RESEARCH ARTICLE

A 2-year retrospective study of endodontic microsurgery for bone fenestration

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Abstract

Objective: To evaluate the clinical efficacy and relevant prognostic factors of endodontic microsurgery in cases with bone fenestration.

Method: The retrospective cohort study was conducted at the Endodontic Department of Hefei Stomatological Hospital, China, and comprised data of patients who underwent endodontic microsurgery between October 1, 2019, and October 31, 2023, who had a follow-up duration of at least 24 months. The patients were grouped according to age, gender, jaw position, tooth position, presence or absence of sinus tract, presence or absence of root canal posts, root canal filling quality, periapical lesion type, bone fenestration or mucosal fenestration, the presence or absence of periodontal disease, and guided tissue regeneration. Factors affecting the healing of bone fenestration with endodontic microsurgery were identified. Data was analysed with SPSS 23.

Results: Of the 52 teeth from 42 patients, 27(52%) belonged to females and 25(48%) to males. Overall, 32(61.5%) teeth were from patients aged >32 years and 20(38.5%) from those aged <28 years (p>0.05). The mean ± SD follow-up period was 29 ± 4.2 months (range: 24-40 months). Mucosal fenestration was involved in 13(25%) cases. The success rate of endodontic microsurgery was 48(92.3%). Periodontal disease and guided tissue regeneration were the factors that affected endodontic microsurgery healing for teeth with bone fenestration ($p<0.05$).

Conclusion: Endodontic microsurgery was an effective method for treating complex periapical lesions, such as bone or mucosal fenestration. Associated periodontal disease and guided tissue regeneration were the significant factors influencing the early healing of bone fenestration with endodontic microsurgery.

Keywords: Bone fenestration, Mucosal fenestration, Endodontic microsurgery, GTR. (JPMA 75: 1372; 2025)

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Introduction

Bone fenestration, a condition frequently encountered in endodontic practice, refers to the exposure of root canal contents or periapical tissues through a defect in the alveolar bone. The aetiology of bone fenestration is diverse, encompassing both physiological or pathological processes. The common predisposing factors for this pathological condition include the absence or thinning of the buccal cortical plate, as well as tooth malposition with a significant labial inclination of the root apex. Other factors may include traumatic injuries to the teeth or alveolar bone, apical inflammation, root resorption and iatrogenic factors, such as orthodontic treatment.[1,2]

Patients with bone fenestration often present with characteristic clinical signs and symptoms. These include localised pain, swelling in the periapical region, and sensitivity to percussion. Additionally, the affected tooth may exhibit discolouration or mobility. The diagnosis of bone fenestration relies primarily on a combination of clinical and radiographic findings. A thorough history and physical examination are essential, and radiographs, including periapical and full-mouth series, provide valuable information regarding the extent and location of the lesion. In complex cases, advanced imaging modalities, such as cone beam computed tomography (CBCT), may be utilised for more precise diagnosis and treatment planning.[3,4] Isolated defects where the root surface is only covered by the periosteum and mucosal tissues are referred to as bone fenestration. Conversely, when the root surface is directly exposed to the oral environment, it is designated as mucosal fenestration.

The management of bone fenestration is tailored to the individual patient, considering factors such as the aetiology, extent of the lesion, and overall health of the patient.[5] Endodontic treatment, including root canal therapy, is often the cornerstone of management. Surgical approaches, such as apicectomy or root resection, may be required in cases where endodontic therapy is unsuccessful, or when the lesion extends beyond the root apex.[6] Periodontal therapy, autologous soft tissue graft, regenerative osseous surgery or orthodontic traction can be employed to preserve the affected tooth and prolong its service life.[7,8]

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In recent years, some studies have reported the clinical efficacy and relevant prognostic factors of endodontic microsurgery,[9,10] but limited research has been done to explore the factors influencing the healing of bone fenestration with endodontic microsurgery. The current study was planned to fill the gap in literature by evaluating the clinical efficacy and relevant prognostic factors of endodontic microsurgery in cases with bone fenestration.

Patients and Methods

The retrospective cohort study was conducted at the Endodontic Department of Hefei Stomatological Hospital, China, and comprised data of patients who underwent endodontic microsurgery between October 1, 2019, and October 31, 2023. After approval from the institutional ethics review committee, the sample size was estimated in line with previous studies.[11] The sample was raised using non-probabilistic consecutive sampling technique. Those included were patients classified as American Society of Anaesthesiologists (ASA)[12] class I or II meeting the criteria for endodontic microsurgery after being diagnosed with bone or mucosal fenestration, and had a follow-up duration of at least 24 months. Those classified as ASA class III or above or with poor compliance, those with incomplete CBCT imaging data prior to surgery, those having teeth with a mobility of II or greater and a crown-to-root ratio <1:1, and patients having teeth with root fractures or perforations in the root canal walls were excluded. All the patients had been informed about the surgical procedure and provided informed consent regarding follow-up examinations and data retention.

The basic information of the patients, relevant preoperative and postoperative signs, and clinical symptom were comprehensively documented, with detailed surgical records and imaging data available for preoperative and postoperative follow-ups.

Prior to surgery, a comprehensive blood test including complete blood count (CBC), coagulation function, hepatitis B and C screening, syphilis and human immunodeficiency virus (HIV) was conducted to exclude any contraindications for the surgery. All surgeries were performed by the same experienced endodontic dentist. As part of the surgical procedure, full-thickness flap reflection was performed to expose the apical region of the tooth. The root apex and surrounding anatomical structures were identified using a surgical microscope. The granuloma was removed along with any infected tissue surrounding the root apex. Sharp, fine instruments were used to minimise trauma to the healthy tissue. Using a high-speed diamond bur, the root tip was cut approximately 3-4mm from the apical foramen. Provided that the length and strength of the residual tooth root were ensured, it was considered permissible to resect all apical tissues located at the bone fenestration area. The resected root tip was ensured to be free of any infected tissue or debris. Using an ultrasonic retrograde file, the canal space was cleaned and shaped to prepare for retrograde filling. The canal was free of debris and a smear layer. The canal space was filled with mineral trioxide aggregate (MTA). The filling material was densely packed and extended beyond the resected root tip. Partial cases achieved guided tissue regeneration (GTR) during the same operation. The flap was repositioned, and the surgical site was sutured using appropriate suturing techniques. A protective dressing was applied, if necessary. Postoperative instructions were provided to the patients, including information on medication usage, dietary restrictions, and follow-up appointments. Antibiotics and pain medications were administered, if indicated. The patients were monitored for any sign of infection or other complications.

At the 12-month and 24-month follow-up visits post-surgery, the healing condition of the bone fenestration of the affected tooth was evaluated by combining clinical symptoms and imaging examinations to determine surgical efficacy. Periapical radiographs or CBCT were used to evaluate the results of endodontic microsurgery.[13] Based on the correlation between patients' clinical symptoms and histological and radiographic manifestations, the four types of healing outcomes proposed by Rud and Molven criterion was used.[14,15] Complete healing indicated disappearance of periapical low-density images, with the periodontal ligament possibly widened, but less than twice the normal width of the periodontal ligament. Incomplete healing meant reduction in periapical low-density images with irregular borders, showing a sunray-like pattern connected or not connected to the apical region. Uncertain healing indicated reduction in periapical low-density images greater than twice the normal width of the periodontal ligament. Unsatisfactory healing meant no change or increase in periapical low-density images. A successful endodontic microsurgery was defined if the affected tooth had no self-conscious symptoms or signs, and if the radiographic evaluation revealed complete healing or incomplete healing. If the affected tooth had clinical symptoms or if the radiographic evaluation indicated uncertain healing or unsatisfactory healing, the endodontic microsurgery was considered a failure.

Data was analysed using SPSS 23. Cohen's kappa coefficient was used to assess the consistency of the interpretation of the imaging findings that was done by two researchers. The patients were grouped according to age, gender, jaw position, tooth position, presence or absence of sinus tract, presence or absence of root canal posts, root canal filling quality, periapical lesion type, bone fenestration or mucosal fenestration, and the presence or absence of periodontal disease and GTR. Data was expressed as frequencies and percentages. The factors affecting the healing of endodontic microsurgery and the healing outcome were used as dependent variables. The association between the healing outcome and corresponding influencing factors was tested using univariate logistic regression analysis to determine the factors for further multivariate analysis. Multivariate analysis of relevant variables was performed using a multivariate logistic regression model, which was interpreted at a significance level of 0.05 to identify the important factors affecting the healing of endodontic microsurgery.

Results

Of the 52 teeth from 42 patients, 27(52%) belonged to females and 25(48%) to males. Overall, 32(61.5%) teeth were from patients aged >32 years and 20(38.5%) from those aged <28 years ($p>0.05$). The mean±SD follow-up period was 29±4.2 months (range: 24-40 months). Mucosal fenestration was involved in 13(25%) cases (Figure).

The consistency test of imaging evaluations revealed a kappa value of 0.886, indicating a high level of agreement between the two assessments.

After a 24-month follow-up, the success rate of endodontic microsurgery was 48(92.3%). Among the 4(7.7%) failed surgeries, 2(50%) showed periodontal swelling and poor osteogenesis after surgery, with deep periodontal pockets connecting to the apical region, leading to persistent pus discharge and eventual extraction at 7.6 months and 12 months, respectively. There was 1(25%) patient with a persistent fistula with no significant clinical symptoms, and after 24 months of observation, the patient decided to undergo extraction and implant restoration. Another tooth was extracted due to fracture after five months. There was 1(25%) patient with persistent apical shadowing, indicating uncertain healing, with mild discomfort upon percussion. After 30 months of follow-up, the patient decided to extend the observation phase.

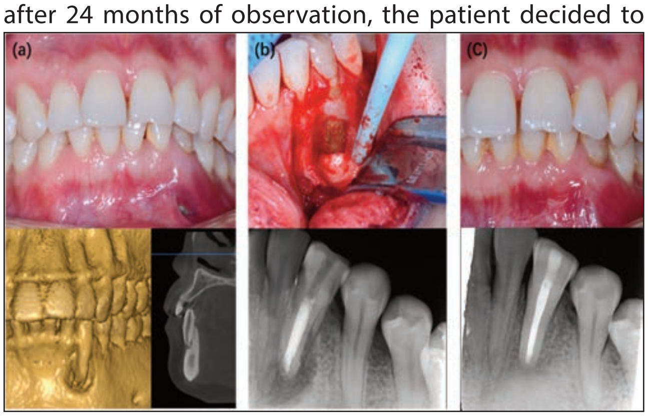

Figure: (A) Preoperative photograph and radiograph. Tooth #33 had mucosal fenestration where periapical tissues penetrate the mucosal layer. (B) Intraoperative photograph and radiograph. Many supragingival calculi were attached to the periapical region because of exposure to the mouth. (C) At 24-months review, the gingival mucosa was found intact, and the healing of the periapical bone fenestration was observed.

Univariate logistic regression analysis revealed that age, gender, upper or lower jaw, tooth position, the presence or absence of a sinus tract, the presence or absence of root canal posts, root filling quality, the type of periapical lesion, bone fenestration or mucosal fenestration, and the presence of periodontal disease or GTR were not significantly correlated with the prognosis of endodontic microsurgery for teeth with apicectomy bone fenestration (Table 1).

Table-1: Univariate logistic regression analysis of the baseline condition of affected teeth and the prognosis of endodontic microsurgery for bone fenestration.

Factor	Success n (%)	Failure n (%)	*p*-value
Age			
<28 (n=20)	19 (95.0)	1 (5.0)	0.388
≥28 (n=32)	28 (87.5)	4 (12.5)	
Age (continuous)	Mean±SD 29.5±6.2		0.256
Gender			
Male (n=25)	22 (88.0)	3 (12.0)	0.578
Female (n=27)	25 (92.5)	2 (7.5)	
Jaw position			
Maxillary (n=33)	30 (90.1)	3 (9.9)	0.866
Mandibular (n=19)	17 (89.4)	2 (10.6)	
Tooth location			
Anterior (n=37)	34 (91.8)	3 (8.2)	0.566
Molar (n=15)	13 (86.6)	2 (13.4)	
Sinus tracts			
Presence (n=35)	33 (94.3)	2 (6.7)	0.447
Absence (n=27)	24 (88.8)	3 (11.2)	
Root canal posts			
Presence (n=10)	9 (90.0)	1 (10.0)	0.963
Absence (n=42)	38 (90.5)	4(9.5)	
Root filling quality			
Perfect (n=40)	37 (92.5)	3 (7.5)	0.357
Faulty (n=12)	10 (83.3)	2 (16.7)	
Periapical lesion type			
Diffuse (n=27)	25 (92.7)	2 (7.3)	0.578
Localized (n=25)	22 (88.0)	3 (12.0)	
Bone fenestration type			
Mucosal fenestration (n=13)	10 (70.0)	3 (30.0)	0.08
Bone fenestration (n=39)	37 (94.8)	2 (5.2)	
Periodontal disease			
Presence (n=19)	15 (78.9)	4 (21.1)	0.065
Absence (n=33)	32 (97.0)	1 (3.0)	
GTR			
Presence (n=21)	20 (95.2)	1 (4.8)	0.348
Absence (n=31)	27 (87.1)	4 (12.9)	

NOTE: The final assessment was made at the 24-month follow-up.

Table-2: Multivariate logistic regression analysis of various influencing factors.

Factors	β	*p*-value	OR (95% CI)
Bone fenestration (ref: Mucosal fenestration)	-2.077	0.111	0.125 (0.010,1.562)
Periodontal disease (ref: Absence)	-3.647	0.014	0.026 (0.001,0.526)
GTR (ref: Absence)	3.335	0.033	28.091 (1.289,612.34)

GTR: Guided tissue regeneration, OR: Odds ratio, CI: Confidence interval.

Multifactor logistic regression analysis revealed that periodontal disease and GTR were the factors that affected endodontic microsurgery healing for teeth with bone fenestration ($p<0.05$). Bone fenestration, although included due to clinical relevance, was not statistically significant ($p=0.111$) (Table 2).

Discussion

Bone fenestration, characterised by the exposure of the root apex through the alveolar bone or gingival tissue, is a clinical manifestation often associated with various periapical diseases. Endodontic microsurgery is an effective approach for treating bone fenestration lesions, particularly severe mucosal fenestration cases with intraoral visibility. The current retrospective study evaluated a total of 52 affected teeth, and the overall two-year surgical success rate was 92.3%, which is consistent with literature.[16] While radiographs can provide a general overview of the periapical disease, CBCT provides clearer and three-dimensional (3D) images for surgical planning, avoiding the interference of adjacent structures in two-dimensional (2D) images. The accuracy rate of CBCT reached 96%, which was significantly greater than that of 2D radiographs. In the current study, preoperative CBCT was required for all the included patients to ensure better preoperative assessment and surgical outcomes.[17] All procedures were performed by the same surgeon to minimise errors arising out of surgical operations.

In this study, two teeth developed periodontal disease and formed deep periodontal pockets during follow-up, connecting the apical region to the external environment and leading to combined periodontal-pulpal lesions, ultimately requiring extraction at 7.6 months and 12 months, respectively. The study excluded patients with severe periodontitis, and both the teeth had exhibited varying degrees of mild periodontal disease prior to surgery, which was managed with systemic periodontal therapy. Endodontic microsurgery can cause local inflammatory reactions in tissues, and if postoperative inflammation is not effectively controlled, especially after apical resection, a reduction in root length and increased stress[18] may exacerbate periodontal inflammation, forming a channel between the apical and periodontal regions, and causing continuous irritation and destruction. This may affect the surgical healing process and exacerbate periodontal disease, leading to loosening and extraction. For surgical procedures involving severe periodontal disease, periodontal treatment should be performed first, followed by endodontic therapy once the periodontal condition is controlled. Studies have shown that the success rate of endodontic microsurgery for teeth with apical lesions and periodontal issues is significantly reduced,[9] and there is a significant difference in prognosis between purely endodontic microsurgery and cases with periodontal damage.[19] The current results of multivariate regression analysis showed that the prognosis of endodontic microsurgery for teeth with periodontitis was poor.

During the follow-up period, one patient in this study developed a vertical root fracture, leading to tooth extraction. It has been reported that vertical root fracture is a common cause of failure in endodontic microsurgery.[20] The root apex was observed under a microscope to ensure no cracks before apical resection and retrograde filling. Research suggests that ultrasonic retrograde preparation can exacerbate pre-existing microcracks in dentin, significantly reducing the retention rate of teeth after surgery.[21] Additionally, it is necessary to completely resect the periapical region outside the alveolar bone during bone fenestration, which may decrease the fracture resistance of the teeth.

This study included 13 teeth with mucosal fenestration, exposing the periapical area to the oral cavity through the alveolar bone and mucosal lining. Seven teeth among them underwent GTR concurrently with endodontic microsurgery. During apical resection, the bone fenestration was resected as much as possible, but if the fenestration was too coronal, only 3mm of the apical tip was resected. The remaining apical area was manually scaled, planed and treated with ethylenediamine-tetraacetic acid (EDTA) and sodium citrate, and then a membrane barrier with bone grafts was used to guide periodontal ligament cells to preferentially colonise the root surface, promoting periodontal tissue regeneration.[22] Multivariate logistic regression analysis in the current study showed a significant association of GTR performed concurrently with surgery. Since periapical bony fenestration penetrates the mucosal layer, there is a high level of oral contamination, often accompanied by periodontal infection pathways. Therefore, the use of a barrier membrane during endodontic microsurgery for such teeth has been recommended to better isolate other tissues and guide periodontal tissue regeneration for optimal healing.[23]

The microsurgical procedure for bone fenestration necessitates not only the elimination of periapical infected tissue, but also a thorough consideration of the aesthetics and functionality of the periodontal mucosa.[24] For bone fenestration, adequate management of soft tissues, which sometimes requires concurrent mucogingival surgery, is essential. It has been documented that within 1-5 years after endodontic microsurgery, there is a gingival margin recession of 0.29mm and a loss of periodontal attachment of 0.2mm.[25] Various incision techniques are employed in endodontic microsurgery, including intrasulcular incisions, papilla-preserving incisions and mucogingival incisions. Studies comparing the effects of intrasulcular incisions and papilla-preserving incisions on gingival tissue have revealed no statistically significant difference in papilla height between the two groups at six months postoperatively. Similar clinical studies observing clinical outcomes one year after surgery have also confirmed that intrasulcular and papilla-preserving incisions have comparable effects on maintaining papilla height and preventing gingival recession.[26]

Age, gender, jaw position, tooth location, postcore restoration status, presence of a sinus tract, root canal filling quality, and type of periapical lesion did not significantly influence the healing outcomes of endodontic microsurgery in the current study. Although the classification based on the median age in this study may differ from that in previous reports, the overall trend suggests that younger patients aged <20 years tend to have higher healing success rates in the short term after surgery.[10]

Regarding gender differences, some argue that males may have lower oral health awareness and treatment compliance than females, and that smoking and systemic diseases may affect healing outcomes, therefore a higher success rate is noted among females.[27] However, the current results did not clearly support such findings.

The current study revealed no significant association between the jaw position or tooth location and surgical outcomes. However, Song et al. indicated that the success rate of maxillary teeth may vary with tooth position, especially maxillary anterior teeth, which often have higher success rates due to their excellent operative visibility and simpler root anatomy.[28] In the current study, although the symptoms of the affected teeth, the quality of root canal therapy, and the presence or absence of postcore restoration did not significantly correlate with the outcomes of endodontic microsurgery and comprehensive preoperative root canal therapy is crucial for eliminating infections within the root canal,[29] ensuring better sealing of coronal restorations, and achieving more stable long-term results.

The current study has certain limitations. The sample size of this retrospective study is relatively small, which may have introduced some sampling error. In the future, prospective studies with larger sample size and extended follow-up period should be planned to obtain more accurate conclusions.

Conclusion

Endodontic microsurgery was found to be an effective method for treating complex periapical lesions, such as bone fenestration and mucosal fenestration. Only GTR and associated periodontal disease were the factors significantly influencing the early healing of endodontic microsurgery.

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Conflict of Interest: None.

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Author Contribution:

LZ: Responsible for diagnosis, treatment, prognosis of these cases and writing.
AW: The assistant of the endodontic surgery and preliminary preparation work.
HZ: The periodontist in these cases was in charge of the periodontal treatment.
QS: Involved in the diagnosis and prognosis of these cases.
LG: The assistant of the endodontic surgery and data analysis.
FZ: Final approval and agreement to be accountable for all aspects of the work.