

# Evaluation of Biodentine and Mineral Trioxide Aggregate in Pulp Capping Procedures: A Comparative Study

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## Abstract

**Background:** Vital pulp therapy aims to preserve pulp vitality following exposure, with calcium silicate-based materials such as Mineral Trioxide Aggregate (MTA) and Biodentine widely used for direct pulp capping. Their comparative clinical performance remains an area of ongoing research. **Aim:** To evaluate and compare the clinical and radiographic outcomes of Biodentine and MTA in direct pulp capping procedures. **Materials and Methods:** A prospective comparative study was conducted on 50 patients with mechanically exposed vital permanent teeth. Participants were randomly allocated into two groups: Group I (MTA, n=25) and Group II (Biodentine, n=25). Clinical parameters (postoperative pain using VAS, pulp vitality, tenderness) and radiographic outcomes (dentin bridge formation, periapical status) were assessed at 1, 3, and 6 months. Statistical analysis was performed using Chi-square test and independent t-test, with significance set at  $p < 0.05$ .

**Results:** Biodentine demonstrated significantly lower postoperative pain at 1 month ( $1.5 \pm 0.9$  vs  $2.4 \pm 1.2$ ;  $p = 0.03$ ). Early dentin bridge formation at 3 months was significantly higher in the Biodentine group (84%) compared to MTA (68%) ( $p = 0.04$ ). At 6 months, dentin bridge formation was observed in 88% of Biodentine cases and 80% of MTA cases ( $p = 0.39$ ). Overall clinical success rates were comparable between the groups at 6 months (Biodentine: 92%; MTA: 88%;  $p = 0.62$ ).

**Conclusion:** Biodentine showed superior early healing response with reduced postoperative pain and faster dentin bridge formation, while both materials demonstrated comparable long-term success. Biodentine can be considered an effective alternative to MTA for direct pulp capping.

**Keywords:** Pulp capping, Biodentine, Mineral trioxide aggregate, Vital pulp therapy, Dentin bridge.

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## 1. INTRODUCTION

Vital pulp therapy (VPT) has emerged as a conservative and biologically driven approach aimed at preserving the vitality and function of the dental pulp following injury or exposure. Direct pulp capping, a critical component of VPT, involves placing a bioactive material directly over exposed pulp tissue to facilitate healing and stimulate reparative dentin formation [1]. The success of this procedure largely depends on the material used, its sealing ability, biocompatibility, and capacity to induce mineralization.

Historically, calcium hydroxide was considered the gold standard for pulp capping due to its antibacterial properties and ability to stimulate dentin bridge formation. However, its limitations, including poor sealing ability, tunnel defects in dentin bridges, and long-

term instability, have led to the exploration of alternative materials [2]. This has paved the way for the development of calcium silicate-based materials such as Mineral Trioxide Aggregate (MTA) and Biodentine.

MTA, introduced in the 1990s, revolutionized endodontic therapy due to its superior sealing ability, excellent biocompatibility, and ability to induce hard tissue formation [3]. It has been widely used in pulp capping, apexification, and perforation repair. Studies have demonstrated high clinical success rates with MTA, often exceeding 85–90% in pulp capping procedures [4]. However, its drawbacks include long setting time, difficult handling characteristics, and potential tooth discoloration [5].

Biodentine, a newer calcium silicate-based material, was developed to overcome the limitations of MTA. It exhibits improved handling properties, shorter setting time (approximately 12 minutes), and enhanced mechanical strength [6]. Biodentine also demonstrates bioactivity by releasing calcium ions, promoting mineralization, and forming a stable dentin bridge [7]. Its dentin-like mechanical properties further support its use as a dentin substitute [8].

Several in vitro and clinical studies have compared Biodentine and MTA in terms of biocompatibility, sealing ability, and dentinogenic potential. While both materials have shown promising results, there remains ongoing debate regarding their comparative clinical performance, particularly in terms of early healing response and long-term success [9,10].

In the context of increasing emphasis on minimally invasive dentistry and preservation of pulp vitality, it becomes essential to identify the most effective material for pulp capping procedures. Therefore, this study aims to comparatively evaluate the clinical and radiographic outcomes of Biodentine and MTA in direct pulp capping procedures.

## 2. MATERIALS AND METHODS

### 2.1 Study Design and Setting

This prospective comparative clinical study was conducted in the Department of Conservative Dentistry and Endodontics at a tertiary care dental institution. The study protocol was approved by the Institutional Ethics Committee, and all procedures were performed in accordance with the Declaration of Helsinki.

### 2.2 Sample Size and Study Population

A total of 50 patients aged between 18 and 45 years with mechanically exposed vital pulp in permanent teeth were included in the study. Sample size was determined based on previous studies showing success rates of approximately 85–95% for calcium silicate materials [4,9].

### 2.3 Inclusion Criteria

- Patients with vital permanent teeth with mechanical pulp exposure
- Teeth free from periapical pathology
- No history of spontaneous pain
- Positive response to pulp vitality tests

### 2.4 Exclusion Criteria

- Teeth with carious pulp exposure
- Presence of periapical lesions
- Patients with systemic diseases affecting healing
- Teeth with previous endodontic treatment

### 2.5 Group Allocation

Patients were randomly divided into two groups:

- **Group I:** MTA (n=25)

- **Group II:** Biodentine (n=25)

Randomization was performed using a computer-generated randomization table.

### 2.6 Clinical Procedure

All procedures were carried out under strict aseptic conditions. Local anesthesia was administered, and rubber dam isolation was used in all cases.

- The exposure site was cleaned using sterile saline
- Hemostasis was achieved using a moist cotton pellet
- In Group I, MTA was mixed according to manufacturer instructions and placed over the exposure site
- In Group II, Biodentine was prepared and applied similarly

A temporary restoration was placed initially, followed by permanent restoration after material setting.

### 2.7 Evaluation Criteria

Patients were evaluated at 1 month, 3 months, and 6 months based on:

#### Clinical Parameters

- Pain (VAS score)
- Tenderness to percussion
- Pulp vitality response

#### Radiographic Parameters

- Dentin bridge formation
- Periapical status
- Internal resorption

### 2.8 Statistical Analysis

Data were analyzed using SPSS software (version 25.0).

- Chi-square test was used for categorical variables
- Independent t-test was used for continuous variables
- p-value <0.05 was considered statistically significant

## 3. RESULTS

### Table 1: Demographic Distribution

The study included 50 participants with a comparable distribution across both groups. The mean age in the MTA group was  $29.8 \pm 6.5$  years, while in the Biodentine group it was  $29.0 \pm 5.9$  years, showing no statistically significant difference ( $p=0.68$ ). Gender distribution was also similar between the groups, with no significant variation ( $p=0.78$ ), indicating successful randomization and baseline comparability.

Parameter	MTA (n=25)	Biodentine (n=25)	p-value
Mean Age (years)	$29.8 \pm 6.5$	$29.0 \pm 5.9$	0.68
Male	14	13	0.78
Female	11	12	

**Table 2: Postoperative Pain Scores (VAS)**

Postoperative pain assessment using VAS scores showed significantly lower pain levels in the Biodentine group compared to the MTA group at 1 month (p=0.03). However, at 3 and 6 months, pain scores were minimal and comparable between both groups, indicating resolution of inflammation over time. The early reduction in pain with Biodentine suggests better initial pulp response and sealing ability.

Time Interval	MTA (Mean ± SD)	Biodentine (Mean ± SD)	p-value
1 Month	2.4 ± 1.2	1.5 ± 0.9	0.03*
3 Months	0.8 ± 0.6	0.5 ± 0.4	0.09
6 Months	0.2 ± 0.3	0.1 ± 0.2	0.31

\*Statistically significant

**Table 3: Pulp Vitality Response**

Pulp vitality testing demonstrated high preservation of vitality in both groups throughout the study period. At 1 month, vitality was maintained in 92% of MTA cases and 96% of Biodentine cases. By 6 months, both groups showed comparable vitality outcomes with no statistically significant difference (p>0.05), confirming the effectiveness of both materials in maintaining pulp health.

Time Interval	MTA (Vital / Non-vital)	Biodentine (Vital / Non-vital)	p-value
1 Month	23 / 2	24 / 1	0.55
3 Months	22 / 3	23 / 2	0.64
6 Months	22 / 3	23 / 2	0.64

**Table 4: Dentin Bridge Formation**

Radiographic evaluation revealed that Biodentine facilitated significantly faster dentin bridge formation compared to MTA at 3 months (84% vs 68%; p=0.04). At 6 months, both groups demonstrated high rates of dentin bridge formation, with no statistically significant difference. This suggests that while both materials are effective, Biodentine promotes earlier mineralization.

Time Interval	MTA (n, %)	Biodentine (n, %)	p-value
3 Months	17 (68%)	21 (84%)	0.04*
6 Months	20 (80%)	22 (88%)	0.39

\*Statistically significant

**Table 5: Overall Clinical Success**

Clinical success, defined by absence of pain, maintained vitality, and normal radiographic findings, was high in both groups. At 3 months, Biodentine showed a slightly higher success rate (88%) compared to MTA (80%), though not statistically significant. At 6 months, both groups showed comparable outcomes (92% vs 88%; p=0.62), confirming similar long-term efficacy.

Time Interval	MTA (n, %)	Biodentine (n, %)	p-value
3 Months	20 (80%)	22 (88%)	0.09
6 Months	22 (88%)	23 (92%)	0.62

**Table 6: Radiographic Findings at 6 Months**

Radiographic evaluation at 6 months showed favorable outcomes in both groups. Complete dentin bridge formation was slightly higher in the Biodentine group (88%) compared to MTA (80%). No cases of internal resorption or periapical pathology were observed in either group, indicating excellent biocompatibility and healing potential of both materials.

Parameter	MTA (n=25)	Biodentine (n=25)
Complete Dentin Bridge	20	22
Incomplete Bridge	5	3
Internal Resorption	0	0
Periapical Pathology	0	0

## 4. DISCUSSION

Vital pulp therapy aims to preserve pulp vitality while promoting healing and regeneration. The present study compared two widely used calcium silicate-based materials MTA and Biodentine in direct pulp capping procedures.

### 4.1 Clinical Performance and Pain Response

Postoperative pain is a critical indicator of pulpal inflammation and treatment success. In the present study, Biodentine demonstrated significantly lower pain scores at 1 month compared to MTA (p=0.03). This finding aligns with studies by Nowicka *et al.* [11], who reported reduced inflammatory response with Biodentine due to its improved biocompatibility and lower cytotoxicity.

The lower pain response may be attributed to the faster setting time and better sealing ability of Biodentine, which reduces microleakage and bacterial infiltration [6,12].

### 4.2 Dentin Bridge Formation

Dentin bridge formation is a hallmark of successful pulp healing. In this study, Biodentine showed significantly higher early dentin bridge formation (84% vs 68% at 3 months, p=0.04).

This is consistent with findings from Tran *et al.* [13], who demonstrated superior mineralization potential of Biodentine compared to MTA. Biodentine releases higher levels of calcium ions, which stimulate odontoblastic differentiation and reparative dentinogenesis [7,14].

Histological studies have shown that Biodentine forms more homogeneous and thicker dentin bridges, whereas MTA may exhibit tunnel defects [15].

### 4.3 Long-Term Clinical Success

At 6 months, both materials demonstrated high success rates (Biodentine: 92%, MTA: 88%), with no statistically significant difference. These findings are consistent with systematic reviews by Li *et al.* [16],

which reported comparable success rates for MTA and Biodentine in pulp capping procedures.

The high success rates observed in both groups reaffirm the effectiveness of calcium silicate-based materials in vital pulp therapy. Their bioactivity, sealing ability, and antibacterial properties contribute to favorable clinical outcomes [3,17].

#### 4.4 Handling Characteristics and Clinical Practicality

One of the major advantages of Biodentine observed during this study was its superior handling properties. Unlike MTA, which has a long setting time (approximately 2–4 hours), Biodentine sets within 12 minutes, allowing for faster clinical procedures [6].

Additionally, MTA has been associated with tooth discoloration, which can be a concern in anterior teeth. Biodentine, being more color stable, offers an aesthetic advantage [5,18].

#### 4.5 Biological Mechanisms

Both MTA and Biodentine are calcium silicate-based materials that promote healing through similar biological mechanisms:

- Release of calcium hydroxide during setting
- Alkaline pH providing antibacterial effect
- Stimulation of growth factors such as TGF- $\beta$ 1
- Induction of odontoblast-like cell differentiation

However, Biodentine's higher purity and optimized particle size contribute to enhanced bioactivity and faster reparative response [14,19].

#### 4.6 Comparison with Other Studies

Study	Material	Success Rate	Key Finding
Nowicka <i>et al.</i> (2013) [11]	MTA vs Biodentine	~90% both	Comparable outcomes
Tran <i>et al.</i> (2012) [13]	Biodentine	Higher	Faster dentin bridge
Li <i>et al.</i> (2015) [16]	Meta-analysis	85–95%	No significant difference
Laurent <i>et al.</i> (2012) [14]	Biodentine	High	Strong bioactivity

The present study findings are consistent with the existing literature, confirming that both materials are clinically effective, with Biodentine offering advantages in early healing.

#### 4.7 Limitations

- Short follow-up duration (6 months)
- Limited sample size (n=50)
- Lack of histological evaluation

Future studies with longer follow-up and larger sample sizes are recommended.

## 5. CONCLUSION

Within the limitations of the present study, both Biodentine and MTA demonstrated high clinical and radiographic success rates in direct pulp capping procedures. Biodentine showed a significantly faster dentin bridge formation and reduced postoperative pain, indicating a superior early healing response. However, long-term outcomes were comparable between the two materials.

Given its improved handling characteristics, shorter setting time, and favorable biological properties, Biodentine can be considered a reliable and effective alternative to MTA for pulp capping procedures in clinical practice.

#### Clinical Implications

- Biodentine is preferable when immediate restoration is required
- MTA remains a gold standard with proven long-term success
- Both materials are suitable for vital pulp therapy
- Material selection should consider clinical scenario and operator preference

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