Journal of Dental Sciences and Education

Original Article

DOI: 10.51271/JDSE-0077

Success rate of apical resection: a retrospective evaluation of associated factors

Neslihan Yılmaz Çırakoğlu*, Muhammed Lölek

Department of Endodontics, Faculty of Dentistry, Karabük University, Karabük, Turkiye

Cite this article as: Yılmaz Çırakoğlu N, Lölek M. Success rate of apical resection: a retrospective evaluation of associated factors. *J Dent Sci Educ.* 2026;4(2):51-55. doi:10.51271/JDSE-0077

Received: 05.01.2026 ◆ **Accepted**: 22.05.2026 ◆ **Published**: 25.05.2026

ABSTRACT

Aims: The aim of this retrospective study was to evaluate the long-term success rate of apical resection procedures and to investigate factors potentially associated with treatment outcomes under routine clinical conditions.

Methods: Clinical records of patients who underwent apical resection at a single academic center between January 2015 and January 2025 were retrospectively reviewed. Demographic variables, tooth characteristics, root-end filling materials, and operator type were recorded. Treatment outcome was assessed based on the absence of clinical symptoms and radiographic reduction in periapical lesion size. Preoperative and follow-up periapical radiographs were calibrated and analyzed using ImageJ software. Statistical analyses were performed using Pearson's Chi-square test or Fisher's exact test for categorical variables. Variables potentially associated with treatment outcome were further evaluated using multivariate binary logistic regression analysis. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to determine independent predictors of treatment success. Inter-observer reliability was assessed using intraclass correlation coefficient (ICC) analysis.

Results: A total of 357 apical resection cases were included, with a mean follow-up period of 72 months (range: 18-120 months). Thirty-six teeth were extracted due to failure of apical resection and were therefore classified as unsuccessful outcomes. Among the remaining 321 cases, successful healing was observed in 240 cases, while unsuccessful healing was observed in 81 cases. Statistically significant associations with treatment outcome were observed for sex, jaw location, operator type, and root-end filling material ($p<0.001$). Multivariate logistic regression analysis demonstrated that sex, root-end filling material, and root morphology were independently associated with treatment outcome.

Conclusion: Within the limitations of this retrospective study, apical resection demonstrated acceptable long-term outcomes under routine clinical conditions. Treatment outcomes appeared to be associated with several clinical and procedural factors, particularly root-end filling material and root morphology.

Keywords: Apical surgery, endodontic microsurgery, retrospective evaluation, treatment outcome

INTRODUCTION

Current evidence highlights the central role of microorganisms in the pathogenesis of pulpal and periradicular diseases; therefore, the primary objective of endodontic treatment is the elimination of infection and the establishment of a long-term seal that prevents bacterial recontamination of the periapical tissues.[1] Conventional orthograde root canal treatment generally demonstrates high success rates. However, when primary treatment or nonsurgical retreatment fails-or when retreatment is not feasible due to anatomical, restorative, or procedural limitations-surgical intervention becomes a necessary alternative.[2]

In such cases, apical surgery, particularly modern endodontic microsurgery (EMS), aims to preserve teeth affected by persistent apical periodontitis. The procedure typically includes root-end resection, ultrasonic root-end cavity preparation, retrograde filling with biocompatible materials, and thorough removal of pathological periapical tissues.[3] Advances in magnification, illumination, ultrasonic instrumentation, cone-beam computed tomography (CBCT), and calcium silicate-based root-end filling materials have substantially improved the predictability and outcomes of EMS.[4,5]

Recent studies consistently report favorable short- and long-term outcomes for EMS. A 2023 clinical study reported a 96.3% success rate at one-year follow-up in teeth with persistent apical periodontitis after failed nonsurgical treatment.[6] Similarly, a 2024 investigation using a simplified microsurgical protocol in selected single-rooted teeth demonstrated sealing ability and clinical outcomes comparable to those of conventional EMS.[7] Furthermore, a systematic review and meta-analysis published in 2021 reported pooled long-term success rates of approximately 91.3% in randomized clinical trials and 78.4% in prospective clinical studies, with follow-up periods ranging from 2 to 13 years.[8]

Corresponding Author: Neslihan Yılmaz Çırakoğlu, neslihanyilmazcirakoglu@karabuk.edu.tr

This work is licensed under a Creative Commons Attribution 4.0 International License.

Radiographic assessment remains the cornerstone for evaluating healing following apical surgery. The classic radiographic classification proposed by Rud and Molven[9] categorizes healing as complete, incomplete, uncertain, or unsatisfactory. Although strict criteria consider only complete and incomplete healing as successful outcomes, several studies have shown that a substantial proportion of lesions classified as "uncertain" at one-year follow-up subsequently progress to successful healing.[10] Consequently, many contemporary studies adopt more lenient criteria, defining success as a measurable reduction in radiolucency rather than complete resolution alone-particularly when CBCT imaging is used.[11]

Despite the generally favorable outcomes reported for EMS, long-term success is influenced by multiple prognostic factors, including tooth type, preoperative lesion size, crestal bone level, the presence of through-and-through defects, and patient-related variables.[12] Therefore, evaluating real-world data from long-term retrospective studies remains essential to better understand the effectiveness and predictability of apical surgery in routine clinical practice.

Accordingly, the present retrospective study evaluates all apical resection procedures performed at our institution over a 10-year period, aiming to determine overall success rates and to assess associated prognostic factors within the context of contemporary microsurgical standards.

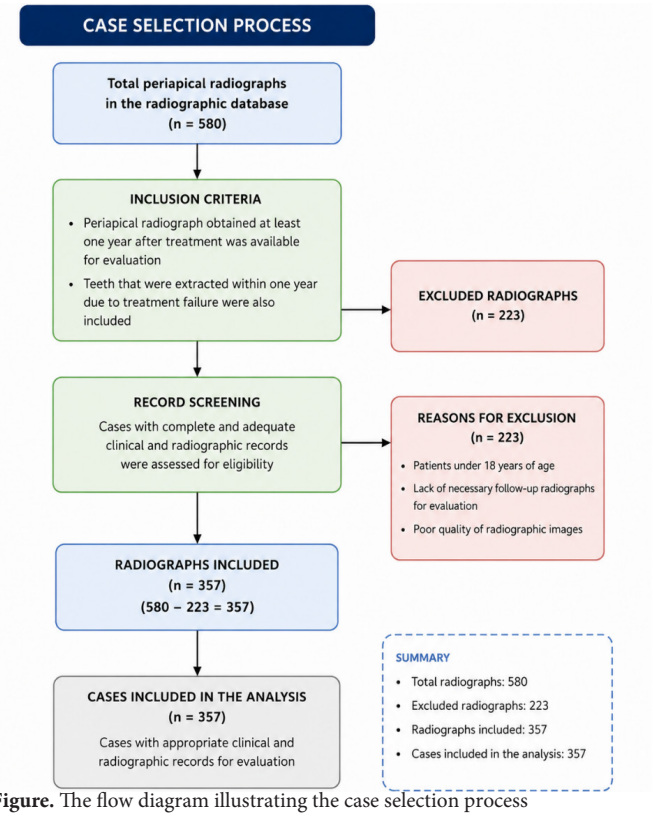

Figure. The flow diagram illustrating the case selection process

METHODS

The study was conducted in accordance with the principles of the Declaration of Helsinki (2013 revision). Ethical approval was obtained from the Karabük University Non-interventional Clinical Researches Ethics Committee (Date: 26.06.2024, Decision No: 2024/1856). As this study had a retrospective design, the requirement for individual informed consent was waived.

Clinical records of all patients who underwent apical resection at the Karabük University Oral and Dental Health Training and Research Hospital between January 2015 and January 2025 were retrospectively reviewed. Demographic variables, including sex, and systemic conditions, as well as tooth number and the type of retrograde filling material used, were extracted from patient charts.

Cases were included if periapical radiographs obtained at least one year after treatment were available for evaluation. Teeth extracted within one year due to treatment failure were also included in the analysis. Cases with incomplete or insufficient clinical or radiographic records were excluded. Of the 580 radiographs initially identified in the radiographic database, 223 were excluded from the study. Reasons for exclusion included age below 18 years, absence of the required follow-up radiographs, and poor radiographic image quality.

Evaluation Criteria for Success

Outcome measures comprised clinical signs and symptoms, including pain, swelling, and sinus tract formation, as well as radiographic changes in the periapical lesion area. Healing was considered successful when (a) no clinical signs or symptoms were present and (b) radiographic evaluation demonstrated a reduction in lesion size. Healing was classified as unsuccessful when clinical symptoms persisted or when the lesion area remained unchanged or increased.

For multirooted teeth, failure in any individual root resulted in classification of the entire tooth as unsuccessful. Periapical bone healing was assessed by comparing calibrated preoperative and follow-up periapical radiographs. Because projection angles differed between radiographs, direct comparison of raw lesion measurements was not feasible. Therefore, the ImageJ TurboReg plugin was used to calibrate both images, after which radiolucent lesion areas were measured and compared using ImageJ software. Imaging procedures and radiographic devices were consistent with those used at the time of treatment.

To assess inter-observer reliability, all 321 radiographic measurements were independently re-evaluated by two experienced examiners. Inter-observer agreement was assessed using intraclass correlation coefficient (ICC) analysis based on a two-way mixed-effects model with absolute agreement. The ICC value was 0.91 ($p<0.001$), indicating excellent agreement between observers.

RESULTS

A total of 357 cases were included in this retrospective cohort study. The mean follow-up period was 72 months (range: 18-120 months). Thirty-six teeth were extracted due to failure of apical resection and were therefore classified as unsuccessful outcomes. Among the remaining 321 cases, successful healing was observed in 240 cases, while unsuccessful healing was observed in 81 cases.

Patient- and tooth-related characteristics of the included cases are summarized in **Table 1**.

Ninety cases involved mandibular teeth, whereas 231 involved maxillary teeth. Twelve teeth were multirooted, and 309 were single-rooted.

Table 1. Demographic and clinical characteristics of the study population

Variable	Category	n (%)
Sex	Female	167 (52.0)
	Male	154 (48.0)
Jaw location	Maxilla	231 (72.0)
	Mandible	90 (28.0)
Root morphology	Single-rooted	309 (96.3)
	Multirooted	12 (3.7)
Root-end filling material	MTA	87 (27.1)
	Other materials	234 (72.9)
Operator	Oral surgeon	231 (72.0)
	General dentsit	90 (28.0)

MTA: Mineral trioxide aggregate

Regarding root-end filling materials, 87 teeth were treated with mineral trioxide aggregate (MTA), whereas 234 teeth received other materials, including amalgam and intermediate restorative material (IRM). With respect to the operator, 231 procedures were performed by oral surgeons, whereas 90 procedures were performed by general dentists. Case allocation was randomly.

Comparisons between successful and unsuccessful cases are presented in **Table 2**. Statistically significant associations with treatment outcome were observed for sex, jaw location, operator type, and root-end filling material (p<0.001). Male patients, mandibular teeth, procedures performed by oral surgeons, and teeth treated with MTA demonstrated higher success rates. No statistically significant association was observed between root morphology and treatment outcome (p=0.783).

Table 2. Comparison of demographic and clinical variables according to treatment outcome

Variable	Failure, n (%)	Success, n (%)	p-value
Sex			<0.001
Female	123 (73.7)	44 (26.3)	
Male	25 (16.2)	129 (83.8)	
Jaw location			<0.001
Mandible	9 (10.0)	81 (90.0)	
Maxilla	139 (60.2)	92 (39.8)	
Operator			<0.001
General dentist	59 (65.6)	31 (34.4)	
Oral surgeon	89 (38.5)	142 (61.5)	
Root-end filling material			<0.001
Other materials	137 (58.5)	97 (41.5)	
MTA	11 (12.6)	76 (87.4)	
Root morphology			0.783
Single-rooted	142 (46.0)	167 (54.0)	
Multirooted	6 (50.0)	6 (50.0)	

MTA: Mineral trioxide aggregate

The results of the multivariate logistic regression analysis are presented in **Table 3**. Sex, root-end filling material, and root morphology were independently associated with treatment outcome. Male sex (OR=14.77, 95% CI: 6.49-33.60, p<0.001) and the use of MTA as a root-end filling material (OR=24.53, 95% CI: 7.68-78.34, p<0.001) were associated with higher odds of treatment success. In contrast, multirooted teeth demonstrated significantly lower odds of successful healing (OR=0.004, 95% CI: 0.001-0.031, p<0.001). After adjustment for potential confounding variables, jaw location and operator type were not independently associated with treatment outcome.

Table 3. Multivariate logistic regression analysis for treatment outcome

Variable	OR	95% CI	p-value
Sex	14.77	6.49-33.60	<0.001
Jaw location	0.32	0.09-1.19	0.089
Operator type	1.13	0.46-2.77	0.797
Root-end filling material	24.53	7.68-78.34	<0.001
Root morphology	0.004	0.001-0.031	<0.001

OR: Odds ratio, CI: Confidence interval

DISCUSSION

The primary limitation of this study is its single-center retrospective design, which may limit the generalizability of the findings and highlights the need for validation through multicenter prospective research. Nevertheless, recent evidence continues to support the predictability and clinical relevance of apical surgery. A 2024 prospective study reported an 88.9% complete healing rate at 12 months and demonstrated that the choice of root-end filling material may influence radiographic healing outcomes.[13] Similarly, a 2024 investigation using a simplified microsurgical protocol in selected short, single-rooted teeth reported sealing ability and clinical outcomes comparable to those achieved with conventional endodontic microsurgery.[7]

Long-term outcomes reported in the literature remain encouraging. A retrospective cohort study documented a 91.4% success rate at one-year follow-up, independent of lesion size, smoking status, or lesion histopathology.[12] In addition, a recent in vitro investigation demonstrated that the bond strength of retrograde filling materials was influenced primarily by the cavity preparation technique-tungsten carbide burs versus ultrasonic retro-tips-rather than by the type of filling material used.[14]

Recent systematic reviews have shown that advances in magnification, ultrasonic retro-preparation, and bioceramic materials have substantially improved the predictability of endodontic microsurgery, with reported success rates exceeding 90%.[8] These findings underscore the importance of appropriate case selection, surgical technique, material choice, and operator experience. They also emphasize the value of long-term retrospective studies, which provide real-world data and may reveal prognostic factors that are not always captured in controlled prospective trials.

Evidence suggests that the most pronounced reduction in periapical lesion size occurs shortly after treatment.[15] One-year follow-up studies report healing rates exceeding 85-90% after root canal treatment and approximately 90-95% after apical surgery.[12,16] Accordingly, and in line with the recommendations of Wu et al.,[17] a minimum follow-up period of one year was adopted in the present study.

Rud and Molven[18] proposed four radiographic healing categories-complete, incomplete, uncertain, and unsatisfactory. Although strict criteria consider only complete and incomplete healing as successful outcomes, longitudinal data indicate that a substantial proportion of lesions classified as

uncertain at one year subsequently progress to successful healing.[12] Consequently, many contemporary studies apply more lenient criteria, particularly when advanced imaging modalities are unavailable.

Given the anatomical complexity of the root canal system and the potential persistence of residual microorganisms, a reduction in lesion size may reflect a favorable host response without posing systemic risk.[15] Therefore, reduction in radiolucency size was adopted as the criterion for successful radiographic healing in the present study.

Periapical radiography remains widely used for postoperative evaluation because of its accessibility, low cost, and minimal radiation exposure. However, its two-dimensional nature limits the detection of buccolingual lesion extension. Previous studies have demonstrated that lesions appearing to heal on periapical radiographs may still show progression on CBCT images.[11] Accordingly, the absence of CBCT imaging represents an important limitation of this study. To address this limitation, CBCT will be incorporated into outcome assessment in future prospective investigations.

Overall, the success rate of endodontic microsurgery observed in this study was lower than the rates reported in recent systematic reviews.[8] This discrepancy may be attributed to the retrospective design and operator variability, as procedures were performed by both oral surgeons and general dentists. These findings further emphasize the potential influence of multiple clinical and procedural factors on surgical outcomes under routine clinical conditions.

Limitations

The prognosis of apical surgery is influenced by multiple clinical factors, including lesion characteristics, preoperative lesion size, presence of "through-and-through" lesions, root-end filling material, coronal restoration quality, systemic factors (e.g, diabetes, smoking) and operator experience. In the present study, statistically significant associations were observed between treatment outcome and several clinical variables, including sex, jaw location, operator type, and root-end filling material. Multivariate logistic regression analysis further demonstrated that sex, root-end filling material, and root morphology were independently associated with treatment outcome. However, these findings should be interpreted cautiously because of the retrospective design and the limited availability of certain clinically relevant variables, including lesion size, smoking status, systemic conditions, and coronal restoration quality. In addition, the limited number of multirooted teeth may have affected the stability of the regression model. Therefore, the regression results should be interpreted with caution.

CONCLUSION

Within the limitations of this retrospective study, apical resection demonstrated acceptable long-term outcomes under routine clinical conditions. Treatment outcomes appeared to be associated with several clinical and procedural factors, particularly root-end filling material and root morphology.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was approved by the Karabük University Non-interventional Clinical Researches Ethics Committee (Date: 26.06.2024, Decision No: 2024/1856).

Informed Consent

This retrospective study used pre-existing anonymized patient data. No additional intervention was performed, and there was no direct patient contact. The study was approved by the Ethics Committee, and the requirement for written informed consent was waived by the ethics committee.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

The authors received financial support from the Scientific and Technological Research Council of Turkiye (TÜBİTAK) under the 2209-A Program for the conduct of this study.

Author Contributions

Concept: NYÇ, ML; Design: NYÇ, ML; Control: NYÇ; Resources: ML; Materials: ML; Data Collection and/or Processing: NYÇ, ML; Analysis and/or Interpretation: NYÇ, ML; Literature Review: NYÇ; Writing the Article: NYÇ; Critical Review: NYÇ, ML.

REFERENCES

1. Rôças IN, Siqueira JF Jr. Root canal microbiota of teeth with chronic apical periodontitis. *J Clin Microbiol.* 2008;46(11):3599-3606. doi:10.1128/JCM.00431-08
2. Setzer FC, Shah SB, Kohli MR, Karabucak B, Kim S. Outcome of endodontic surgery: a meta-analysis of the literature-part 1: comparison of traditional root-end surgery and endodontic microsurgery. *J Endod.* 2010;36(11):1757-1765. doi:10.1016/j.joen.2010.08.007
3. Kim S, Kratchman S. Modern endodontic surgery concepts and practice: a review. *J Endod.* 2006;32(7):601-623. doi:10.1016/j.joen.2005.12.010
4. von Arx T, Walker WA III. Microsurgical instruments for root-end cavity preparation following apicoectomy: a literature review. *Endod Dent Traumatol.* 2000;16(2):47-62. doi:10.1034/j.1600-9657.2000.016002047.x
5. Tsesis I, Rosen E, Taschieri S, Telishevsky Strauss Y, Ceresoli V, Del Fabbro M. Outcomes of surgical endodontic treatment performed by a modern technique: an updated meta-analysis of the literature. *J Endod.* 2013;39(3):332-339. doi:10.1016/j.joen.2012.11.044
6. Tang Y, Xu K, Chen Y, Lu L. Evaluating the efficacy of endodontic microsurgery for teeth with an undeveloped root apex and periapical periodontitis after nonsurgical treatment failure. *BMC Oral Health.* 2023;23:414. doi:10.1186/s12903-023-03117-5
7. Zheng C, Wu W, Zhang Y, Tang Z, Xie Z, Chen Z. A novel simplified approach for endodontic retrograde surgery in short single-rooted teeth. *BMC Oral Health.* 2024;24:150. doi:10.1186/s12903-024-03879-6
8. Pinto D, Marques A, Pereira JF, Palma PJ, Santos JM. Long-term prognosis of endodontic microsurgery: a systematic review and meta-analysis. *Medicina (Kaunas).* 2020;56(9):447. doi:10.3390/medicina56090447
9. Rud J, Molven O. Periapical healing after endodontic surgery. *Acta Odontol Scand.* 1972;30(4):395-404.
10. Rud J, Molven O. Prognosis of teeth subjected to apical surgery. *Int Endod J.* 1990;23(1):1-13.
11. von Arx T, Jensen SS, Hänni S, Friedman S. Five-year longitudinal assessment of the prognosis of apical microsurgery. *J Endod.* 2012;38(5):570-579. doi:10.1016/j.joen.2012.02.002
12. Setzer FC, Kohli MR, Shah SB, Karabucak B, Kim S. Outcome of endodontic surgery: a meta-analysis of the literature-part 2: comparison of endodontic microsurgical techniques with and without the use of higher magnification. *J Endod.* 2012;38(1):1-10. doi:10.1016/j.joen.2011.09.021
13. Kaur IP, Sroa RB, Debbarma M, Pallawi S, Kumar A. Outcome assessment of three different methods of root-end preparation and filling materials in endodontic surgery: a comparative clinical prospective study. *Contemp Clin Dent.* 2024;15(2):77-83. doi:10.4103/ccd.ccd_570_23

14. Tok S, Ayrancı LB. Examination of the bond strength of retrograde filling in teeth with failed apical resection after retreatment: effect of tungsten carbide burs versus ultrasonic retro-tips. *Appl Sci.* 2025;15(7):3441. doi:10.3390/app15073441
15. Ørstavik D. Time-course and risk analyses of the development and healing of chronic apical periodontitis in man. *Int Endod J.* 1996;29(3):150-155. doi:10.1111/j.1365-2591.1996.tb01361.x
16. Ng YL, Mann V, Gulabivala K. A prospective study of the factors affecting outcomes of non-surgical root canal treatment: part 2: tooth survival. *Int Endod J.* 2011;44(7):610-625. doi:10.1111/j.1365-2591.2011.01873.x
17. Wu MK, Wesselink PR, Walton RE. Timing of follow-up after endodontic treatment. *Int Endod J.* 2009;42(4):289-298.
18. Rud J, Molven O. Prognosis of root resection. *Int J Oral Surg.* 1973;2(3):131-144.