ORIGINAL RESEARCH

# Comparative Evaluation of Effectiveness of Calcium Hydroxide, MTA, and TheraCal LC in Indirect Pulp Capping in Primary Molars: *In Vivo* Study

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## Abstract

**Aim:** This investigation aimed to observe the effects of Dycal, mineral trioxide aggregate (MTA), and TheraCal LC, as indirect pulp-capping materials in primary molars.

**Materials and methods:** About 75 children with lower primary molars aged between 4 and 7 years suggested for IPC were selected and randomly allocated into: Group I – Dycal, group II – MTA, and group III – TheraCal LC. An immediate postoperative radiograph was taken after the procedure. Recall examination was done after 3 and 6 months for clinical and radiographic assessment. The radiographs were digitized, and the amount of thickness of dentin was assessed using Corel Draw software. The values were tabulated and subjected to paired *t*-tests and independent *t*-tests for intra and intergroup analysis, respectively. The $p$-value < 0.05 was considered statistically significant.

**Results:** There was a statistically significant increase in dentin thickness in the first 3 months compared to the 6-month follow-up. At the end of the research phase, TheraCal LC had more tertiary dentin deposited than MTA, followed by Dycal.

**Conclusion:** TheraCal LC can be a reliable indirect pulp-capping agent in primary teeth.

**Clinical significance:** Indirect pulp capping (IPC) is a very extensively employed treatment regimen to manage extensive caries. For many decades, calcium hydroxide has been regarded as the benchmark of pulp capping materials. With several advancements in materials for restoration, TheraCal LC a resin-modified, light-cured calcium silicate-filled liner serves as a pulp-capping agent and dentin protector, promoting pulp healing and preserving vitality as an obstacle cum protector of the dental pulp complex.


**Keywords:** Calcium hydroxide, Indirect pulp treatment, Mineral trioxide aggregate, Primary teeth, TheraCal LC.

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## Introduction

The burden of deep caries marks a threat to all the ages and the socially disadvantaged communities worldwide. Deep caries progress through the enamel and dentin into the deeper layers of the tooth and reach the pulp (the soft tissue containing nerves and blood vessels). Maintenance of pulp vitality is a crucial target in restorative dentistry.[1,2] Dental caries is a common chronic infectious resulting from tooth-adherent cariogenic bacteria, primarily Streptococcus mutans, which metabolize sugars to produce acid, demineralizing the tooth structure over time.[3] Deep caries are caused by several factors, primarily driven by acid demineralization by cariogenic bacteria in dental plaque. Key factors include frequent sugar intake, poor oral hygiene, saliva composition, and medical conditions like diabetes. It involves plaque formation, acid production, and demineralization, leading to inflammation and pain. The clinical features of these lesions are dark cavities, tooth sensitivity, abscess formation, which can be assessed by visual examination, radiographs, and sensitivity testing. The treatment approach depends on the severity and the condition of the pulp. In early caries, use small, non-cavitated lesions, fluoride treatment, and improve oral hygiene. Use minimal dentin involvement to restore the cavity in incipient caries. In deep caries, when the pulp is inflamed or infected, a pulpectomy (root canal) is required.[1,3]

Pulp capping is done to preserve the vitality of a tooth when the pulp is exposed. Vital pulp therapy aims to safeguard the vitality of dental pulp while aiding in the re-establishment of

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pulpal components to recommence the pulp complex.[2] Protection of the pulpal complex can stretch the continuing viability of teeth via several simple restorative approaches.[4,5] Indirect pulp capping (IPC) has been proposed as a conservative pulp therapy for several decades. It is a technique for deep caries management without any features of pulp degeneration.[6,7] This stimulates tertiary dentin formation, shunning pulp exposure and maintaining pulp vitality. The treatment intends to conserve surviving odontoblasts and stimulate reactive dentin emergence in the pulp-dentin junction. For long, calcium hydroxide [$Ca(OH)_2$] remained the principal agent used in pulp-capping therapy.[8] It was pioneered in dentistry by Hermann and has formally been accepted as the preferred material for pulp capping for several decennaries.[9,10] Nevertheless, the quest for other substitutes continues due to certain disadvantages of $Ca(OH)_2$, such as self-hardening, microleakage, creation of tunnel defects in dentin bridges, inadequate antibacterial activity, scar tissue formation, excessive solubility, inferior dentin bonding, disintegration, and necrosis in the superficial region.[2,4,7,11,12]

Today, it is being replaced by materials that exhibit alike clinical results. Examples include cements containing calcium silicate, collagen, growth factors, enzymes, and stem cells.[7,9] Nevertheless, there is a need for an urgent development of an ideal pulp-capping agent.[13] An ideal pulp-capping material must possess features such as aiding in tertiary dentin formation, safeguarding pulp vitality, inhibiting bacterial leakage, intercepting secondary caries, affixing to dentin and to restorative materials creating a satisfactory seal, encouraging mineralization and promote normal development of root.[7,9,14]

The use of biomimetic, bioinspired, and bioactive biomaterials strives to solve hassles by replicating a natural environment.[13] One such material is the mineral trioxide aggregate (MTA), a biocompatible dentin substitute, has a lot of benefits which include radiopacity, the ability to stimulate mineralized tissue development, sealing ability, and bioactivity.[4,15] However, there are a few drawbacks like tooth discoloration, long setting time, difficult handling, and high solubility during setting.[14,15] TheraCal Light Cured (LC) by Bisco Inc. was introduced to get around the drawbacks of MTA. It is a novel resin-modified, light-cured, white tricalcium-silicate based hybrid single paste that is used as a pulp capping material designed to address issues with bonding to overlying resin restorations.[16–20] It holds advantages like shorter setting time, better sealing efficacy, higher pH, agreeable antimicrobial potency, reduced solubility, remineralizing potential, simple handling, lesser film thickness, and good tolerance by odontoblastic cells.[19–21] Furthermore, it causes a decreased incidence of hard tissue staining because of its proficient bioactivity.[19] It has similitude with MTA, in addition to the ability to cease microbial discharge, taper dentin hypersensitivity and boost pulpal repair.[7] TheraCal LC operates as a barricade and protectant of the dental pulpal complex.[9] It liberates calcium ions which stimulate odontoblasts and fibroblasts, thereby creating mineralized tissues It develops a scaffold on affected dentin, encourages the production of reparative dentin, and imparts a biological adhesion by means of a chemical bond with the dentin shielding the pulp.[11] With its distinct composition, capacity to dual-cure, and superior biocompatibility, TheraCal presents a novel approach to pulp capping. As a dependable option for pulp-capping treatments, it can maintain the pulp vitality, lessens postoperative sensitivity, and offers long-term protection to the pulp making it clinically significant to use in pulp-capping treatments. Whereas MTA is a bioactive substance that promotes dentinogenesis and fosters an environment that is ideal for pulp healing. It also has good sealing ability and biocompatibility. It ensures long-term tooth health and a lasting restoration by promoting the maintenance of pulp vitality, fostering the creation of dentin bridges, and demonstrating excellent success rates in pulp-capping treatments.[18–20] The current research aimed to explore better tools to prevent deep caries. As it was reported by The World Health Organization (WHO) that dental caries affects around 60–90% of children at school age, which negatively affects the quality of life of children and their families hence, a need was felt to look for better interventions.[20] Hence, this study was conceived to evaluate the clinical and radiographic success rate of IPC utilizing three materials: Dycal, MTA, and TheraCal LC. The above materials were chosen due to their benefits for pain abatement and prevention of further tooth decay.

## Materials and Methods

The current study is a randomized control study which was conducted in the Department of Paediatric and Preventive Dentistry, Sri Siddhartha Dental College and Hospital, Tumkur, Karnataka. The University Ethics Committee approved the study protocol and procedures (ref. no. IEC/2015-16/11). With a level of significance set at $\alpha = 0.05$, the effect size of 20%, and power of 85%, with reference to George V et al.[21] Around 75 healthy cooperative children aged 4–7 years were randomly allocated into three groups depending on the materials used for pulp capping. Group I-Dycal, group II-MTA, group III-TheraCal LC. Informed consent was obtained prior from their parents. Primary mandibular molars without any underlying systemic illness, and teeth that have occlusal, deep, or proximal caries that extend past half of the dentin thickness were included in the study. A tooth that was nonvital, positive for spontaneous pain, tender on percussion, radiographic evidence of pathological root resorption, radiographic evidence of deep caries involving more than two-thirds of dentin thickness, Abscess/fistula, mobility, physiological resorption beyond one-third of the root, inter-radicular/periapical pathology were excluded from the study. This trial adhered to the standards outlined in the declaration of Helsinki for medical experimentation involving human volunteers. A single operator completed the entire clinical procedure, the follow-up was done by two skilled pediatric dentists who were "blinded" to the materials. Following the administration of local anesthesia, isolation was done with a rubber dam. All carious dentin from peripheral walls was eliminated using a high-speed 330 diamond bur, and a copious water stream was given. The wet, soft, necrotic dentin was hand excavated on the pulpal walls until leathery and firm dentin was contacted, which was confirmed by visual and tactile ways. The cavity was flushed with sterile saline and dried.[22]

### Group I (Dycal)

According to the manufacturer's instructions, calcium hydroxide (Dycal) was mixed with equal portions of catalyst and base paste to create a uniform mixture, and then applied using a condenser to the created cavity. Gentle pressure was applied with cotton pellets for the adaptation of Dycal.

### Group II (MTA)

Mineral trioxide aggregate (Dentsply Tulsa Dental, Tulsa, OK, USA) powder was mixed with sterile water for 30 seconds to get a sandy consistency. An amalgam carrier was used to place the mixture within the created cavity using mild pressure with wet cotton pellets.

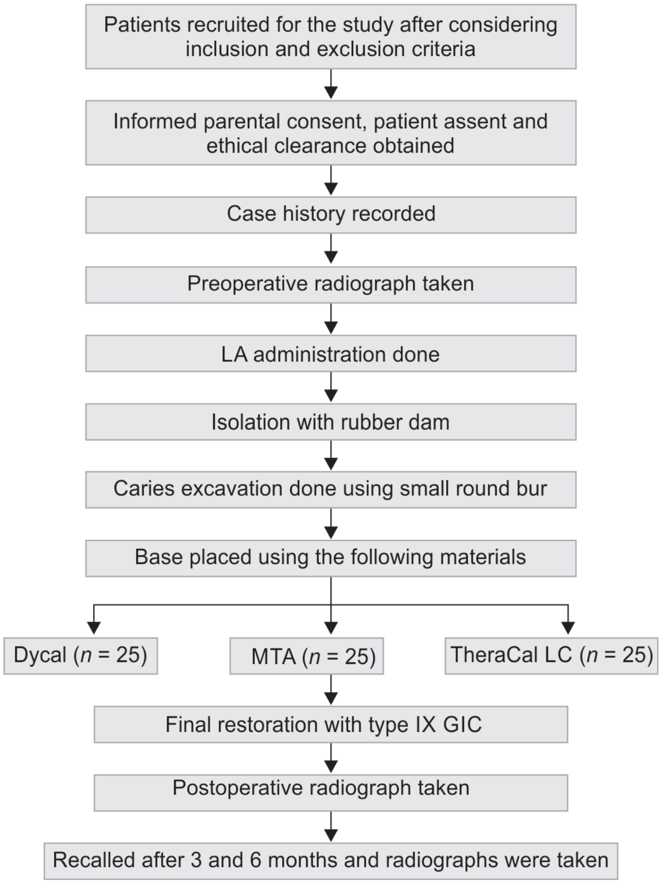



**Fig. 1:** Flowchart of the methodology

### Group III (TheraCal LC)

TheraCal LC was smeared on the prepared cavity at 1 mm thickness using a needle-tip syringe and light-cured for 20 seconds.[23] The cavities were then restored with type IX GIC. After removing the rubber dam, the restorations were inspected for any occlusal interferences. On termination of the procedure, a postoperative intraoral periapical radiograph (IOPA) was obtained at baseline using a paralleling technique. To standardize the radiographs, the extension cone paralleling (XCP) method was employed. The radiographs were then digitized and uploaded to the computer for further analysis (Fig. 1).

In this study, CorelDraw software (version 13) was employed for performing statistical analysis. This software evaluated the surge in thickness of dentin at baseline, 3rd and 6th-month follow-up. The examination was done by a single independent examiner who was blinded to the study. Dentin thickness was measured using the software's reference points, which included the cementoenamel junction and the highest point on the floor of the pulp chamber. The measurements were made till the bottom of the restoration. The quantity of dentin deposited at every time gap was measured by the difference in the values acquired from the initial and follow-up radiographs. Clinical success was considered to have occurred when the pulp remained vital and showed no spontaneous or nocturnal pain, sensitivity to pressure or any stimuli, abscess, sinus, fistula, or swelling of the periodontal tissue during any subsequent follow-up examinations. Treatment was successful when the pulp remained vital with no signs of spontaneous pain and no radiographic evidence of pathologic change noticed at the end of the study period. All the data obtained was compiled on a Microsoft Excel sheet and analysis was done using the SPSS software version 20 (IBM Corporation, Armonk, New York, United States). Intragroup and intergroup comparison for an increase in dentin thickness was carried out using paired *t*-test and independent *t*-test. The *p*-value $< 0.05$ was considered statistically significant.

## Results

The clinical and radiographic evaluations were done for all the patients at baseline, 3 months after treatment, and 6 months after indirect pulp therapy. The success rate was 100% since none displayed any symptoms of resorption, furcal radiolucency, movement, discomfort, or sensitivity. The mean dentin precipitated at 3 months was 0.095 mm ($p = 0.0005$) which was found statistically significant.

The intragroup comparison of the mean dentin deposited in the Dycal group at 6 months was 0.144 mm ($p < 0.0001$). It was statistically significant whereas the mean dentin deposited between 3 and 6 months was 0.048 mm ($p = 0.0854$) which was not statistically significant (Table 1 and Fig. 2A). This indicates that there is more tertiary dentin formed during the initial three months in comparison to the next three months following the IPC using Dycal. The mean dentin deposited in the MTA group at three months (0.102 mm ($p = 0.0390$)), was statistically significant. Although the mean dentin deposited between three and six months was 0.058 mm ($p = 0.2306$), which was statistically insignificant, the mean dentin deposited at six months was 0.161 mm ($p = 0.0015$), which was statistically significant. This shows that more tertiary dentin is generated during the first three months following IPC with MTA than during the subsequent three months. The mean dentin deposited at three months was 0.134 mm ($p = 0.0292$) which was statistically significant (Table 1 and Fig. 2B). The mean dentin deposited in the TheraCal LC group between 3 and 6 months was 0.061 mm ($p = 0.3756$), which was found statistically insignificant, suggesting the formation of more tertiary dentin during the first three months following IPC using TheraCal LC. The mean dentin deposited at six months was 0.196 mm ($p = 0.0020$), which was also statistically significant as demonstrated in (Table 1 and Fig. 2C).

A statistically significant increase in dentin thickness was recorded in MTA, Dycal, and TheraCal LC groups during the intergroup analysis using an independent *t*-test, with a *p*-value of 0.0003 for post-op, 0.0003 for 3 months, and 0.0001 for 6 months. The mean dentin deposited at 3 months in the MTA group was 0.102 mm, 0.095 mm in the Dycal group, and 0.134 mm in the TheraCal LC group. The mean dentin deposited at 6 months in the MTA group was 0.161 mm, 0.144 mm in the Dycal group, and 0.196 mm in the TheraCal LC group. The difference in dentin thickness between 3 and 6 months in the MTA group was 0.058 mm, 0.048 mm in the Dycal group, and 0.061 mm in the TheraCal LC group. These results suggested the superiority of TheraCal LC to MTA followed by Dycal (Table 2 and Fig. 3). Overall, TheraCal LC is better than the other two groups on account of its maximum mean values, maximum standard deviation, and greater statistical significance levels for all 3 periods: Baseline, 3 months, and 6 months.

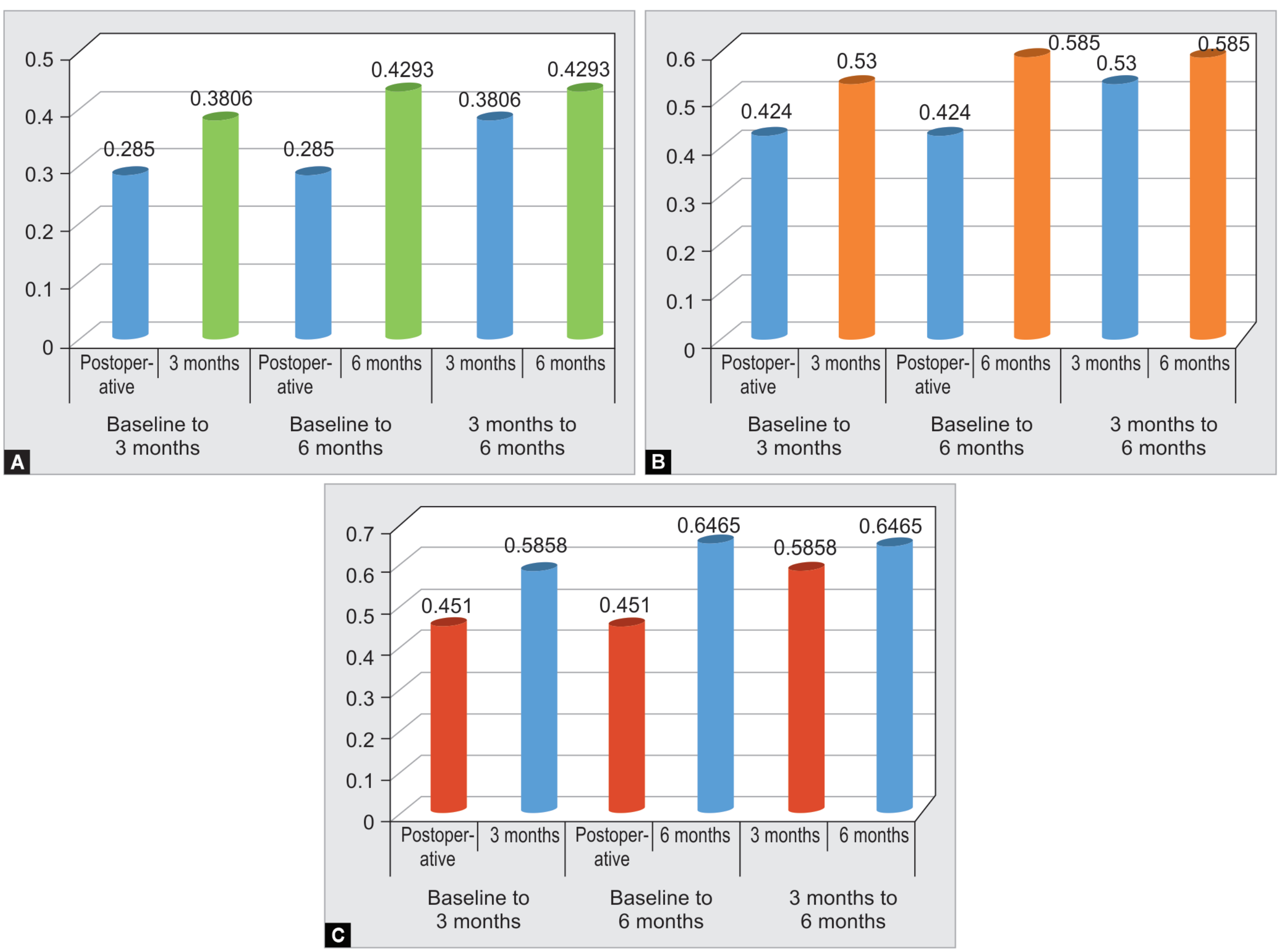
## Discussion

The present study was conducted to evolve better interventions to tackle the growing menace of deep caries especially in children worldwide. Calcium hydroxide has been the gold standard material of choice in deep caries management, however, it does

**Table 1:** The intragroup comparison mean and standard deviations of the value of dentin thickness in the Dycal, MTA, TheraCal TC group postoperatively, after 3 and 6 months

| | *Variables* | *Mean* | *Standard deviation* | *p-value* | *Statistical significance* |
|---|---|---|---|---|---|
| Dycal | Post-op | 0.2850 | 0.08770 | 0.0005*** | HS |
| | 3 Months | 0.3806 | 0.09757 | | |
| | Post-op | 0.2850 | 0.08770 | <0.0001*** | HS |
| | 6 Months | 0.4293 | 0.1028 | | |
| | 3 Months | 0.3806 | 0.09757 | 0.0854 | NS |
| | 6 Months | 0.4293 | 0.1028 | | |
| MTA | Post-op | 0.4239 | 0.1639 | 0.0390* | Significant |
| | 3 Months | 0.5259 | 0.1687 | | |
| | Post-op | 0.4239 | 0.1639 | 0.0015** | Significant |
| | 6 Months | 0.5847 | 0.1663 | | |
| | 3 Months | 0.5259 | 0.1687 | 0.2306 | NS |
| | 6 Months | 0.5847 | 0.1663 | | |
| TheraCal LC | Post-op | 0.4510 | 0.1786 | 0.0292* | Significant |
| | 3 Months | 0.5858 | 0.2405 | | |
| | Post-op | 0.4510 | 0.1786 | 0.0020** | Significant |
| | 6 Months | 0.6465 | 0.2396 | | |
| | 3 Months | 0.5858 | 0.2405 | 0.3756 | NS |
| | 6 Months | 0.6465 | 0.2396 | | |

$p \leq 0.05$/* is significant




**Figs 2A to C:** (A) Showing the intragroup comparison—Dycal group; (B) Showing the intragroup comparison—MTA group; (C) Showing the intragroup comparison - TheraCal LC group

**Table 2:** Intergroup comparison of MTA, Dycal group, and TheraCal LC groups

| *Variables* | *Materials* | *Mean* | *Standard deviation* | *p-value* | *Significant* |
|---|---|---|---|---|---|
| Post-op | MTA | 0.4239 | 0.1639 | 0.0003*** | HS |
| | Dycal | 0.2850 | 0.08770 | | |
| | TheraCal LC | 0.4510 | 0.1786 | | |
| 3 months | MTA | 0.5259 | 0.1687 | 0.0003*** | HS |
| | Dycal | 0.3806 | 0.09757 | | |
| | TheraCal LC | 0.5858 | 0.2405 | | |
| 6 months | MTA | 0.5847 | 0.1663 | 0.0001*** | HS |
| | Dycal | 0.4293 | 0.1028 | | |
| | TheraCal LC | 0.6465 | 0.2396 | | |

$p \leq 0.05$ is significant

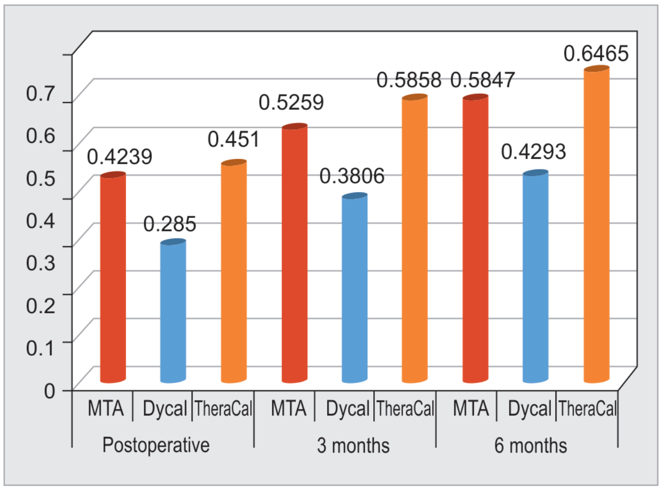



**Fig. 3:** Showing the intergroup comparison—MTA, Dycal group and TheraCal LC group

exhibit certain limitations, such as poor bonding ability to dentin and sealing capabilities, suboptimal physical properties, gradual dissolution, and the occurrence of tunnel defects in the dentin bridge which has led to the development of various alternate materials.[8,12] Calcium silicate materials (CSMs) are emerging materials that are still being experimented for their potential use in dentistry. Among them, mineral trioxide aggregate (MTA), and Biodentine are traditional calcium silicate-based materials used in pulp capping these materials have proved to stimulate dentin formation promoting the formation of a dentin bridge, improved mechanical properties, excellent biocompatibility. Biodentine has a faster setting time compared to MTA, which can be advantageous in reducing chair time and improving efficiency during procedures. While both materials have demonstrated favorable outcomes in clinical studies. TheraCal is a light-curable, resin-modified calcium silicate material. Its adhesive properties provide faster setting and improved moisture tolerance compared to MTA and Biodentine.[8,15,18] It has better physical properties, enhanced durability, increased stability, and reduced solubility and better compressive strength compared to MTA and Biodentine. Since there are very limited comparative studies, this study aimed to perform an evaluation of clinical and radiographic efficacy of TheraCal in IPC of primary molars in comparison with MTA and calcium hydroxide.

The current analysis revealed a clinical success of 100% for all three materials. George et al. detected clinical success of 80% with Dycal after 6 months. A case of sinus opening was reported after 6 months in the Dycal group following IPC in primary molars; this result contrasted with previous findings.[21] Casagrande et al. demonstrated a success of 73.3% in the Dycal group at the end of 4 years whereas Benoist et al. showed 73% success at the end of 6 months in the Dycal group.[24,25] Aeinehchi et al. stated that Dycal is linked with tissue necrosis added to inflammation through the commencing phase of placement (3 months) following IPC. Seemingly, MTA-capped samples had presented with chronic inflammation, hyperemia, and pulpal necrosis after 3 months.[26] Cannon et al. had confirmed a case of pulpal necrosis in TheraCal LC. The complete success of our study may be attributed to appropriate case selection, strict isolation protocol, the operator's expertise in caries removal, good coronal seals, and the motivation of the patients to attend recall visits. Participants aged 4–7 years were recruited to achieve adequate cooperation which may be lacking in the younger age-group. This age range also gives precise results due to the relative maturation from complete root development to clinically obvious resorption, where the maturating pulp has a powerful dentinogenetic and repair ability. Also, the success of the present study suggests that single-sitting IPC is viable in primary dentition.[6] Krasner et al. suggested the distinguishable reference points for detecting the floor of the pulp chamber. They substantiated that the floor of the pulp chamber is always situated in the center of the tooth at the plane of the cement-enamel junction, the most compatible landmark for locating the pulp chamber.[27] Hence, this was considered the landmark to carry out all the measurements in our investigation.

The intragroup comparison of Dycal showed an average increase in dentin thickness of 0.144 mm in 6 months whereas George et al., showed an average increase in dentin thickness of 0.097 mm at 6 months and Benoist et al. reported a 0.085 mm increase in dentin thickness over 6 months, further corroborating our study results.[21,25] Limitations of Dycal include high solubility in tissue fluids, leading to material disappearance resulting in tunnel defect formation in reparative dentin underneath the capping, thereby not achieving a permanent seal.[12]

In our study, the MTA group showed tertiary dentinogenesis at 3- and 6-months follow-up. The intragroup comparison of MTA revealed an average increase in dentin thickness of 0.161 mm in 6 months. George et al. showed 0.143 mm of dentin deposition at 6 months and Benoist et al. showed 0.114 mm of increase in dentin thickness over 6 months.[25] These values are in accordance with the current study. Santos et al. validated that calcium and hydroxyl ions may be released from MTA during storage in moist conditions for up to 360 hours aiding in tertiary dentinogenesis, which may be the reason for denser dentinogenesis in our study.[28,29]

TheraCal LC is a fourth-generation calcium silicate-based paste.[10,11] It is a convenient choice for children who cannot combat long appointments. Gandolfi et al., observed higher calcium-releasing ability and lower solubility with TheraCal LC than ProRoot MTA or Dycal.[9] Menon et al. reported that TheraCal LC as an IPC agent showed a success rate of 87.8%, which was greater than Dycal (84.6%).[19] This is also in accordance with our study. The current study results suggest that TheraCal LC is a promising IPC agent for primary molars.

### Limitations and Future Directions

These outcomes are based on a short-term trial. Also, no 3D imaging technique was used in the current study for the visualization of the calcified barrier. This study will be useful for clinicians as TheraCal LC shows acceptable results as an IPC agent and demonstrates good efficacy in tertiary dentin deposition. It can be a promising alternative for managing deep carious lesions by clinicians due to its ease of handling and lesser setting time. Further studies with larger sample sizes and longer follow-up periods are required to evaluate the role of these materials.

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