**Int. j. adv. multidisc. res. stud.** 2025; 5(2):1052-1055

**Received:** 06-02-2025
**Accepted:** 16-03-2025

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

# Comparison between Calcium silicate, Mineral Trioxide Aggregate and Calcium Hydroxide on the Induction of Reparative Dentin following Pulpotomy

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**DOI:** https://doi.org/10.62225/2583049X.2025.5.2.3942

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**Abstract**

This *in-vivo* study used calcium silicate, MTA and calcium hydroxide pulpotomy of premolar tooth to investigate the potential for reparative dentin development without causing unfavorable side effects. For cosmetic reasons, a pulpotomy was used to treat a patient's right first premolar tooth. In order to expose the pulp, a round cavity with a diameter of 2 mm was initially created on the occlusal surface using a flat end fissure bur and a high-speed hand piece under adequate cooling conditions. After using sterile cotton pellets to staunch the bleeding, Dycal®, MTA and Biodentine™ was applied to the exposed pulp tissue in accordance with the manufacturer's instructions. The tooth was pulled at 4 weeks under local anesthetic, and it was preserved for 24 hours in 4% neutral buffered formaldehyde. After being demineralized, the specimen was imbedded in paraffin. A blind observer used a light microscope fitted with a digital camera and a computer for histometry to examine a series of sections containing pulp tissue that had been longitudinally serially sectioned at a thickness of 6 µm. Lastly, the experimental tooth's amount of newly generated hard tissue was measured. The findings indicated that the exposed pulp tissue is only partially covered by the 0.9 ± 0.2 µm thick layer of reparative dentin development by Dycal®. The histological sections of Dycal® showed no inflammation in the entire extension of the root canal and the presence of stenosis and dentin barrier formation. Thickness of reparative dentin formation is 1.2 ± 0.2 µm and completely covers the exposed pulp tissue by MTA. The healing of pulp was satisfactory with without affecting the normal function of the remaining pulp. The thickness of reparative dentin formation by Biodentine™ was 1.4 ± 0.4 µm that completely covered the exposed pulp tissue. In conclusion, Calcium-silicate based pulpotomy material is capable to induce pulpal wound healing and reparative formation in the exposed teeth without affecting the normal function of the remaining pulp. More study was need for conclusive result.

**Keywords:** Vital Tooth, Pulpotomy, Calcium hydroxide, Reparative Dentin Formation

## Introduction

When the local environment is conducive, the dentinal pulp's natural ability to make reparative dentin is activated[1]. Clarifying the variables and mechanism underlying this healing is crucial for both scientific and therapeutic reasons, as predictable bio-induction of dentin production would significantly alter the results of pulp therapy. Nevertheless, no biological method for the regulated induction of the reparative process—such as the use of traditional calcium hydroxide—has proven effective in clinical settings for the tooth pulp thus far [2]. In order to protect the pulp and promote the creation of new hard tissue, a commercially available calcium hydroxide paste (Dycal®) is frequently used to cap unintentional pulp exposures and pulpal walls in cavities. Because of their high pH and consequent antibacterial and anti-inflammatory properties, newly made calcium hydroxide pastes are frequently chosen as pulp-capping materials in endodontics for direct pulp capping and pulpotomy reasons.

MTA was created in 1993 by Mahmood Torbinejad at Loma Linda University. Tricalcium silicate, tricalcium aluminate, tricalcium oxide, and other mineral oxides are the main constituents of this mineral powder, which is made up of hydrophilic particles. It has a pH of 12.5 and takes around 4 hours to set when exposed to moisture. According to earlier research, its advantageous qualities—such as good sealing ability, biocompatibility, bactericidal activity, radiopacity, and the capacity to set in the presence of blood or tissue fluids—make it the perfect material for pulp therapy.

A silicate-based substance called BiodentineTM (Septodont, Saint-Maur-des-Fossés, France) is utilized as a dentin restorative material and has endodontic indications as well [2-4]. The powder's primary ingredient is a tri-calcium silicate, to which $ZrO_2$ and $CaCO_3$ have been added. The liquid is made up of a water-reducing agent and $CaCl_2$. This material has great compressive and flexural strength, as well as chemico-mechanical bonding with composite and teeth. The current study aimed to investigate the effects of calcium silicate, calcium hydroxide, and mineral trioxide aggregate on the *in vivo* induction of reparative dentin after pulpotomy.

**Materials & methods:**

**Pre-operative procedure:** Patient's name, age, sex, tooth number and clinical diagnosis was recorded.

**Surgical procedure:**

Sixty non-carious permanent premolar teeth were collected from participants who need extraction of their teeth for Orthodontic reasons, was used as study population. These teeth were divided by traditional lottery method, as a total, among the 20 teeth were used for Biodentine™ , 20 teeth for MTA and 20 teeth for Dycal®. These teeth were divided into four groups according to observation times as follows: 1 week (5 teeth in each treatment group) 3 weeks (5 teeth in each treatment group), 4 weeks (5 teeth in each treatment group), 8 weeks (5 teeth in each treatment group).

**Exposure of the pulp***:*

After mouth preparation of each patient, a round shape cavity (diameter: 2 mm) was prepared on the occlusal surface to expose the pulp by using a flat end fissure bur (Shofu Dental Corporation, Japan) with a high-speed hand piece under sufficient cooling arrangement.

**Treatment:**

In group A, following control of bleeding with sterile cotton pellets, the exposed pulp tissue was covered with Biodentine™ (Septodont, France) according to manufacturer's recommendations. The liquid from single ampoule was emptied in the capsule and the capsule was triturated for 30 sec on a mixing device (Cap-mix) at a speed of 4000-4200 rotation/min. The freshly mixed Biodentine has a putty-like consistency and was packed in the exposure site using a plastic filling instrument (supplied by the manufacturer). The working time of Biodentine™ is up to 6minutes with a final set at around 10-12 minutes. Finally, restoration of the tooth was performed with flowable composite resin.

In group B, MTA powder was mixed on a paper pad with distilled water 3:1 powder water ratio. They were mixed for about 1 min to ensure all powder particles are hydrated by gain a creamy consistency. Once the material acquired this consistency, it was applied with the help of amalgum carrier and gently packed into the treatment site with hand plugger and pressed with moistened cotton pellet.

In group C, following control of bleeding with sterile cotton pellets, the exposed pulp tissue was covered with Dycal® (DENTSPLY, Germany) according to manufacturer's recommendations. All procedures were performed by the same operator. The test materials were applied randomly after the cavity preparation and pulp capping has been performed.

**Study Variable:**

Qualitative analysis: Sampling and histology:

At 1, 3, 4 and 8 weeks after pulp capping, teeth was extracted under local anesthesia and fixed in cold 4% neutral buffered formaldehyde for 24 hours. The specimens were dematerialized and embedded in paraffin. After longitudinal serial sectioning (6µm), every second section was stained with haematotoxylin and eosin. Series of sections containing pulp tissue was observed by a blinded observer in a light microscope equipped with a digital camera and computer for histometry.

Quantitative analysis of new hard tissues:

The amount of new hard tissue formed subjacent to each treatment was assessed from each experimental tooth. The area covered by newly formed hard tissue in these sections were measured by using digital, histometry equipment. Results were given as the mean for each tooth in independed parallel groups according to age and treatment. The Biodentine™, MTA and Dycal® groups were compared statistically using the ANOVA and Student's t-test for parallel groups.

**Data Collection & statistical analysis:**

The study subjects were selected on the basis of selection criteria from the patients attending outpatient clinic of the Department of Conservative Dentistry & Endodontics, BSMMU. The relevant findings were recorded in the data collection sheet. After completion, the data were presented in the form of tables, figures and graphs as necessary. Collected data were analyzed by computer based statistical software, Statistical Package of Social Science (SPSS) version 19 (SPSS Inc. Chicago, USA) (IBM®SPSS®Statistics.www.spss.com.hk/software/statistics).

The result of reparative dentin was expressed as mean ± SD (Standard deviation). ANOVA and student-t test was applied to assess the difference between the Biodentine, MTA and Dycal. 95% confident interval (P value <0.05) was followed for the testing level of significance.

**Results**

At four weeks following pulpotomy, the necrotic tooth in calcium hydroxide exhibited no clinical indications or symptoms of pulpal or periradicular illnesses. The thickness of reparative dentin formation by Dycal was 0.9 ± 0.2µm and incompletely covers the exposed pulp tissue.

The histological sections of MTA showed no inflammation in the entire extension of the root canal and the presence of stenosis and dentin barrier formation. Thickness of reparative dentin formation is 1.2 ± 0.2 µm and completely covers the exposed pulp tissue. The healing of pulp was satisfactory with without affecting the normal function of the remaining pulp.

The thickness of reparative dentin formation by Biodentine was 1.4 ± 0.4 µm that completely covered the exposed pulp tissue.

Statistical analysis showed that the thickness of reparative dentin of MTA and Calcium silicate was significantly high than that of calcium hydroxide ($p>0.05$). However, no significant difference was found between the MTA and calcium silicate.

**Discussion:**

Histological evaluations of pulpal responses to vital pulp therapy revealed that the formation of dentinal bridges under calcium hydroxide was unpredictable. Furthermore, there was irritation in pulps coated with calcium hydroxide. Previous studies also showed that, in comparison to MTA and Biodentine™ cement, dentinal bridges made under calcium hydroxide exhibited fewer quality tunnel faults and were thinner [5-7].Pulpal inflammation, dystrophic calcifications, and foci of necrosis were additional unfavorable findings in calcium hydroxide.[5] The investigation's findings showed that the human tooth pulp does not react predictably to calcium hydroxide. However, the results of another trial were encouraging; there was pulp necrosis but no dentinal bridge formation [8].

Another intriguing discovery was that, for four weeks following pulpotomy, the necrotic tooth in calcium hydroxide exhibited no clinical indications or symptoms of pulpal or periradicular illnesses. Research has indicated that the effectiveness of calcium hydroxide-based vital pulp therapy diminishes over time [8]. Consequently, following crucial pulp therapies over an extended period of time is crucial, especially if calcium hydroxide is being employed.

The histological sections of the MTA revealed stenosis, dentin barrier development, and the absence of inflammation along the root canal's extension. In contrast to our findings, Agamy *et al*.; [9] examined the pulp response to white and gray MTA and discovered a firm tissue barrier in both groups. It is worth mentioning that the pattern of necrotic and subjacent inflammatory layers is comparable to that found in teeth treated with formocresol, but without the undesirable features of carcinogenicity and risk of causing enamel defects and abnormal root development of the permanent successor [10].

Although some authors showed incomplete hard tissue barrier formation.Fei *et al*. [11] our findings show that the use of MTA pulpotomy can provide a favorable pulp tissue response. However, the lack of control over the tooth extraction period results in the difficulty to obtaining the histological slides [12]. Even though our results are encouraging, the number of teeth assessed histologically was obviously small and cannot be extrapolated to general population. Further long-term follow-up studies are needed to evaluate the histological reaction of the dental pulp mainly to MTA. Based on this study, MTA are effective for pulpotomy of tooth.

In contrast, unlike calcium hydroxide, the dentin bridge made of the calcium silicate-based material (e.g. Biodentine) displayed a well localized pattern in the afflicted area. Dentinal tubules could be clearly seen, and there was an improvement in dentin quality and odontoblast structure in calcium silicate. Moreover, a clinical study conducted by Jalan *et al*. [13] on 45 human premolar teeth revealed that following 45 days of direct pulp capping with calcium hydroxide and calcium silicate, the dentin bridge in the teeth coated with calcium silicate was consistently thicker and more continuous and showed less dentinal inflammation than the teeth coated with calcium hydroxide. The current study does not provide an explanation for the mechanism of dentin bridge development. Shayengan *et al*. [14] investigated how pigs responded to calcium silicate pulpotomy at 7-, 28-, and 90-day intervals after the procedure. Their findings show that the calcium silicate-based substance Biodentine™ has bioactive properties; it does not cause moderate to severe pulp inflammation while repairing hard tissues. They also mentioned that the material's capacity to generate hydroxyapatite crystals, which could improve sealing ability, allowed it to preserve a marginal integrity. Because of its superior sealing capacity, there is no chance of microleakage that could result in necrosis or infection of the pulp, jeopardizing the effectiveness of crucial pulp therapy

**Conclusion**

Calcium-silicate based pulpotomy material is capable to induce pulpal wound healing and reparative formation in the exposed teeth without affecting the normal function of the remaining pulp. More study was need for conclusive result.

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