Prospective Clinical Study Evaluating Endodontic Microsurgery Outcomes for Cases with Lesions of Endodontic Origin Compared with Cases with Lesions of Combined Periodontal–Endodontic Origin

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Abstract

The aim of this study was to evaluate the outcomes of endodontic microsurgery by comparing the healing success of cases having a lesion of endodontic origin compared with cases having a lesion of combined endodontic-periodontal origin. Data were collected from patients in the Department of Conservative Dentistry, Dental College, Yonsei University, Seoul, Korea between March 2001 and June 2005. A total number of 263 teeth from 227 patients requiring periradicular surgery were included in this study. Patients were recalled every 6 months for 2 years and every year thereafter to assess clinical and radiographic signs of healing. A recall rate of 73% (192 of 263 patients) was obtained. The successful outcome for isolated endodontic lesions was 95.2%. In endodontic-periodontal combined lesions, successful outcome was 77.5%, suggesting that lesion type (ABC vs DEF) had a strong effect on tissue and bone healing. *(J Endod 2008;34:546–551)*

Key Words

Clinical outcome, endodontic-periodontic lesion, isolated endodontic lesion, microsurgery, periradicular surgery, success rate

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Endodontic microsurgery is a surgical procedure performed with the aid of a microscope, ultrasonic instruments, and modern microsurgical instruments (1–3). The microscope provides magnification and illumination, essential for identifying minute details of the apical anatomy. Ultrasonic instruments facilitate the precise root-end preparation that is within the anatomic space of the canal. These technical advances permit endodontic surgical procedures to be performed with precision and predictability, thus eliminating the disadvantages inherent in traditional periradicular surgery such as large osteotomy, beveled apicoectomy, inaccurate root-end preparation, and poor visualization (4). The clinical success criteria of traditional periradicular surgery with burs and amalgam root-end fillings are based on the absence of symptoms and on radiographic evidence of healing. This clinical success has been reported to range from 19%–90%, with the majority of the studies reporting in the low 50% range (4, 5). In contrast, successful outcomes of all the microsurgical approaches are reported to be around 90% (2, 6–9). One such study by Rubinstein and Kim (2, 6) used strict microsurgical methods including ultrasonic instruments, microscopes, and SuperEBA as a root-end filling-material. For that particular study, cases with isolated endodontic lesions were selected. The short-term follow-up after 1 year and the long-term follow-up after 5–7 years showed healing in 96.8% and 91.5% of the cases, respectively. Another study by Chong et al. (7), also with microsurgical methods, reported a success rate of 87% with intermediate restorative material (IRM) root-end fillings and 92% with mineral trioxide aggregate (MTA).

It has been known that individual variables including age, sex, tooth type, and preoperative signs and symptoms do not significantly affect postsurgical healing (5). However, the location of bone loss, especially a localized complete loss of marginal bone, the presence and height of the intact buccal bone covering the root, and involvement of furcation are significant contributing factors that affect the periradicular surgical outcome (10–16). Attempts have been made to classify these endodontic microsurgical cases into groups on the basis of the etiology, presence and size of the periradicular lesion, the degree of tooth mobility, as well as the pocket depth (4, 8).

Kim and Kratchman (4) classified periradicular lesions into categories A–F (definitions provided in Table 1). Lesion types A, B, and C represent lesions of endodontic origin and are ranked according to increasing size of periradicular radiolucency. Lesion types D, E, and F represent lesions of combined endodontic-periodontal origin and are ranked according to the magnitude of periradicular breakdown. Although other classification schemes have been developed (8), this A–F classification has advantages such as ease of clinical use.

Many studies have been conducted in an attempt to examine the success of microsurgical methods, which include only isolated endodontic lesions (2, 9–13). In contrast, relatively fewer studies have applied modern periradicular microsurgical techniques evaluating outcomes of cases involving the combined endodontic-periodontal lesions. The purpose of this study was, therefore, to evaluate the outcomes of endodontic microsurgery and compare the healing success of the isolated endodontic

TABLE 1. Case Distribution

Variable	No of teeth	Description
Age (y)		
11–20	14	
21–30	70	
31–40	44	
41–50	45	
51–60	39	
61–70	21	
>71	4	
Sex		
Male	76	
Female	151	
Tooth type		
Anterior	147	
Premolar	70	
Molar	46	
Arch		
Maxilla	183	
Mandible	80	
Lesion type*		
A	37	Absence of a periradicular lesion with no mobility, a normal pocket depth, but has unresolved symptoms after nonsurgical therapies have been exhausted.
B	73	Presence of a small periradicular lesion in the apical quarter and by clinical symptoms such as discomfort or sensitivity to percussion as sinus tract. Teeth have normal periodontal probing depths and no mobility.
C	94	Large periradicular lesions progressing coronally, but without periodontal pockets and/or mobility.
D	17	Clinically similar to those in class C, but have periodontal pockets >4 mm, and there is no communication with the pocket and the periradicular lesion.
E	17	Deep periradicular lesions with endodontic-periodontal communication to the apex, but no obvious fracture.
F	25	Apical lesion and complete denudement of the buccal plate but no mobility.

*Classification scheme from Kim and Kratchman (4).

lesion (cases A–C) with the endodontic-periodontal combined lesion (cases D–F) as classified by Kim and Kratchman (4).

Materials and Methods

Case Selection

Data were collected from patients in the Department of Conservative Dentistry, Dental College, Yonsei University, Seoul, Korea between March 2001 and June 2005. A total number of 263 teeth from 227 patients requiring periradicular surgery were included in the study. Teeth with mobility class II or greater, horizontal and vertical fractures, and perforation were excluded from the study. The distribution of the cases recorded is shown in Table 1. Apical lesion types were classified according to the classification system developed by Kim and Kratchman (4) (see Figure 1 for examples), and these definitions and the distribution of cases are presented in Table 1.

All patients were placed on a preoperative regimen of antibiotics and anti-inflammatory drugs. Two hundred fifty milligrams of oral amoxicillin 3 times daily was prescribed starting a day before surgery and continued for a total of 7 days. Ibuprofen (400 mg) was administered 1 hour before surgery and after surgery for all patients.

Surgical Techniques

With the exception of incisions, flap elevation, and suturing, all surgical procedures were performed with an operating microscope (OPMI PICO; Carl Zeiss, Göttingen, Germany). All clinical procedures were carried out by the same operator.

After patients were anesthetized with 2% lidocaine with 1:80,000 epinephrine, sulcular or mucogingival incisions were chosen, depending on the type and aesthetic requirements of the case. For additional hemostasis during surgery, cotton pellets soaked in 0.1% epinephrine (Bosmin; Jeil Inc, Seoul, Korea) and/or ferric sulfate (Astringedent; Ultradent Products, Inc, South Jordan, UT) were applied topically as required (3, 5).

The tissue was gently reflected toward the apical area with a Molten 2–4 curette (G Hartzell and Son Inc, Concord, CA). In cases with mandibular second premolars or first molars, the mental foramen was identified by reflecting a vertical incision that was placed on the mesial to the first premolar. A KP1 retractor (G Hartzell and Son Inc) was then placed just coronal to the mental foramen, and a 1.5-cm-long and 2-mm-deep groove was made by using a Lindenmann bur (3, 5). This groove was designed to protect the mental foramen during the surgical procedure by anchoring the serrated end of the retractor.

Osteotomies were performed with an H161 Lindemann bone cutter (Brasseler, Savannah, GA) in an Impact Air 45 handpiece (Palisades Dental, Englewood, NJ). A Columbia 13–14 curette (G Hartzell and Son Inc) and a Jacquette 34/35 scaler (G Hartzell and Son Inc) were used for periradicular curettage. A 3-mm root tip with a 0- to 10-degree bevel angle was sectioned with a 170-tapered fissure bur under copious water-spray. Root-end preparation s extending 3 mm into the canal space along the long axis of the root were made with KIS ultrasonic tips (ObturaSpartan, Fenton, MO) driven by a piezoelectric ultrasonic unit (Spartan MTS; ObturaSpartan). Isthmuses, fins, and other significant anatomic irregularities were identified and treated with the ultrasonic instruments. Then the resected root surfaces were stained with methylene blue and inspected with micromirrors (ObturaSpartan) under high magnification of 20× to 26× to examine the cleanness of the root-end preparation and to identify other anatomic details. The prepared root-end cavity was dried with a Stropko irrigator/drier (Obtura/Spartan). One of 3 root-end filling materials was chosen and randomly selected: IRM (Caulk Dentsply, Milford, DE), Super EBA (Harry J. Bosworth, Skokie, IL), and ProRoot MTA (Dentsply, Tulsa, OK). The adaptation of the filling material to the canal apical walls was confirmed with the aid of an operating microscope at high magnification. For teeth with a lesion type F, calcium sulfate was placed into the periradicular bone defect, and the denuded buccal surface was covered with CollaTape (Integra NeuroSciences, Plainsboro, NJ). The wound site was closed and sutured with 5 × 0 monofilament sutures, and a postoperative radiograph was taken. The patients were instructed regarding the postoperative care, the sutures were removed 4–7 days postoperatively, and healing progress was checked and recorded.

Clinical and Radiographic Evaluation

Patients were recalled every 6 months for 2 years and every year thereafter to assess clinical and radiographic signs of healing.

On every recall visit, routine examination procedures were followed to identify and evaluate any signs and/or symptoms or loss of function, tenderness to percussion or palpation, subjective discomfort, mobility, sinus tract formation, or periodontal pocket formation.

Figure 1. (*A*) Radiographic image of class A on tooth #15. (*B*) Radiographic image of class B on tooth #12. (*C*) Radiographic image of class C on tooth #4. (*D*) Radiographic image of class D on tooth #12. (*E*) Radiographic image of class E on tooth #13. (*F*) Radiographic (f-i) and clinical (f-ii) image of class F on tooth #10.

Assessment

The radiographic findings, taken from 2 angles (straight and 20-degree mesial or distal) were evaluated independently by 2 examiners with the same criteria used by Molven et al. (14, 15) who were unaware of the type of retrofilling material used in the case.

The 2 examiners standardized the evaluation criteria before the case analyses, so that their results were based on the same evaluation methods and conditions. The healing classification was as follows: (1) complete healing defined by the re-establishment of the lamina dura, (2) incomplete healing, (3) uncertain healing, and (4) unsatisfactory healing. The criteria for successful outcomes included the absence of clinical signs and/or symptoms and radiographic evidence of complete or incomplete healing (15). Criteria for failure included any clinical signs and/or symptoms and radiographic evidence of uncertain or unsatisfactory healing (14).

The treatment success was tabulated and analyzed statistically with the Pearson χ^2 test, with a significance level of .05.

Results

Of the 263 cases treated, 190 cases came for a recall during a period of 12 months. Two cases that had failed within less than a year were also included in the failure category regardless of the follow-up period. A recall rate of 73% (192 of 263 patients) was obtained. Distribution of the cases in relation to the recall period is shown in Table 2. Four cases were excluded because teeth were extracted as a result of a root fracture that had not been diagnosed during the surgical procedures. Of the 188 cases recalled, 172 cases were included in the success category, 149 with complete healing and 23 with incomplete healing. The overall success rate of cases in all classified groups was 91.5%. The failure group included 16 cases and consisted of 5 uncertain and 11 unsatisfactory healing cases. The treatment outcome related to the lesion type is shown in Table 3. The lesion types A, B, and C are considered to be of isolated endodontic origin, and the combined success rate of this group was deduced to be 95.2% (Fig. 2). The lesion types D, E, and F are considered to be of varying degrees of endodontic-periodontal origin, and the combined success rate of these groups was reported to be 77.5% (Fig. 3). This is significantly lower than types A, B, and C ($P < .05$).

Discussion

The goal of periradicular surgery is to remove all necrotic tissues from the surgical site, to completely seal the entire root canal system, and to facilitate the regeneration of hard and soft tissues including the formation of a new attachment apparatus (16). Whether traditional or microsurgical techniques are used, all necrotic tissues in the surgical sites, ie, bone crypt, can be removed with equal efficiency. However, one of the major limitations of traditional surgical methods is the inability to optimally manage the resected root surface, leading to incomplete sealing of the infected root canal system (3, 5). The root canal system is complex. Correct and precise identification of the details of the canal anatomy after apicoectomy is difficult with the naked eye and even when using low magnification. We have found that even at high magnification we were unable to detect all details accurately. In fact, the resected root surface had to be stained with methylene blue, which selectively stains the periodontal ligament, fracture lines, granulation tissues, and pulp tissues, to accentuate the canal anatomy (3, 5). Thus, the use of the microscope at high magnification along with methylene blue staining addresses many of the surgical issues that are not solved by using the nonmicroscopic, traditional surgical method. In addition, the advantages of the microsurgical technique used in this study included a

TABLE 2. Distribution of Cases Related to Recall Period

Recall period	No. of cases
Less than 1 y	2
1 y	51
1.5 y	27
2 y	47
3 y	37
4 y	22
5 y	6

TABLE 3. Number of Assessment Results Related to Lesion Type

	Lesion A	Lesion B	Lesion C	Leison D	Lesion E	Lesion F
Complete healing	24	45	57	6	6	11
Incomplete healing	4	7	4	4	1	3
Uncertain healing					1	4
Unsatisfactory healing		1	6		3	1

smaller osteotomy and a flatter or no bevel angle that ultimately served to conserve cortical bone and root length.

Furthermore, the use of ultrasonic instruments allowed for conservative, coaxial root-end preparation, which was sealed with biologically acceptable root-end filling material and was able to satisfy the requirements for mechanical and biologic principles of endodontic surgery (1, 3).

The disparity of endodontic success published previously could be explained by differences in the study designs, sample sizes, the recall period, and the lack of clear and consistent evaluation criteria for clinical and radiographic parameters of healing (4, 5). Other factors that can affect the prognosis in periradicular surgery include the patient's systemic conditions, amount and location of bone loss, the quality of any previous root canal treatment or retreatment, coronal restoration, occlusal microleakage, surgical materials and techniques, and the surgeon's ability (17, 18). It is important to understand that the success of endodontic surgery often depends on the condition of the tooth. For instance, the presence and size of preoperative periradicular radiolucencies were shown by some authors to adversely affect the outcome of periradicular surgery (5, 9, 10, 13, 17, 19–21). Other authors suggest that although the presence of a periradicular lesion might adversely affect the outcome, the size of the lesion does not (5, 20). Therefore, there is no clear consensus that small lesions heal better than larger lesions (22). A careful preoperative diagnosis and appropriate case selection are prerequisites for improving surgical success (12).

Many studies designed to examine the success of the microsurgical method include only isolated endodontic lesions, ie, periradicular radiolucency without mobility and with a normal pocket depth (2, 9–13). Cases presenting with severe periodontal disease, mobility, through and through bone defects, root resorption, total loss of the buccal plate, and vertical fractures were excluded from these studies. Thus, the high success reported with the microsurgical method only covers endodontic lesions without any periodontal complications. However, in real clinical situations there are many cases that include some degree of periodontal-endodontic combined lesions.

In this study, we did not exclude cases with periodontal defects and total loss of the buccal plate. Rather, we included cases with varying magnitude of periodontal-endodontic involvement according to the classification of preexisting alveolar bone status and periodontal pocket depth suggested by Rubenstein and Kim (2) and Kim and Kratchman (4). The treatment success of cases with isolated endodontic lesion in classes A, B, and C combined was 95.2% after 1 year. This is similar to outcomes reported in previous studies (2, 7). There is growing consensus that cases in the A, B, and C categories do not represent significant surgical treatment problems and that these conditions do not adversely affect treatment outcomes. In addition, there is no significant difference in the treatment success within these classifications, which provides support to the concept that the presence and the size of a pervious lesion do not adversely affect the clinical outcome of periradicular surgery as long as there is no periodontal defect. The only difference is that healing of a larger lesion takes longer than the healing of a smaller one. In a situation in which the 2 periradicular radiolucencies are connected, for instance in a mandibular first molar with 2 apices in close proximity, the surgical procedure results in an even larger lesion, and the healing might not be the same as in a single, relatively large lesion. In fact, complete healing of these cases took longer than 1 year.

Cases in classes D, E, and F present with serious difficulty and challenges. Although these cases are in the endodontic domain, a proper and successful treatment outcome requires not only endodontic microsurgical techniques but also concurrent bone grafting and membrane barrier techniques (4, 23). In this study, we used calcium sulfate and CollaTape (Integra NeuroSciences) as graft materials. Calcium sulfate is a simple, highly biocompatible, effective graft substitute (24). It is a rapidly resorbing material that leaves behind a calcium phosphate lattice, which promotes bone regeneration (23–25). According to the results observed by Pecora et al. (23) in a histologic study conducted in rats, the presence of the calcium sulfate barrier for 3 weeks was enough to halt the ingrowth of soft connective tissue and promote osseous formation. The healing success in classes D, E, and F combined was

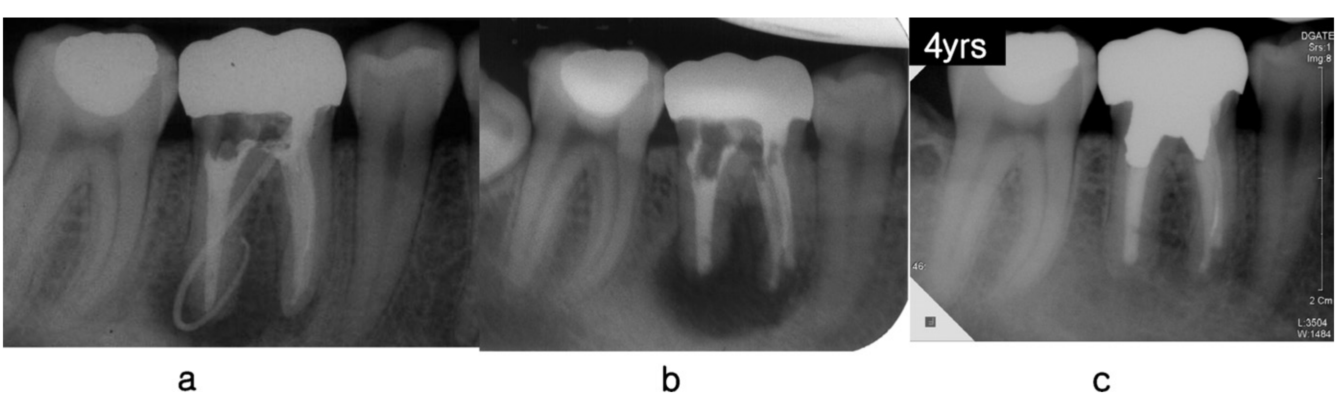

Figure 2. (*A*) Preoperative fistula tracing radiograph of tooth #30 in a 24-year-old man with a history of nonsurgical retreatment twice by endodontist. Preoperative probing depth was within normal limits. Note periradicular radiolucency of class C mainly in the distal canal. (*B*) Immediate postoperative radiograph. MTA was used to retrofill the mesial and distal canals. (*C*) Four-year follow-up radiograph with evidence of a reformed periodontal ligament and resolution of the radiolucency.

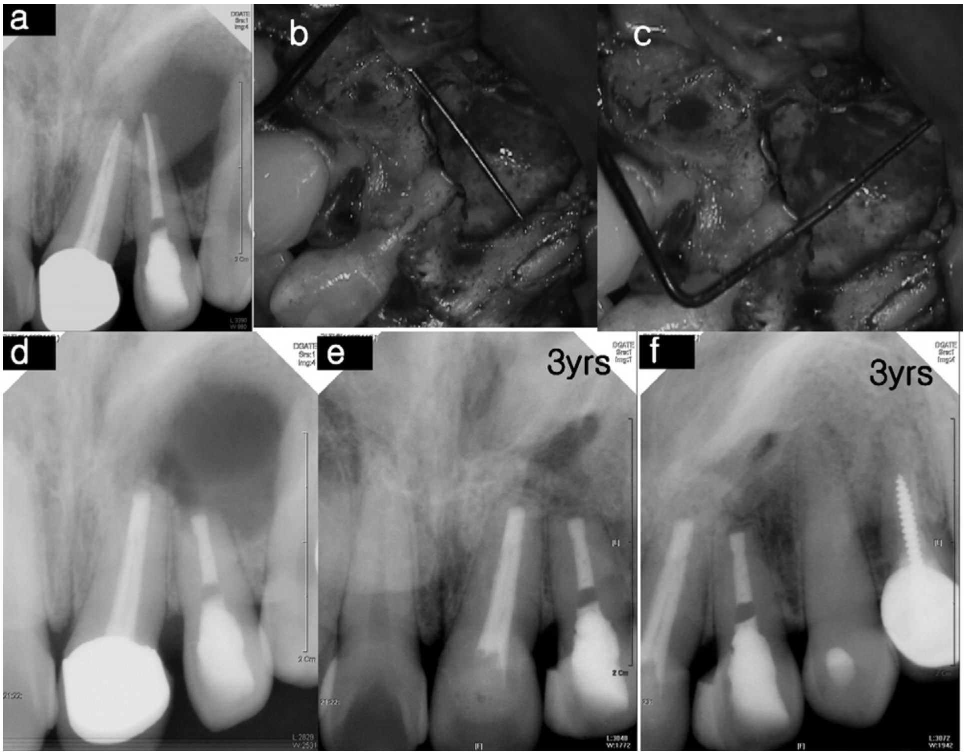

Figure 3. (*A*) Preoperative radiograph of teeth #9 and 22 in a 45-year-old woman with a history of nonsurgical retreatment by endodontist. Preoperative probing depth was greater than 9 mm on the labial area on tooth #10. Note cystic-like large periradicular radiolucency on tooth #10. (*B* and *C*) Clinical images during endodontic microsurgery. Note large bone defect on teeth #9 and 10 (12 × 12 mm) and no buccal plate on tooth #10, which was categorized under class F. The histopathologic diagnosis was apical periodontal cyst. (*D*) Immediate postoperative radiograph. Super-EBA was used to retrofill canals. (*E* and *F*) Three-year follow-up radiographs with 2 different angles showing incomplete healing and regrowth of periodontal ligament.

77.5%, significantly lower than that of classes A, B, and C combined, which was 95.2%. The predictable and successful management of these cases is a true challenge. Even though the healing success of classes D, E, and F combined was lower than that of classes A, B, and C combined, 77.5% was nevertheless higher than that reported in many studies with traditional surgical techniques. The relatively high treatment success reported in this study, especially the 77.5% in classes D, E, and F combined, might be attributable to the inherent advantages of the microsurgical technique used and/or the use of grafting material.

When evaluating treatment results related to the follow-up periods, it was relevant that the majority of success and failure cases occurred during the first postoperative year (2, 12). In our study, 3 failures were seen before the pre-established follow-up period because these patients presented with a sinus tract.

Three root-end filling materials were randomly used: 9 cases with IRM, 132 cases with SuperEBA, and 47 cases with MTA. Successful outcomes were seen with all 3 filling materials: 88.9% with IRM (8 of 9 cases), 91.7% with SuperEBA (121 of 132 cases), and 91.5% with MTA (43 of 47 cases). Recently, Wong et al. (26) reported a treatment success of about 75% with various root-end filling materials for a longer observation period. It is possible that the differences in healing rate between these 2 studies might be due to differences in study population, clinician experience, surgical techniques, and/or inclusion criteria. There was no significant difference in the success between the different root-end filling materials used when microsurgical techniques were used. Chong et al. (7) reported that the use of MTA as a root-end filling material resulted in excellent healing, but they found it was not significantly better than healing with IRM. On the contrary, amalgam might not be a good root-end filling material because results of animal studies (27) repeatedly showed poor outcomes.

Although IRM, SuperEBA, and MTA all provided an equal degree of healing, similar to findings reported in previous clinical retrospective and prospective studies, the results of histologic and cellular studies with animal models and stem cells have clearly shown that MTA is far superior to other materials and that it has the capacity to induce bone, dentin, and cementum formation, actually resulting in the regeneration of periradicular tissues including periodontal ligament and cementum (27–29). Judging from the clinical outcome study results and the results of animal and stem cell research, we believe that MTA is the root-end filling material of choice in microsurgery. However, we do note that additional clinical research with MTA is required to validate this claim.

In conclusion, the successful outcome of endodontic microsurgery for isolated endodontic lesions was 95.2% at the 1- to 5-year follow-up examination. In endodontic-periodontal combined lesions, successful outcomes were lower than those obtained for the isolated endodontic lesions but still moderately high at 77.5%, suggesting that lesion type (ABC vs DEF) had a stronger effect on tissue and bone healing. Because the follow-up period in this study was between 1–5 years postoperatively, a long-term outcome study will be undertaken in the future. (Figure 1).

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