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Original Article

The effect of mineral trioxide aggregate use on tooth survival following apical resection: A retrospective cohort study

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Abstract

Aim: Among the various materials used as root-end filling materials, Mineral Trioxide Aggregate (MTA) is distinguished by its superior biocompatibility and sealing properties. The aim of this study was to evaluate the association between MTA use as a root-end filling material and tooth survival following apical resection.
Materials and Methods: This retrospective study included a total of 385 permanent teeth from 272 patients who underwent apical resection between 2020 and 2025, with follow-up periods ranging from 12 to 60 months. The study group consisted of teeth in which MTA was used as the root-end filling material, whereas the control group comprised cases in which no root-end filling material was applied. The primary outcome measure was tooth survival (extraction status) during the follow-up period.
Results: Among the evaluated teeth, MTA was not applied in 361 teeth (93.8%), whereas it was applied in 24 teeth (6.2%). Apical resection was most frequently performed in the maxillary anterior region (n = 228), while the lowest number of surgical procedures was observed in the mandibular posterior region (n = 33). At the end of the follow-up period, the extraction rate was 5.8% in teeth without MTA and 8.3% in teeth treated with MTA. No statistically significant difference was found between the groups in terms of tooth survival ($p > 0.05$). However, this finding should be interpreted with caution due to the relatively small number of teeth treated with MTA.
Conclusion: The findings of this study do not allow for a definitive conclusion regarding the effect of MTA use on long-term tooth survival following apical resection. The marked sample imbalance between groups and the low number of cases in the MTA group substantially limited the statistical power. Therefore, the results should be interpreted as exploratory.

Keywords: Apical resection, mineral trioxide aggregate, tooth survival, root-end filling

INTRODUCTION

Apical surgery is an endodontic surgical procedure aimed at functionally preserving a tooth within the oral cavity through surgical means in cases where a periapical lesion fails to heal despite conventional endodontic treatment (1). In situations where periapical healing cannot be achieved following root canal treatment, apical surgery is considered one of the final treatment approaches and an alternative to tooth extraction (2,3). The primary objective of this surgical approach is to remove the infected periapical tissues, followed by root-end resection, preparation of a retrograde cavity, and subsequently achieving effective apical sealing with an appropriate filling material (4,5).

The clinical success of apical resection is closely related not only to the accuracy of the surgical technique but also to the use of a biocompatible and well-sealing filling material to fill the retrograde cavity prepared after root-end resection (4). The biocompatibility, sealing ability, and interaction of the retrograde filling material with periapical tissues play a crucial role in the postoperative healing process (5,6). For these reasons, retrograde filling materials have long been a subject of research.

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From past to present, various retrograde filling materials have been proposed, including amalgam, zinc oxide–eugenol–based cements such as Intermediate Restorative Material (IRM) and Super Ethoxybenzoic Acid (Super EBA), composite resins, and bioactive ceramic-based materials (6). Among these, Mineral Trioxide Aggregate (MTA) has become widely used in endodontic surgery in recent years due to its high biocompatibility, sealing capacity, and hydrophilic nature (4,7). In an animal study conducted by Kurt et al., it was reported that the efficacy of MTA in reducing pulpal inflammation yielded more favorable outcomes compared to Concentrated Growth Factor (CGF) (8). Although MTA has been reported to be compatible with periapical tissues and to support hard tissue formation, the literature presents varying and occasionally conflicting findings regarding its long-term clinical outcomes (7,9-12).

Advancements in surgical techniques, including the use of operating microscopes, ultrasonic preparation systems, and bioactive cements, have led to the emergence of the concept of apical microsurgery, and these methods have been reported to provide higher success rates compared to conventional apical surgery (6,13-15). However, the long-term success of apical surgery is not solely dependent on the material used; it is also influenced by multiple factors such as root morphology, the quality of the orthograde root canal filling, and the surgical technique employed (9).

Studies comparing the long-term survival effects of different retrograde filling materials following apical resection are limited in the literature (6,12). To the best of our knowledge, there is a lack of sufficient data directly comparing tooth survival rates between cases with and without the use of MTA over follow-up periods of 12–60 months (6).

Therefore, the aim of this study was to evaluate the survival of teeth treated with and without MTA following surgical intervention for periapical lesions that failed to heal despite endodontic treatment, over a follow-up period of 12–60 months. The null hypothesis (H_0) of the study was formulated as follows: “The use of MTA has no significant effect on long-term tooth survival following apical resection.”

MATERIALS AND METHODS

Demographic Characteristics of the Participants

This study was conducted in accordance with the principles of the Declaration of Helsinki and the Medical Research Ethical Guidelines, following approval from the İnönü University Health Sciences Scientific Research Ethics Committee (Ethics Committee No: 2025/8346, Date: 30.09.2025).

This retrospective cohort study was carried out in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (16). The study was conducted by reviewing the dental records of patients who underwent apical resection between 2020 and 2025, with follow-up periods ranging from 12 to 60 months. The basic demographic characteristics of the individuals included in the study were as follows: the mean age was 45.6 ± 12.4 years (range: 13–77 years) (Figure 1).

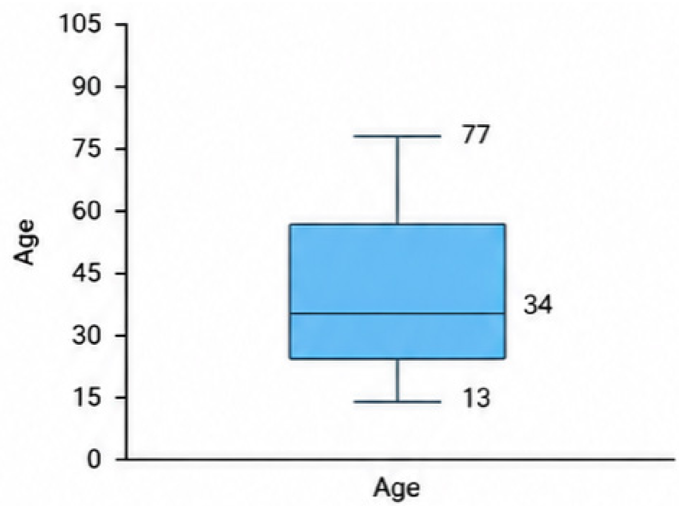

Figure 1. Mean age of the participants (created with BioRender)

The total number of participants was 272, of whom 145 were female and 127 were male. A total of 385 teeth from these 272 patients were evaluated. In some patients, apical resection was performed on more than one tooth. The study was conducted based on the total number of teeth obtained from the patients.

Patient records were retrospectively reviewed from the archives of the İnönü University Faculty of Dentistry. Demographic variables (age and sex), intraoral localization of the treated tooth (anterior/posterior), the retrograde filling material used (MTA applied/not applied), and the extraction status of the tooth during the follow-up period were evaluated. The primary outcome measure was defined as tooth retention, namely extraction-free survival, during the follow-up period; teeth that remained in situ were considered retained, whereas extracted teeth were classified as extraction events.

Inclusion Criteria:

1. Permanent teeth that underwent apical resection between 2020 and 2025,
2. Cases with at least 12 months of clinical and/or radiographic follow-up records,
3. Patients with complete demographic and clinical data.

Exclusion Criteria:

1. Cases with incomplete clinical, radiographic, or follow-up data,
2. Teeth with root fractures,
3. Individuals with systemic diseases that could affect healing,
4. Cases with a follow-up period shorter than 12 months.

Surgical procedures were performed under local anesthesia. Following a sulcular incision, a full-thickness mucoperiosteal flap was elevated, and osteotomy was carried out where necessary to provide access to the surgical field. Approximately 3 mm of the apical root portion was resected and excised. If a concomitant lesion was identified in the relevant area, it was curetted. In the MTA group, a retrograde cavity approximately 3 mm in depth was prepared using a bur. After achieving hemostasis in all cases, the flaps were sutured using 4-0 resorbable monofilament sutures. Ultrasonic preparation systems and an operating microscope were not used during the procedures. The groups were categorized into two main groups: teeth treated with MTA and those not treated with MTA. The decision to use MTA as a root-end filling material was based on the surgeon's clinical judgment and intraoperative findings. In the postoperative period, all patients were prescribed amoxicillin and clavulanic acid (1 g), ibuprofen (400 mg), and a mouth rinse.

Statistical Analysis

IBM SPSS Statistics 26.0 (IBM Corp., Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.) and MS Excel 2024 were used for statistical analyses and calculations. In the statistical evaluation, frequency (n) and percentage (%) values were used to present the distribution of demographic and clinical variables. The normality of the age variable was assessed through graphical methods and the Shapiro–Wilk test. Descriptive statistics were presented as Mean ± Standard Deviation and Median (Minimum–Maximum) values. Cross-tabulations were generated to compare categorical variables according to MTA status, and frequency (n), percentage (%), and chi-square test statistics were reported. The Mann–Whitney U test was used for the comparison of nonparametric data. Statistical significance was set at $p < 0.05$. Fisher's exact test was used when expected cell counts were below 5.

RESULTS

In this retrospective study, a total of 385 permanent teeth from 272 patients were evaluated, with the number of female patients being higher than that of male patients. Among the evaluated teeth, MTA was not applied in 361 teeth (93.8%), whereas it was used as a root-end filling material in 24 teeth (6.2%).

Apical resection was most frequently performed in the maxillary anterior region, accounting for 59.2% (n = 228) of cases. This was followed by the maxillary posterior (23.0%; n = 89), mandibular anterior (9.4%; n = 35), and mandibular posterior (8.6%; n = 33) regions, respectively (Figure 2).

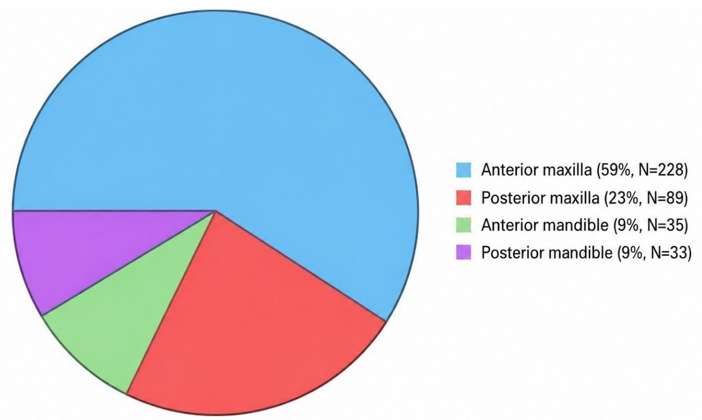

Figure 2. Distribution of surgical sites (created with BioRender)

No statistically significant difference was found between the groups when comparing the regional distribution of teeth treated with and without MTA ($\chi^2 = 0.931$, $p = 0.818$) (Table 1).

Similarly, no statistically significant difference was found between the groups in terms of the distribution of MTA application according to tooth number ($\chi^2 = 19.452$, $p = 0.853$) (Table 1).

During the follow-up period, of the 385 teeth evaluated, 362 (94.0%) were retained, while 23 (6.0%) were extracted. The extraction rate was 5.8% (21/361) in teeth without MTA, compared to 8.3% (2/24) in teeth treated with MTA. The

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difference between the groups was not statistically significant according to Fisher's exact test (p = 0.429) (Table 1). However, this result should be interpreted with caution due to the relatively small number of teeth treated with MTA.

When extraction status was evaluated in terms of maxillary and mandibular regions, no statistically significant difference was found between teeth treated with and without MTA (p > 0.05) (Table 1).

Table 1. Comparison of clinical characteristics according to MTA status

Variable		MTA: No (n = 361) n (%)	MTA: Yes (n = 24) n (%)	Test statistic: c²	Test statistic: p
Tooth region	Maxillary anterior	213 (59.0)	15 (62.5)	0.931	0.818
	Maxillary posterior	83 (23.0)	6 (25.0)		
	Mandibular anterior	34 (9.4)	1 (4.2)		
	Mandibular posterior	31 (8.6)	2 (8.3)		
Tooth number	11	31 (8.6)	1 (4.2)	19.452	0.853
	12	46 (12.7)	2 (8.3)		
	13	17 (4.7)	1 (4.2)		
	14	18 (5.0)	1 (4.2)		
	15	13 (3.6)	2 (8.3)		
	16	10 (2.8)	0 (0.0)		
	17	1 (0.3)	0 (0.0)		
	21	49 (13.6)	5 (20.8)		
	22	51 (14.1)	4 (16.7)		
	23	17 (4.7)	2 (8.3)		
	24	15 (4.2)	0 (0.0)		
	25	20 (5.5)	1 (4.2)		
	26	8 (2.2)	2 (8.3)		
	31	9 (2.5)	0 (0.0)		
	32	5 (1.4)	0 (0.0)		
	33	5 (1.4)	0 (0.0)		
	34	3 (0.8)	0 (0.0)		
	35	2 (0.6)	0 (0.0)		
	36	7 (1.9)	2 (8.3)		
	37	2 (0.6)	0 (0.0)		
	41	5 (1.4)	0 (0.0)		
	42	4 (1.1)	1 (4.2)		
	43	5 (1.4)	0 (0.0)		
	44	5 (1.4)	0 (0.0)		
	45	5 (1.4)	0 (0.0)		
	46	6 (1.7)	0 (0.0)		
	47	1 (0.3)	0 (0.0)		
	48	1 (0.3)	0 (0.0)		
Extraction	No	340 (94.2)	22 (91.7)	-	0.429
	Yes	21 (5.8)	2 (8.3)		
Maxilla	No	64 (17.7)	3 (12.5)	-	0.372
	Yes	297 (82.3)	21 (87.5)		
Mandible	No	297 (82.3)	21 (87.5)	-	0.372
	Yes	64 (17.7)	3 (12.5)		

MTA: Mineral Trioxide Aggregate

Table 2 presents the relationship between MTA application status and extraction according to tooth number. Apical resection was most frequently performed on the maxillary left lateral incisors (n = 55), maxillary left central incisors (n = 54), maxillary right lateral incisors (n = 48), and maxillary right central incisors (n = 32).

Table 2. Distribution of tooth number, MTA status, and extraction outcome

Tooth number	MTA-extraction			
	No-No	No-Yes	Yes-No	Yes-Yes
	n	n	n	n
11	29	2	1	0
12	45	1	2	0
13	17	0	1	0
14	15	3	1	0
15	13	0	2	0
16	8	2	0	0
17	1	0	0	0
21	48	1	5	0
22	51	0	4	0
23	17	0	2	0
24	15	0	0	0
25	18	2	1	0
26	6	2	0	2
31	9	0	0	0
32	5	0	0	0
33	3	2	0	0
34	2	1	0	0
35	2	0	0	0
36	6	1	2	0
37	1	1	0	0
41	5	0	0	0
42	3	1	1	0
43	5	0	0	0
44	5	0	0	0
45	4	1	0	0
46	5	1	0	0
47	1	0	0	0
48	1	0	0	0

MTA: Mineral Trioxide Aggregate

Overall, the majority of teeth undergoing apical resection were located in the maxilla, with a total of 317 teeth in the maxilla and 68 teeth in the mandible evaluated.

DISCUSSION

In this study, a total of 385 teeth were evaluated, and it was observed that apical resection was most frequently performed in the maxillary anterior region. Similarly, in the literature, Ajayi et al. reported that the teeth most commonly undergoing surgical procedures were located in the maxillary anterior region (17). This finding may be explained by the anatomical position of anterior maxillary teeth and the relative ease of surgical access.

In the evaluation based on the surgical site, the statistical results obtained from our study were found to be consistent with the findings of Öğütlü et al., who reported that apical surgery is most frequently performed in the maxillary anterior region and least frequently in the mandibular posterior region, with the highest survival rates observed in maxillary anterior teeth (18).

The high survival rates observed in maxillary anterior teeth have been attributed to the fact that the apices in this region provide a wider field of view and are more easily accessible, thereby allowing for more effective and well-sealed obturation during root canal treatment (9). In the present study, the more frequent application of MTA in the maxillary anterior region may likewise be associated with the accessibility of these anatomical structures.

In contrast, in our study, apical resection was least frequently performed in mandibular posterior teeth. This finding is generally consistent with the study by Liao et al., which reported that apical surgery is less commonly performed in the mandibular posterior region; however, that study differs partially in that posterior teeth were predominantly premolars (19). The limited surgical access in the mandibular posterior region, the complexity of anatomical structures, and the presence of adjacent anatomical landmarks may explain why apical surgery is less frequently preferred in these teeth.

Long-term tooth survival rates following periradicular surgery have been reported in the literature to range approximately between 60% and 80%. In a large-scale study based on the Swedish national database, it was shown that approximately two-thirds of teeth remained in situ after a 10-year follow-up period (20). Similarly, in a randomized controlled trial comparing surgical and non-surgical retreatment methods, the long-term survival rate was found to be 76% (21).

It has also been reported that studies evaluating treatment approaches for teeth with periapical lesions exist in the literature. In a ten-year prospective study conducted by Riis et al., no statistically significant difference was found between surgical and non-surgical endodontic retreatment methods in terms of long-term tooth survival. Additionally, it is noteworthy that no retrograde filling material was used following apical resection in that study (21). These findings suggest that tooth survival is not solely dependent on the retrograde filling material but is influenced by multiple clinical and biological factors.

In the literature, inadequate obturation has been reported as one of the most common causes of failure in apical surgery (3). Insufficient condensation and adaptation of the retrograde filling material may result in void formation in the apical region, leading to microleakage; these microgaps, in turn, provide a favorable environment for bacterial proliferation (22,23). In this context, the sealing properties and biocompatibility of the retrograde filling material are among the key factors determining the success of apical surgery.

Currently, MTA has become one of the most widely preferred materials in endodontics due to its high sealing ability, biocompatibility, and its capacity to stimulate hard tissue formation (24,25). However, its handling difficulty and relatively long setting time are considered disadvantages (26). In a retrospective study, the clinical effects of MTA and IRM were compared, and no statistically significant difference was reported between the groups (27). Similarly, studies conducted by Chong et al. and Kim et al. reported no statistically significant differences in radiographic or clinical success rates among MTA, IRM, and Super EBA (12, 25). In addition to retrospective studies, a prospective study by Chong et al. also demonstrated that MTA did not exhibit statistically significant superiority over IRM in terms of radiographic and clinical healing at the 12- and 24-month follow-ups (28).

Yan et al. reported differing findings regarding the biological effects of MTA in an experimental study. In this study, which compared the biotoxicity and osteoinductive properties of Bioaggregate and MTA, it was reported that MTA may exert toxic effects on proliferating periodontal ligament fibroblasts, and that this effect may be associated with the bismuth and aluminum ions present in its composition. In contrast, Bioaggregate, which is aluminum-free and contains nanocrystalline hydroxyapatite, was reported to stimulate PDL fibroblasts and to exhibit lower cytotoxicity compared to MTA (29). These findings suggest that the biological effects of MTA may vary depending on its material composition and the cellular environment.

In this study, the conventional surgical technique was applied in all cases, and microsurgical techniques were not utilized. There is strong evidence in the literature indicating that the surgical approach has a determining effect on radiographic and clinical healing outcomes. In a comprehensive analysis conducted by Amador-Cabezalí et al., it was reported that failure rates were higher in cases performed using conventional surgical techniques compared to microsurgical methods (6).

In studies with follow-up periods of five years or longer, apical microsurgery has been reported to demonstrate favorable long-term clinical and radiographic outcomes (30-32). Pallarés-Serrano et al. reported an average clinical success rate of 81% after a nine-year follow-up in cases where MTA was used (33), while von Arx et al. observed radiographic healing in 81.5% of 119 teeth at a ten-year follow-up (24). It should be emphasized that several previous studies primarily evaluated radiographic healing or overall clinical success rather than extraction-free survival; therefore, direct comparison with the present findings should be interpreted cautiously. In the present study, the lack of a statistically significant association between MTA application and tooth survival should be interpreted within the limitations of the study.

In the present study, there is an imbalance in the sample distribution between the groups of teeth treated with and without MTA. This may reduce statistical power and make it more difficult to detect small effect sizes. Therefore, the possibility of a Type II error should be considered when interpreting the findings.

Limitations

The retrospective cohort design of the present study entails several methodological limitations. Because the application of MTA was not randomized and was determined according to clinical judgment, selection bias and confounding by indication cannot be excluded. The imbalance in sample size between the study groups and the differences in application between mandibular and maxillary regions increased sample heterogeneity, thereby limiting the generalizability and interpretation of the findings. In addition, the inclusion of more than one tooth from the same patient may have introduced a potential clustering effect and weakened the assumption of independence between observations. Potential confounding variables such as tooth type, lesion size, periodontal status, restoration status, quality of previous endodontic treatment, and follow-up duration were not adjusted for in the statistical analysis.

Furthermore, due to the inherent nature of retrospective studies, limitations in accessing certain clinical and radiographic data should also be taken into consideration. Therefore, future studies should be designed as prospective, multicenter investigations incorporating standardized surgical techniques and relevant clinical variables.

CONCLUSION

The findings obtained from this study do not allow for a definitive conclusion regarding the effect of MTA use after apical resection on long-term tooth survival. Nevertheless, considering the bioregenerative properties of MTA reported in the literature, it is emphasized that long-term tooth retention depends not only on the material used but also on the quality of the orthograde filling, the surgical technique applied, and patient-specific factors such as periodontal status and the presence of a coronal restoration.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that there is no financial support.

Ethical Approval
This study was conducted in accordance with the ethical principles for medical research as outlined in the Declaration of Helsinki, following approval from the İnönü University Health Sciences Scientific Research Ethics Committee (Ethics Committee No: 2025/8346, Date: 30.09.2025).

Informed Consent
Since this was a retrospective study, patient consent had been obtained beforehand.

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