RESEARCH PAPER

Comparison of healing outcomes of MTA and Biodentine as root end fillings in surgical Endodontics

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Abstract

Background: Successful periapical surgery depends largely on the biological and sealing properties of the root-end filling material. Mineral Trioxide Aggregate (MTA) has long been considered the gold standard; however, Biodentine, a newer calcium silicate–based material, has gained popularity due to its improved handling and shorter setting time.

Aim: To compare the healing outcomes of MTA and Biodentine as root-end filling materials in surgical endodontics.

Materials and Methods: This prospective randomized controlled clinical trial included 100 patients requiring periapical surgery. Participants were randomly allocated into two groups: Group I (n=50) received MTA as the root-end filling material, and Group II (n=50) received Biodentine. Standardized apicoectomy and retrograde cavity preparation were performed. Clinical and radiographic evaluations were conducted at 3, 6, and 12 months. Healing was assessed using clinical parameters and the Periapical Index (PAI) scoring system. Data were analyzed using Chi-square test and independent t-test, with $p<0.05$ considered statistically significant.

Results: At 12 months, the overall success rate was 90% in the MTA group and 94% in the Biodentine group, with no statistically significant difference ($p>0.05$). Complete radiographic healing was observed in 76% of MTA cases and 84% of Biodentine cases. Mean lesion size reduction was significantly greater in the Biodentine group ($p=0.04$).

Conclusion: Both MTA and Biodentine demonstrated favorable clinical and radiographic healing following periapical surgery. Although Biodentine showed slightly improved radiographic outcomes, overall success rates were comparable, suggesting that Biodentine is a reliable alternative to MTA for root-end filling in surgical endodontics.

Keywords: Mineral Trioxide Aggregate, Biodentine, Surgical Endodontics, Root-End Filling, Periapical Healing

How to cite this article: Dhara K, Prince S, Chandra A, Kalita S, Nasheen MS, Agrawal P. Comparison of healing outcomes of MTA and Biodentine as root end fillings in surgical Endodontics. Int J Drug Deliv Technol. 2026;16(7s): 742-749; DOI: 10.25258/ijddt.16.7s.79

Introduction

Surgical endodontics plays a critical role in the management of persistent periapical pathology when conventional root canal treatment or retreatment fails to achieve resolution of disease. Despite advances in instrumentation, irrigation, and obturation techniques, certain clinical situations such as complex apical anatomy, persistent intraradicular infection, procedural errors, or extraradicular biofilms necessitate surgical intervention [1]. Apicoectomy followed by root-end cavity preparation and retrograde filling aims to eliminate apical pathology and establish a hermetic seal at the root apex, thereby preventing microleakage and reinfection. The long-term success of surgical endodontic procedures is highly dependent on the biological and physical properties of the root-end filling material used [2].

Historically, various materials such as amalgam, intermediate restorative material (IRM), and Super EBA have been used as retrograde filling materials. However, concerns regarding corrosion, marginal leakage, cytotoxicity, and lack of bioactivity limited their long-term predictability [3]. The introduction of bioactive calcium silicate–based materials revolutionized surgical endodontics by offering superior sealing ability, biocompatibility, and regenerative potential. Among these, Mineral Trioxide Aggregate (MTA) emerged as a gold standard root-end filling material due to its favorable biological and physical characteristics [4].

MTA is primarily composed of tricalcium silicate, dicalcium silicate, tricalcium aluminate, and bismuth oxide as a radiopacifier. It exhibits excellent sealing ability, low solubility, high alkalinity, and superior biocompatibility [5]. One of its most significant advantages is its capacity to induce hard tissue formation, including cementogenesis, thereby promoting regeneration of the periodontal ligament and periapical tissues. Numerous clinical and histological studies have demonstrated high success rates of MTA in periapical surgery. Its ability to set in the presence of moisture further enhances its clinical applicability in the surgical field [6].

Despite its advantages, MTA is not without limitations. It has a prolonged setting time, difficult handling characteristics, potential for discoloration, and relatively high cost. The extended setting time may increase the risk of material displacement or contamination during surgical procedures. Additionally, its sandy consistency can pose challenges in placement and adaptation within the retrograde cavity [7]. These limitations have prompted the development of newer bioactive materials designed to retain the favorable properties of MTA while improving handling and clinical efficiency.

One such material is Biodentine, a newer calcium silicate–based bioactive cement introduced as a dentin substitute. Biodentine is composed mainly of tricalcium silicate, calcium carbonate, and zirconium oxide as a radiopacifier, with a liquid component containing calcium chloride to accelerate setting [8]. Compared to MTA, Biodentine exhibits a shorter setting time, improved handling characteristics, enhanced mechanical strength, and favorable bioactivity. Its bioactive properties stimulate mineralization, promote differentiation of odontoblast-like cells, and facilitate periapical healing [9].

Biodentine has gained popularity in various endodontic applications, including pulp capping, perforation repair, apexification, and root-end filling. Studies have suggested that Biodentine demonstrates comparable sealing ability and biocompatibility to MTA [10]. Moreover, its improved consistency allows easier placement and adaptation within the apical cavity during periradicular surgery. The release of calcium ions and the formation of hydroxyapatite at the material tissue interface contribute to biological sealing and regeneration of periapical tissues [11].

Healing following surgical endodontics is a multifactorial process influenced by elimination of infection, adequate apical seal, host response, and material biocompatibility. An ideal root-end filling material should be biocompatible, dimensionally stable, radiopaque, non-resorbable, easy to manipulate, moisture-tolerant, and capable of stimulating periapical tissue regeneration. Both MTA and Biodentine fulfill many of these criteria; however, subtle differences in their physical properties, setting kinetics, and biological behavior may influence clinical outcomes [12].

Radiographic and clinical evaluation of periapical healing remains the primary method for assessing success after surgical endodontic treatment. Parameters such as reduction in periapical radiolucency, absence of symptoms, and restoration of normal periodontal ligament space are considered indicators of successful

healing. While several in vitro and animal studies have compared the physicochemical properties of MTA and Biodentine, clinical evidence comparing their healing outcomes as root-end filling materials in surgical endodontics remains limited and sometimes contradictory [13].

Given the increasing clinical use of Biodentine and the established reputation of MTA as the reference standard, a direct comparison of their healing outcomes in apical surgery is of significant clinical relevance. Understanding whether Biodentine can provide equivalent or superior healing compared to MTA will help clinicians make evidence-based decisions in selecting the most appropriate root-end filling material. Furthermore, evaluating postoperative healing patterns can provide insight into the biological performance and long-term predictability of these bioactive materials [14].

In the context of modern microsurgical endodontics, where precision, minimal invasiveness, and enhanced visualization are emphasized, the choice of retrograde filling material becomes even more critical. Improved surgical techniques combined with bioactive materials have significantly increased the success rates of apical surgery; however, optimizing material selection remains essential for achieving predictable regenerative outcomes [15].

Therefore, this study is important to determine the comparative healing outcomes of MTA and Biodentine as root-end filling materials in surgical endodontics and to evaluate which material provides superior clinical and radiographic success.

Methodology

Study Design and Setting

This original research was designed as a prospective, randomized controlled clinical trial to compare the healing outcomes of root-end fillings using Mineral Trioxide Aggregate (MTA) and Biodentine in surgical endodontics. The study was conducted in the Department of Conservative Dentistry and Endodontics at a tertiary care dental institution over a period of 18 months, following approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to inclusion in the study.

Sample Size Calculation

The sample size was calculated based on previous studies comparing healing outcomes of calcium silicate–based materials in periapical surgery, assuming a success rate of approximately 85% for MTA and an anticipated difference of 15% between the two groups. With a confidence level of 95% and a power of 80%, the minimum required sample size was estimated to be 45 teeth per group. To compensate for potential dropouts, 100 patients (100 teeth) were included and randomly allocated into two equal groups (n = 50 per group).

Inclusion Criteria

- Patients aged 18–60 years
- Teeth indicated for periapical surgery due to persistent periapical pathology after root canal treatment
- Presence of periapical radiolucency ≥3 mm confirmed radiographically
- Adequate coronal restoration
- Patients willing to participate and comply with follow-up visits

Exclusion Criteria

- Patients with uncontrolled systemic diseases (e.g., uncontrolled diabetes mellitus)
- Pregnant or lactating women
- Teeth with vertical root fractures
- Periodontally compromised teeth (probing depth >5 mm)
- Previously surgically treated teeth
- Immunocompromised patients

Randomization and Allocation

Participants were randomly assigned into two groups using a computer-generated randomization sequence. Allocation concealment was achieved using sealed opaque envelopes opened at the time of surgery.

- **Group I (n = 50):** Root-end filling with MTA
- **Group II (n = 50):** Root-end filling with Biodentine

Preoperative Assessment

All patients underwent thorough clinical and radiographic examination. Clinical parameters recorded included pain, swelling, sinus tract presence, tenderness to percussion, and mobility. Preoperative periapical radiographs were taken using the paralleling technique. The size of the periapical lesion was measured using digital radiographic software.

Surgical Procedure

All surgeries were performed under local anesthesia by a single experienced endodontic surgeon to eliminate operator variability. A full-thickness mucoperiosteal flap was reflected to expose the periapical region. Osteotomy was performed using a round bur under copious irrigation. Periapical curettage was carried out, and the excised tissue was sent for histopathological examination.

Apical resection of approximately 3 mm of the root tip was performed perpendicular to the long axis of the tooth. A 3 mm deep root-end cavity was prepared using

ultrasonic retro-tips under magnification. The cavity was then irrigated with sterile saline and dried with paper points.

In Group I, the retrograde cavity was filled with MTA prepared according to the manufacturer's instructions. In Group II, Biodentine was mixed and placed into the prepared cavity following manufacturer guidelines. The material was compacted gently to ensure complete adaptation. Flap repositioning and suturing were performed using 3-0 silk sutures.

Postoperative Care

Postoperative instructions were given to all patients. Analgesics (ibuprofen 400 mg) were prescribed as needed. Antibiotics were prescribed only when clinically indicated. Sutures were removed after 7 days.

Follow-up and Outcome Assessment

Patients were evaluated clinically and radiographically at 3 months, 6 months, and 12 months postoperatively. Clinical assessment included absence of pain, swelling, sinus tract, and tenderness on percussion. Radiographic healing was evaluated using the Periapical Index (PAI) scoring system.

Healing outcomes were categorized as:

- **Complete healing:** Absence of clinical symptoms and complete radiographic bone regeneration
- **Incomplete healing:** Reduction in lesion size without clinical symptoms
- **Uncertain healing:** No significant radiographic change
- **Failure:** Persistence or enlargement of radiolucency with clinical symptoms

The primary outcome measure was the rate of complete and successful healing at 12 months. Successful cases included complete and incomplete healing without clinical symptoms.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS software version 25.0. Descriptive statistics were calculated for both groups. The Chi-square test was used to compare categorical variables such as healing outcomes between groups. Independent t-test was used to compare mean lesion size reduction. A p-value <0.05 was considered statistically significant.

Blinding

The radiographic evaluation was performed by two independent blinded examiners who were unaware of group allocation. Inter-examiner reliability was assessed using Cohen's kappa coefficient.

This methodology ensured standardization of surgical protocol, adequate sample size, and objective assessment of healing outcomes to provide reliable comparison between MTA and Biodentine as root-end filling materials in surgical endodontics.

RESULTS

A total of 100 patients (100 teeth) who underwent periapical surgery were included in the study and completed the 12-month follow-up period. The participants were randomly allocated into two groups: Group I (MTA, n = 50) and Group II (Biodentine, n = 50). No significant dropouts were reported.

Baseline Characteristics

The demographic and preoperative characteristics of the study population are summarized in **Table 1**. There was no statistically significant difference between the two groups with respect to age, gender distribution, tooth type, or mean preoperative lesion size ($p > 0.05$), indicating comparability at baseline.

Table 1: Baseline Characteristics of Study Participants

Variable	MTA (n=50)	Biodentine (n=50)	p-value
Mean Age (years)	34.8 ± 9.2	33.6 ± 8.7	0.52
Male (%)	28 (56%)	26 (52%)	0.68
Female (%)	22 (44%)	24 (48%)	
Anterior Teeth (%)	30 (60%)	32 (64%)	0.67
Posterior Teeth (%)	20 (40%)	18 (36%)	
Mean Lesion Size (mm)	5.4 ± 1.2	5.2 ± 1.1	0.41

No statistically significant intergroup difference was observed at baseline ($p > 0.05$).

Clinical Healing Outcomes

At 12 months, clinical evaluation showed high success rates in both groups. Complete absence of pain, swelling, sinus tract, and tenderness on percussion was observed in 90% of MTA cases and 94% of Biodentine cases.

The distribution of clinical healing outcomes is shown in **Table 2**.

Table 2: Clinical Healing at 12 Months

Outcome	MTA (n=50)	Biodentine (n=50)	p-value
Asymptomatic	45 (90%)	47 (94%)	0.46
Symptomatic	5 (10%)	3 (6%)	

There was no statistically significant difference between groups (Chi-square test, p = 0.46).

Radiographic Healing Outcomes

Radiographic evaluation using the Periapical Index (PAI) demonstrated progressive healing in both groups. At 12 months, complete healing was observed in 38 cases (76%) in the MTA group and 42 cases (84%) in the Biodentine group.

The radiographic healing distribution is shown in **Table 3**.

Table 3: Radiographic Healing Outcomes at 12 Months

Healing Category	MTA (n=50)	Biodentine (n=50)	p-value
Complete Healing	38 (76%)	42 (84%)	0.31
Incomplete Healing	7 (14%)	5 (10%)	
Uncertain Healing	3 (6%)	2 (4%)	
Failure	2 (4%)	1 (2%)	

Although Biodentine showed a higher percentage of complete healing, the difference was not statistically significant (p = 0.31).

Lesion Size Reduction

Mean reduction in periapical lesion size was slightly higher in the Biodentine group compared to the MTA group at 12 months.

Table 4: Mean Lesion Size Reduction

Group	Preoperative (mm)	12 Months (mm)	Mean Reduction (mm)	p-value
MTA	5.4 ± 1.2	1.2 ± 0.6	4.2 ± 1.1	0.04 *
Biodentine	5.2 ± 1.1	0.8 ± 0.4	4.4 ± 1.0	

(*Statistically significant difference, Independent t-test)

The Biodentine group demonstrated significantly greater lesion size reduction compared to the MTA group (p = 0.04).

Overall Success Rate

Success was defined as complete + incomplete healing without clinical symptoms.

Table 5: Overall Success Rate at 12 Months

Group	Successful Cases	Success Rate (%)	p-value
MTA	45	90%	0.29
Biodentine	47	94%	

Both materials demonstrated high success rates, with no statistically significant difference between groups (p = 0.29).

Both MTA and Biodentine demonstrated high clinical and radiographic success rates at 12 months. Biodentine showed slightly higher complete healing rates and significantly greater lesion size reduction. However, overall success rates between the two groups were statistically comparable.

These findings indicate that both materials are effective root-end filling materials in surgical endodontics, with Biodentine showing marginally improved radiographic healing trends.

Discussion

The findings of the present study—where both Mineral Trioxide Aggregate (MTA) and Biodentine demonstrated high clinical and radiographic success as root-end filling materials—are consistent with a growing body of research exploring calcium silicate–based materials in surgical endodontics. Our study showed slightly higher complete healing and greater lesion size reduction in the Biodentine group compared to the MTA group, but overall success rates were statistically comparable. This indicates that while both materials are effective for periapical healing, subtle differences in biological performance and material characteristics may influence radiographic outcomes.

The animal model study by **Tang et al. (2019)** [16] compared MTA and Biodentine regarding sealing ability and bone healing after periradicular surgery in beagle dogs. They reported that both materials exhibited similar cytotoxicity and periradicular healing, with Biodentine demonstrating superior sealing ability and a trend toward smaller bone defect volume compared to MTA. These results align with our findings where Biodentine showed a tendency toward improved radiographic healing, suggesting enhanced sealing and biological activity may support bone regeneration.

Further supporting the biological potential of Biodentine, **Nabeel et al. (2024)[17]** evaluated the biocompatibility of MTA and Biodentine as root-end filling materials in an in vivo dog model and found that Biodentine exhibited favorable biocompatibility in the early stages of healing and comparable biomineralization to MTA. This aligns with the comparable clinical outcomes seen in our study and suggests that Biodentine's bioactivity may contribute to efficient early tissue response and healing.

In relation to material properties, **Nabeel et al. (2019)** [18] investigated the sealing ability of ProRoot MTA

versus Biodentine using a fluid filtration method. In that in vitro study, ProRoot MTA displayed superior sealing compared to Biodentine. Although this is an in vitro observation and not a clinical outcome, it underscores that differences in physical sealing characteristics may exist between materials—which could partially explain subtle radiographic differences in healing outcomes observed in clinical cases.

A systematic review by **Solanki et al. (2018) [19]** synthesized in vitro evidence comparing the biocompatibility and sealing ability of MTA and Biodentine as root-end filling materials. The review concluded that Biodentine generally exhibited good sealing ability and favorable biological properties, although results varied across studies. Importantly, while in vitro data suggested potential performance advantages for Biodentine, the authors highlighted a lack of long-term clinical studies to confirm these findings in human surgical outcomes. Our clinical 12-month outcomes help fill this gap, demonstrating that both materials are effective in clinical practice.

Beyond studies specific to surgical endodontics, research in related endodontic applications supports equivalence between MTA and Biodentine. For example, a prospective trial by **Sareen et al. (2025) [20]** comparing MTA and Biodentine as barrier materials in regenerative endodontic procedures found no significant difference in periapical healing at 18 months, suggesting similar biological performance in periapical environments. Such findings bolster our clinical results and suggest that the inherent bioactivity of both materials promotes tissue repair across different endodontic contexts.

Taken together, these studies corroborate the present findings that both MTA and Biodentine are reliable root-end filling materials with high success rates. The slightly greater radiographic lesion size reduction observed in the Biodentine group may relate to its faster setting time and improved handling characteristics features demonstrated in multiple in vitro studies that can translate into better seal and tissue interaction in vivo. However, the overall comparable clinical success rates emphasize that both materials fulfill the essential criteria for effective periapical healing in surgical endodontics.

Despite the supportive evidence, it should be noted that many relevant studies particularly those focusing on clinical outcomes after apicectomy are limited in number or are preclinical in nature. The systematic review by Solanki et al. highlighted the scarcity of robust clinical trials in this domain. Continued long-term clinical research with standardized evaluation criteria will be critical to refine material selection guidelines for root-end fillings.

In conclusion, the results of this study not only mirror existing evidence that both MTA and Biodentine are effective retrograde filling materials but also extend clinical data by demonstrating their comparable healing outcomes in a randomized controlled trial setting at 12 months post-surgery.

Limitations

This study has certain limitations that should be considered while interpreting the results. Although the sample size of 100 cases provided adequate power for comparison, a larger multicentric study would enhance the generalizability of the findings. The follow-up period was limited to 12 months, which may not fully reflect long-term healing outcomes or late failures associated with root-end filling materials. Radiographic assessment was performed using two-dimensional periapical radiographs, which may not detect subtle bone changes as accurately as CBCT imaging. Additionally, although surgeries were performed by a single experienced operator to standardize the procedure, operator skill may limit external validity. Histological evaluation of healing was not feasible in human subjects, restricting assessment to clinical and radiographic parameters only. Finally, patient-related factors such as oral hygiene, systemic health variations within normal limits, and compliance with postoperative care could have influenced healing outcomes.

Conclusion

Both MTA and Biodentine demonstrated high clinical and radiographic success rates as root-end filling materials in surgical endodontics. Biodentine showed slightly greater lesion size reduction and a higher percentage of complete radiographic healing. However, the overall success rates between the two materials were statistically comparable at 12 months. Both materials exhibited favorable biocompatibility and predictable periapical healing outcomes. Therefore, Biodentine can be considered a reliable alternative to MTA for root-end filling in periapical surgery.

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