectively, which were divided into an experimental group (n = 50) and a control group (n = 50) according to the treatment methods. Experimental group received pulpotomy with Thera Cal LC as bioceramic pulp-capping material versus control group with MTA as pulp-capping agent. Comparative studies were conducted to assess the clinical effectiveness and differences between both pulp-capping techniques. At 12 months postoperatively, the experimental group showed a significantly higher success rate than the control group (96.00% *vs.* 80.00%, $p < 0.05$). Post-treatment inflammatory markers (Tumor Necrosis Factor-alpha (TNF-α), Interleukin-6 (IL-6) and Interleukin-8 (IL-8)) were substantially lower in the experimental group ($p < 0.05$). Furthermore, significantly lower pain scores and higher comfort and satisfaction scores were obtained in the experimental group ($p < 0.05$). Experimental group adverse reactions were also lower in the experimental group ($p < 0.05$). TheraCal LC bioceramic material treats early chronic pulpitis in deciduous teeth effectively. Clinically, it is an excellent therapeutic option for emergence of permanent dentition, pain relief, comfort and improvement of patient satisfaction.

Keywords

Mineral trioxide aggregate; Bioceramic material; Early chronic pulpitis in deciduous teeth; Pulpotomy

1. Introduction

Pulpitis is an inflammatory condition that affects the dental pulp tissue, a prevalent oral health concern. A tooth's dental pulp consists of nerves, blood vessels, and connective tissues within the pulp cavity. Pulpitis can be precipitated by infection in this area [1, 2]. In children, chronic pulpitis often arises secondary to caries in deciduous teeth. Treatment in pediatric cases focuses on preserving deciduous teeth until their permanent successors emerge [3]. While root canal therapy has been a traditional intervention, it is associated with pain that can compromise pediatric patient cooperation and suboptimal outcomes. Pulpotomy has gained traction as a preferred approach. In this minimally invasive procedure, inflamed or infected pulp tissue is removed, preserving the remaining healthy pulp and fostering regeneration with biocompatible materials [4, 5]. Mineral Trioxide Aggregate (MTA) serves as a pulpal capping material in vital pulpotomies and is widely used in pediatric dentistry. In addition to its excellent biocompatibility and sealing abilities, it also facilitates regeneration of periapical tissues, which solidifies its status as an ideal pulp-capping agent [6]. Post-MTA pulpotomy dentin bridges have superior quality, but drawbacks, like challenging manipulation, postoperative tooth discoloration aesthetics impact, and long curing time have curtailed its clinical utility [7]. However, bioceramic materials have been introduced and adopted in recent years. TheraCal LC, a light-curable calcium silicate-based resin, boasts attributes like swift setting, robustness, ease of use, radiopacity, direct pulp capping without discoloration, and good biocompatibility, demonstrating promising outcomes in pulpotomy procedures [8, 9]. Clinical research on their use as pulp capping agents, however, is limited. Thus, this study aims to elucidate the clinical efficacy of MTA and TheraCal LC bioceramics in deciduous teeth pulpotomy treatments.

2. Materials and methods

2.1 General data

The clinical data of 100 children with early chronic pulpitis in deciduous teeth treated at our institution between January 2021 and January 2023 were included retrospectively, which were divided into an experimental group (n = 50) and a control group (n = 50) according to the treatment methods. Both groups had comparable baseline characteristics ($p > 0.05$) (Table 1).

TABLE 1. General data of both groups ($\bar{x} \pm s$).

Group	n	Gender (male/female)	Age (yr)
Experimental group	50	29/21	8.31 ± 1.35
Control group	50	27/23	8.43 ± 1.36
χ^2/t	-	0.162	0.443
p	-	0.687	0.659

Inclusion Criteria: (1) Conforming to diagnostic criteria for early chronic pulpitis in deciduous teeth. It may be asymptomatic. Symptoms may include: Discomfort when chewed food stuck in cavities. A mild, persistent or dull pain. Transient pain or discomfort from cold or hot stimuli. Spontaneous pain, radiating pain or paroxysmal pain. Examination: Surface may show color changes or ink-stain-like discoloration, surface integrity breakage with visible near-pulp caries, tenderness upon probing. There is no significant pain or slight discomfort during percussion. X-ray: The tooth crown may have a translucent area, with no pathological changes in the periapical tissues. (2) In good physical health, capable of communicating normally, and without any adverse dental treatment history. (3) Absence of spontaneous pain symptoms. Teeth are not mobile or tender to percussion, and soft tissues around the teeth are normal. (4) Signed informed consent.

Exclusion Criteria: (1) History of spontaneous tooth pain. (2) Swollen gums. (3) Systemic diseases or coagulation disorders. (4) Presence of other periodontal diseases.

2.2 Methods

Initial radiographic examination was followed by pulpectomy of the primary teeth for all children. TheraCal LC material (BISCO, USA, product number: 228-DDCLH-33014P) and MTA (Dentsply, USA, product number: 005-MTAA040500000400) were used as pulpotomy agents for the experimental and control groups, respectively.

Vital pulpotomy procedure: A sterile drape was placed and local anesthesia was administered using articaine (Jiangsu Hengrui Medicine, Lianyungang, Jiangsu, China, specification: 1.7 mL, articaine hydrochloride: 68 mg, adrenaline: 0.017 mg; batch numbers: 20150907, 20161204). A rubber dam and a high-volume evacuator were employed to prevent contamination. A high-speed bur or excavator was used to remove carious tissue and decayed material until pulp exposure was evident. A sterile treatment tray and bur were prepared after opening the surgical pack and changing instruments. The pulp chamber roof was then uncovered to expose the pulp cavity. To eliminate all traces of dentin and pulp debris, the coronal pulp was removed to a depth of 2–3 mm using a low-speed diamond bur, intermittently irrigated with 1.5% sodium hypochlorite solution and 0.9% saline solution. Using a sterile cotton ball, pressure was applied to the pulp surface for 5 minutes to achieve hemostasis.

Each group received a different pulpotomy agent. For the control group, MTA 1–3 mm thick was applied over the pulp stumps, covered with a small cotton ball and sealed with glass ionomer cement (GIC) (3M ESPE, USA, product number: 011-SMT2JQ3515), ensuring complete 3M resin coverage. Alternatively, the experimental group received a 1 mm thick coating of TheraCal LC on the root stump and pulp chamber floor, and was light-cured for 20 seconds. A damp cotton ball was used to clean residue, GIC was applied as a base, and nanocomposite resin (3M ESPE, USA, product number: 011-SZ1NM7018CT) was meticulously applied to fill the cavity. Throughout the procedure, sterile conditions were maintained rigorously, and the same dentist performed all treatments.

2.3 Observation indicators

(1) Postoperative treatment success rate: Clinical and radiographic examinations were performed on all children at 3, 6 and 12 months postoperatively. A successful treatment required the absence of spontaneous pain or sensitivity to thermal stimuli, absence of percussion and palpation tenderness, normal tooth mobility, no gingival swelling or sinus tracts, normal pulp vitality tests and electric vitality tests. Successful treatment was confirmed by X-ray periapical films that showed no internal or pathological external resorption at the root apex, as well as no low-density shadows at the bifurcation or periapical regions. Failures were recorded when any criteria were not met. (2) Analysis of cytokine levels in gingival crevicular fluid: Fluid was collected by inserting moisture-absorbing paper tips into the periodontal pocket or sulcus until resistance was felt, then holding for 30 seconds. After 30 s, the same operation handles the second paper tip. The appropriate dose was collected. Subsequent analysis using an automatic biochemistry analyzer (AU5800) measured levels of Tumor Necrosis Factor-alpha (TNF-α), Interleukin-6 (IL-6), and Interleukin-8 (IL-8). (3) A comparison of pain scores between both groups was conducted using the Visual Analogue Scale (VAS) method, with a total score of 10 points. 0 indicates no pain, 1–3 mild pain, 4–6 moderate pain, and $\geq$7 severe pain. (4) Comparison of comfort and satisfaction scores based on a satisfaction questionnaire developed by our hospital. Both groups of parents completed the satisfaction questionnaires divided into 5 parts, including doctor's diagnosis and treatment, nursing, medical environment, treatment anxiety and treatment comfort. Each part was scored out of 20, with a total satisfaction score of 100. Higher scores indicate higher satisfaction with treatment. Both groups' comfort status was evaluated using the Kolcaba General Comfort Questionnaire (GCQ) [10] Scores varied from 5 to 20 points for each of the four items including emotional changes, daily activities, physiological and psychological aspects. A score of 5 indicates the least comfortable, while a score of 20 represents the most comfortable, with higher scores reflecting greater patient comfort. Overall, the total score was 80 points, with higher scores indicating

greater comfort. (5) Adverse reactions: Any adverse reactions that occur within a week after surgical treatment in children, including elevated body temperature, occlusal pain, and oral infections.

2.4 Statistical methods

Statistical analysis was performed with SPSS 22.0 (IBM, Armonk, NY, USA). Quantitative data were described as mean and standard deviation ($\bar{x} \pm s$), and compared using t-test. Qualitative data were described as percentages (%) and compared using χ^2 test. $p < 0.05$ is considered statistically significant.

3. Results

3.1 Postoperative treatment success rate

After 3 and 6 months postoperatively, neither group showed significant differences in success rates ($p > 0.05$). However, after 12 months, the experimental group showed a significantly higher success rate than the control group (96.00% *vs.* 80.00%) ($p < 0.05$) (Table 2).

3.2 Cytokines in gingival crevicular fluid

There was a reduction in TNF-α, IL-6 and IL-8 in both groups after treatment. The experimental group had significantly lower TNF-α, IL-6 and IL-8 levels ($p < 0.05$) (Table 3).

3.3 Pain scores

Following treatment, both groups scored lower on pain than they did before. Significantly lower VAS scores were obtained in the experimental group than in the control group ($p < 0.05$) (Table 4).

3.4 Comfort and satisfaction scores

Significantly higher comfort and satisfaction scores were observed in the experimental group ($p < 0.05$) (Table 5).

3.5 Adverse reactions

The incidence of adverse reactions in the experimental group was significantly lower than in the control group ($p < 0.05$) (Table 6).

4. Discussion

Dental caries among children increase annually due to inadequate oral hygiene habits, the proliferation of refined food options, and a lack of strict dietary control [11]. As permanent teeth erupt after deciduous teeth loss, untreated pulpitis can adversely affect permanent teeth and impact the child's life [12]. To preserve deciduous teeth and eradicate inflammation before permanent teeth erupt, effective management of childhood pulpitis is critical. Mastication and speech will be mitigated as a result. Early-stage pulpitis in deciduous teeth is most commonly treated with root canal therapy and vital pulpotomy [13]. Despite its common use, root canal therapy has a relatively high failure rate, which results in suboptimal permanent teeth development and compromised masticatory function, ultimately affecting oral health and facial aesthetics [14]. Conversely, vital pulpotomy preserves the coronal pulp and root health, which aligns more closely with practical therapeutic goals. Capping material selection is essential to pulpotomy success.

Pulpotomy entails the thorough removal of infected pulp tissue while preserving healthy pulp, thereby preserving the large amount of viable pulp tissue. It requires the removal of decayed matter, followed by the application of an appropriate capping agent to facilitate healing [15, 16]. Ideally, capping agents for pulpotomy should be antibacterial, biocompatible, sealable and easy to use [17]. Historically, Vitapex root canal filler was frequently when filling deciduous teeth, but it degraded rapidly and had the potential for secondary infection. Recent advancements have led to the effective use of MTA in treating pulpitis. However, concerns remain regarding calcium hydroxide ($Ca(OH)_2$) concentration consistency due to chairside mixing variability, which could affect capping pressure. Additionally, studies indicate that MTA exhibits suboptimal dental tissue compatibility, water solubility, and seal ability, resulting in leakage post-capping [18]. Some materials' strong alkalinity may lead to superficial pulp tissue corrosion, and consequent necrosis. Furthermore, constituents such as iron and magnesium may induce tooth discoloration and display cytotoxic properties, which make MTA unsuitable for pulp capping in clinical settings. TheraCal LC, a novel light-curable resin-modified calcium silicate material, represents an advantageous capping option due to its ease of use and significant reduction in clinical operation time for deciduous teeth pulpotomy [19]. The material was reported to be less cytotoxic than other resin-based light-cured liners [20]. This study suggests similar efficacy in short-term clinical outcomes between groups at 3- and 6-months post-treatment. Interestingly, at 12 months post-treatment, the experimental group exhibited a significantly higher success rate than the control group ($p < 0.05$), which indicates that while MTA and TheraCal LC both demonstrate comparable short-term therapeutic benefits, TheraCal LC is associated with improved long-term results. TheraCal LC's formulation includes hydrophobic monomers that encase tricalcium silicate. After capping, Ca^{2+} released

TABLE 2. Comparison of postoperative treatment success rates between both groups (n (%)).

Group	n	3 months after surgery	6 months after surgery	12 months after surgery
Experimental group	50	49 (98.00%)	49 (98.00%)	48 (96.00%)
Control group	50	48 (96.00%)	46 (92.00%)	40 (80.00%)
χ^2	-	0.000	0.842	6.061
p	-	1.000	0.359	0.014

TABLE 3. Cytokine levels in gingival crevicular fluid indicators between both groups ($\bar{x} \pm s$).

Group	n	TNF-α (ng/mL)		IL-6 (pg/mL)	
		Before treatment	After treatment	Before treatment	After treatment
Experimental group	50	4.43 ± 0.74	1.73 ± 0.35	3.71 ± 0.63	1.29 ± 0.28
Control group	50	4.29 ± 0.69	2.36 ± 0.49	3.64 ± 0.71	1.96 ± 0.44
t	-	0.978	7.398	0.522	9.084
p	-	0.330	<0.001	0.603	<0.001
t_1	-	23.323		24.821	
p_1	-	<0.001		<0.001	
t_2	-	16.123		14.222	
p_2	-	<0.001		<0.001	
Group	n	IL-8 (pg/mL)			
		Before treatment		After treatment	
Experimental group	50	80.64 ± 13.88		50.34 ± 7.47	
Control group	50	81.30 ± 14.11		61.31 ± 10.94	
t	-	0.236		5.856	
p	-	0.814		<0.001	
t_1		13.593			
p_1		<0.001			
t_2		7.917			
p_2		<0.001			

Note: t: between both groups; t_1: t before and after treatment (experimental group); t_2: t before and after treatment (control group). p_1: p before and after treatment (experimental group); p_2: p before and after treatment (control group).
TNF-α: Tumor Necrosis Factor-alpha; IL-6: Interleukin-6; IL-8: Interleukin-8.

TABLE 4. The VAS scores of both groups ($\bar{x} \pm s$, points).

Group	n	Before treatment	After treatment
Experimental group	50	6.60 ± 1.51	1.64 ± 0.52
Control group	50	6.58 ± 1.69	2.86 ± 0.66
t	-	0.062	10.267
p	-	0.950	<0.001
t_1	-	21.961	
p_1	-	<0.001	
t_2	-	14.498	
p_2	-	<0.001	

Note: t: between both groups; t_1: t before and after treatment (experimental group); t_2: t before and after treatment (control group). p_1: p before and after treatment (experimental group); p_2: p before and after treatment (control group).

TABLE 5. Comparison of comfort and satisfaction scores between both groups ($\bar{x} \pm s$, points).

Group	n	Comfort	Satisfaction
Experimental group	50	74.30 ± 3.20	96.16 ± 1.07
Control group	50	69.34 ± 4.35	90.63 ± 2.17
χ^2		6.495	16.162
p		<0.001	<0.001

TABLE 6. Comparison of adverse reactions between both groups (n (%)).

Group	n	Elevated body temperature	Occlusal pain	Oral infection	Total
Experimental group	50	1 (2.00%)	0	1 (2.00%)	2 (4.00%)
Control group	50	2 (4.00%)	1 (2.00%)	2 (4.00%)	5 (10.00%)
χ^2					34.557
p					<0.001

upon application which enhances dentin mineralization and stimulates reparative dentin formation. Additionally, it possesses antibacterial properties. During moist conditions, the resin components facilitate sustained Ca^{2+} and OH^- release for at least 28 days. This extended calcium release favors hydroxyapatite formation and odontoblast differentiation, culminating in new dentin production—a key factor in TheraCal LC's superior performance over MTA for long-term pulpal inflammation management.

Similarly, Yilmaz Sıla reported clinical success rates of 96.4% for Ortho MTA and 92.8% for Retro MTA in vital pulpotomy of primary molars, which supports this study's observations [21]. There was a significant reduction in inflammatory cytokine levels (TNF-α, IL-6 and IL-8) following TheraCal LC application, compared to MTA ($p < 0.05$). This indicates a milder inflammatory response following TheraCal LC application. Gingival crevicular fluid, derived from interstitial plasma and epithelial residues, serves as a biological indicator of gingival inflammation through its inflammatory markers. There is a growing body of evidence that TNF-α, IL-6 and IL-8 not only act as critical pro-inflammatory mediators but also play roles in osteoclastogenesis and bone metabolism, thereby influencing gingival inflammation processes [22]. TheraCal LC and MTA hinder osteoclast formation and activity due to Si ions release. However, both materials have minimal differences in their effects [23]. Compared to MTA, TheraCal LC significantly enhances dental pulp stem cell adhesion, migration, and osteoblastic differentiation, which may explain why TheraCal LC elicits less inflammatory responses during vital pulpotomy procedures [24]. Gene sets were found to be associated with inflammation and TNF-α are upregulated in all tested materials. This was caused by activation of the NF-κB (nuclear factor kappa-light-chain-enhancer of activated B cells) pathway by signaling [25]. Post-treatment, experimental cohort participants reported significantly lower pain scores ($p < 0.05$), suggesting that TheraCal LC may reduce pain perception quickly. In addition to its antibacterial properties, biocompatibility, adhesive qualities, and effective sealing of dental tissues, the material exhibits no cytotoxicity. To minimize patient discomfort, adhere to sterile surgical protocols, remove infected pulp meticulously, and minimize apical region pain and swelling. The prevalence of adverse reactions was less frequent in the experimental group than the control group ($p < 0.05$), indicating that TheraCal LC offers superior safety when treating early chronic pulpitis through pulpotomy in deciduous teeth. Mahmoud's study confirms these findings, showing that cells treated with TheraCal LC did not exhibit cytotoxicity, illustrating the material's enhanced safety profile [26]. Therefore, TheraCal LC, has demonstrated potential for improving long-term treatment outcomes and facilitating the eruption of permanent teeth, yielding favorable clinical results when used as a capping agent for pulpotomies in the management of early chronic pulpitis in deciduous. This study, however, may be biased by its small sample size. The conclusion of future investigations should be strengthened by expanding sample size and including multicenter trials.

5. Conclusions

In conclusion, TheraCal LC is clinically effective and safe as a direct capping agent for pulpotomies in deciduous teeth, showing potential for application in treating early chronic pulpitis in deciduous teeth.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

YW—designed the study and carried them out; YW, TF, LPW, TG—supervised the data collection, analyzed the data, interpreted the data; YW, XH—prepared the manuscript for publication and reviewed the draft of the manuscript. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Ethics Committee of the Fifth Affiliated Hospital of Xinjiang Medical University (Approval no. XYDWFYLSH-2023-117). Written informed consent was obtained from a legally authorized representative for anonymized patient information to be published in this article.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Khijmatgar S, Bellucci G, Creminelli L, Tartaglia GM Jr, Tumedei M. Systemic antibiotic use in acute irreversible pulpitis: evaluating clinical practices and molecular insights. International Journal of Molecular Sciences. 2024; 25: 1357.

[2] Dharshya S, Suma B, Sathish S, Vasudevan A, Natanasabapathy V. The outcome of GaAlAs diode laser (980 Nm) pulpotomy in patients with symptomatic irreversible pulpitis assessed using CBCT—randomised controlled trial with an 18-month follow-up. European Endodontic Journal. 2024; 9: 35–43.

[3] Ahmed HMA, El-Karim I, Duncan HF, Krastl G, Galler K. Implications of root, pulp chamber, and canal anatomy on pulpotomy and revitalization procedures. Clinical Oral Investigations. 2023; 27: 6357–6369.

[4] Farhadi A, Safarzadeh A, Nekouei AH, Sabeti M, Manochehrifar H, Shahravan A. Comparative outcomes of pulpotomy in mature molars with irreversible pulpitis: a non-randomized trial evaluating calcified and non-calcified pulp chambers. Iranian Endodontic Journal. 2024; 19: 13–21.

[5] Donnelly A, Foschi F, McCabe P, Duncan HF. Pulpotomy for treatment of complicated crown fractures in permanent teeth: A systematic review. International Endodontic Journal. 2022; 55: 290–311.

[6] Bashar AK, Kabir MN, Ghosh R, Sajedin M, Rahman MM. Early inflammatory response of dental pulp in response to biodentin and mineral trioxide aggregate as pulp-capping agents. Mymensingh Medical Journal. 2023; 32: 1038–1045.

[7] Parameswaran M, Vanaja Madanan K, Kumar Maroli R, Raghunathan D. Efficacy of calcium enriched mixture cement, mineral trioxide aggregate and calcium hydroxide used as direct pulp capping agents in deep carious lesions—a randomised clinical trial. European Endodontic Journal. 2023; 8: 253–261.

[8] Feiz A, Shams M, Faghihian H, Yousefi P. The effect of intraorifice barriers (TheraCal LC, Lime-Lite and Ionoseal) on the fracture resistance and failure patterns of endodontically treated teeth submitted to intracoronal bleaching. Dental Research Journal. 2023; 20: 2.

[9] Zeater B, Abboud S, Hanafi L. Comparison of the effects of TheraCal LC and mineral trioxide aggregate on direct pulp capping (DPC) based on histological findings. Cureus. 2022; 14: e25326.

[10] Gonzalez-Baz MD, Pacheco Del Cerro E, Ferrer-Ferrándiz E, Araque-Criado I, Merchán-Arjona R, de la Rubia Gonzalez T, *et al*. Psychometric validation of the Kolcaba general comfort questionnaire in critically ill patients. Australian Critical Care. 2023; 36: 1025–1034.

[11] van Meijeren-van Lunteren AW, Voortman T, Wolvius EB, Kragt L. Adherence to dietary guidelines and dental caries among children: a longitudinal cohort study. European Journal of Public Health. 2023; 33: 653–658.

[12] Meva AZ, Akif SM. Prevalence and associated factors of dental caries in Syrian immigrant children aged 6–12 years. Children. 2023; 10: 1000.

[13] El Karim IA, Duncan HF, Fouad AF, Taha NA, Yu V, Saber S, *et al*. Effectiveness of full pulpotomy compared with root canal treatment in managing teeth with signs and symptoms indicative of irreversible pulpitis: a protocol for prospective meta-analysis of individual participant data of linked randomised clinical trials (PROVE). Trials. 2023; 24: 807.

[14] Mokhtari H, Milani AS, Zand V, Shakuie S, Nazari L. The effect of different concentrations and temperatures of sodium hypochlorite irrigation on pain intensity following endodontic treatment of mandibular molars with irreversible pulpitis: a randomized, double-blind clinical trial. Clinical and Experimental Dental Research. 2023; 9: 859–867.

[15] Taha NA, Abuzaid AM, Khader YS. A randomized controlled clinical trial of pulpotomy versus root canal therapy in mature teeth with irreversible pulpitis: outcome, quality of life, and patients' satisfaction. Journal of Endodontics. 2023; 49: 624–631.e622.

[16] Tewari N, Goel S, Mathur VP, O'Connell AC, Johnson RM, Rahul M, Sultan F, Goswami M, Srivastav S, Ritwik P. Success of medicaments and techniques for pulpotomy of primary teeth: an overview of systematic reviews. International Journal of Paediatric Dentistry. 2022; 32: 828–842.

[17] Haghgoo R, Molaasadolah F, Taghizade F, Ansari G, Asgary S. Three-year outcome of diode laser pulpotomy of primary molars using three pulp capping agents: a split-mouth randomized clinical trial. Journal of Evidence-Based Dental Practice. 2023; 23: 101920.

[18] Kumar SR, Patnaik A. Mineral trioxide aggregate (MTA) as a filler in dental composite: evaluation of micro-hardness and wear properties. Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering. 2023; 237: 1988–1998.

[19] Mahapatra J, Nikhade P, Patel A, Taori P, Relan K. Comparative evaluation of the efficacy of light-cured calcium hydroxide and a fourth-generation calcium silicate cement (TheraCal LC) as indirect pulp capping materials in patients with deep carious lesions: a randomized parallel-group clinical trial. Cureus. 2022; 14: e28882.

[20] Bortoluzzi EA, Niu L, Palani CD, El-Awady AR, Hammond BD, Pei D, *et al*. Cytotoxicity and osteogenic potential of silicate calcium cements as potential protective materials for pulpal revascularization. Dental Materials. 2015; 31: 1510–1522.

[21] Yılmaz S, Keleş S. Efficacy of orthoMTA, retroMTA and ferric sulphate as pulpotomy agents in primary molars: a randomized clinical trial. European Oral Research. 2023; 57: 144–150.

[22] Sabeti MA, Nikghalb KD, Pakzad R, Fouad AF. Expression of selected inflammatory mediators with different clinical characteristics of pulpal inflammation. Journal of Endodontics. 2024; 50: 336–343.

[23] Bhushan J, Sethi S, Joshi R, Singla R, Sidhu K. Effect of different irrigants on the push-out bond strength of biodentine and TheraCal LC when used for perforation repair in simulated condition. Journal of Conservative Dentistry. 2023; 26: 321–325.

[24] Rani R, Namdev R, Singhal R, Singhal P, Goel N, Jha S. Comparative evaluation of effectiveness of TheraCal LC, MTA, and calcium hydroxide in direct pulp capping in primary molars: randomized clinical study. International Journal of Clinical Pediatric Dentistry. 2023; 16: S213–S219.

[25] Hyung NO, Sun LH, JaeHwan K, Chae YK, Hong SJ, Kang SW, *et al*. Differential gene expression changes in human primary dental pulp cells treated with biodentine and TheraCal LC compared to MTA. Biomedicines. 2020; 8: 445.

[26] Mahmoud K, Azza K, Amira E. A comparative histological study of the effect of TheraCal LC and biodentine on direct pulp capping in rabbits: an experimental study. Clinical Oral Investigations. 2022; 27: 1013–1022.

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