Clinical Outcome and Prognostic Factors of Endodontic Surgery in Retrospective Cohort of Yonsei University Between 2004 and 2017

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Clinical Outcome and Prognostic Factors of Endodontic Surgery in Retrospective Cohort of Yonsei University Between 2004 and 2017

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I will not neglect to learn new things. Through this research, I will try to have a better mindset as a clinician in the future.

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Abstract

Clinical Outcome and Prognostic Factors of Endodontic Surgery in Retrospective Cohort of Yonsei University Between 2004 and 2017

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I. Introduction

Most of the recent clinical studies on the outcomes of endodontic microsurgery have included only hundreds of cases; therefore, it is necessary to analyze the outcomes in a larger cohort. Therefore, the purpose of this retrospective study was to evaluate the short-term outcomes and prognostic factors of endodontic microsurgery in a large cohort from Yonsei University Dental Hospital between 2004 and 2017.

II. Materials and Methods

We searched the clinical database of patients who had received endodontic microsurgery between 2004 and 2017 at the Department of Conservative Dentistry, Yonsei University College of Dentistry and Dental Hospital. For each case, the outcome was determined as success or failure according to clinical and radiographic evaluations performed between 1 and 2 years postoperatively. Univariate analysis using t-tests, chi-squared tests, or Fisher's exact tests were performed to examine the differences in the variables based on the outcome. Multivariate logistic regression analysis followed by a stepwise method was performed to identify prognostic factors influencing the outcome and estimate their effects.

III. Results

In total, 2,021 cases of endodontic microsurgery were included. The overall success rate was 84.0 % (1,697/2,021). Older age (odds ratio [OR] = 0.98, 95% confidence interval [95%CI] = 0.97-0.99), male gender (OR = 0.71, 95%CI = 0.55-0.91), molar tooth (OR = 0.49, 95%CI = 0.37-0.66), premolar tooth (OR = 0.65, 95%CI = 0.47-0.90), endodontic-periodontal combined lesion (OR = 0.48, 95%CI = 0.35-0.67), and mineral trioxide aggregates retrofilling material (OR = 1.62, 95%CI = 1.14-2.29) were significantly associated with the outcome of endodontic microsurgery ($p < 0.05$).

IV. Conclusions

Within the limitations of this study, the short-term outcomes of endodontic microsurgery are favorable. The findings from this large cohort suggest that age, gender, tooth type, lesion type, and retrofilling material can affect the outcomes of endodontic microsurgery.

Key words: Endodontic surgery; Large cohort; Treatment outcome; Prognostic factor

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(Directed by Professor Euiseong Kim)

I. INTRODUCTION

When non-surgical root canal treatment fails, surgical endodontic treatment may be considered before extraction. The anatomical complexity of the root canal system, the presence of biofilm that cannot be resolved with root canal cleaning and medication, extraradicular infection, and iatrogenic errors (including perforation, zip, and ledge) that occur during root canal treatment make it difficult to heal the lesion after non-surgical root canal treatment. If these factors can be resolved surgically, the tooth can be maintained

(Hargreaves et al. 2011; Fabricius et al. 1982). The significance of surgery (Wolcott et al. 2005; Stropko 1999) lies in the removal of anatomical variations such as apical deltas, accessory canals, apical canal bifurcation, and isthmus, the removal of pathologic processes, contaminated apices, pathologic tissue, and foreign materials, the removal of operator errors in non-surgical treatment including ledges, blockages, zips, perforations, and separated instruments, the enhanced removal of soft tissue lesions, access to the canal system, post and core, and the evaluation and creation of apical seals.

The success rate of traditional apical surgery is as low as 50-60% (Song and Kim 2011). Since the introduction of a modern technique using a high-magnification microscope, the success rate of surgery has increased dramatically. Although the retrofilling material, inclusion, and exclusion criteria are different for each paper, endodontic microsurgery has shown a high success rate. Mineral trioxide aggregates (MTA) and super-ethoxy benzoic acid (Super-EBA) are general-purpose zinc oxide eugenol-based cements reinforced with EBA that may be used in crown cementation, temporary dressing, or as a cavity liner. Intermediate restorative material (IRM) is a zinc oxide eugenol-based cement reinforced with polymethacrylate (Ainsworth 2012). Tsesis et al. (2009) reported a success rate of 91.6% for endodontic microsurgery in a meta-analysis. Christiansen et al. (2009) reported a success rate of 96% with MTA retrofilling after 1 year of follow-up; von Arx et al. (2010) also reported a 91.3% success rate with MTA retrofilling after 1 year of follow-up, and Song, Shin, et al. (2011) reported a success rate of 92.9% using MTA and Super-EBA retrofilling after 1-7 years of follow-up.

It has been reported that significant factors affecting the outcomes of surgery include female gender, age of anterior teeth, isolated endodontic lesion, adequate root filling length, and the retrofilling materials MTA and Super-EBA (Song, Shin, et al. 2011; Song et al. 2013). Lui et al. (2014) reported that female gender, anterior maxillary teeth, and preoperative pocket depth of 3 mm were significant for the outcome of endodontic surgery. von Arx et al. (2019) reported that tooth type was a significant factor (with a higher success rate for maxillary molars than maxillary premolars).

Zhao et al. (2018) reported several limitations; subgroup analysis of patients with some stages according to clinical staging has not been performed due to the limited sample size. Sauerland et al. (2002) reported that if a larger number of confounders need to be adjusted for study, more than one confounder is controlled simultaneously in the multivariate analysis. Johnston et al. (2019) studied sample size calculation methods in retrospective burden of illness studies and reported that the required sample size rapidly changed according to the coefficient of variation within the width of a 95% confidence interval (95%CI).

In the study of nonsurgical endodontic treatment, several studies have been conducted in a large cohort. In a study by Ricucci et al. (2011), a success rate of 90.3% was achieved in 1,369 cases conducted by a single operator, and the relationship between the success rates related to the preoperative pathologic state was studied. Mareschi et al. (2020) reported a success rate of 84.1% in 1,097 cases and interpreted that the 79% success rate of Prati et al. (2018)'s study affected the sample size. According to studies with a large sample size of more than 1,000 cases, the success rate of non-surgical root canal treatment is reported to be 84-90%. This result is somewhat different from the success rate of studies with small sample sizes. Mareschi et al. (2020) reported that the success rate differs depending on the sample size, and that the smaller the sample size, the more affected by the tooth extraction due to fracture.

There are many papers on the prognostic factors that influence the outcomes of apical surgery, but most include only 100-200 samples. Song et al. (2012) included 172 samples, Kruse et al. (2016) included 19 samples, Çalışkan et al. (2016) included 103 samples, and Truschnegg et al. (2020) included 87 samples. One of the reasons for the difference in the results regarding significant factors is the sample size. Song et al. (2012) included 172 cases and mentioned that outcomes according to lesion type could not be evaluated because of the small sample size. Although the healing success rate of endodontic-periodontal combined lesions was lower than that of isolated endodontic lesions in a previous study (Kim et al. 2008; Dietrich et al. 2003), in Song's study, among the seven cases involving proven failure at the long-term follow-up, only one case had a periodontally involved lesion. When the number of samples is small, this may lead to a biased conclusion.

Therefore, the purpose of this retrospective study was to evaluate the short-term outcomes of endodontic microsurgery in a large cohort between 2004 and 2017 from Yonsei University Dental Hospital and to determine the prognostic factors affecting the outcomes of endodontic surgery.

II. MATERIALS AND METHODS

1. Case Cohort

This retrospective study was approved by the Yonsei University Committee for Research on Human Subjects (2004-4) and was conducted at the Department of Conservative Dentistry, Yonsei University College of Dentistry and Dental Hospital. A clinical database was searched for patients who underwent endodontic microsurgery between March 2004 and December 2017. Each patient's clinical and radiographic records were reviewed, and eligibility for this study was assessed based on the inclusion and exclusion criteria.

The inclusion criteria for this study were as follows:

1. Cases of endodontic microsurgery with available preoperative, intraoperative, and postoperative records and follow-up radiographs

2. Presence of lesions associated with a single root without adjacent root involvement. If the lesions of adjacent roots were involved, they were excluded from the case, and the uninvolved single root was separated and made into a case.

3. Completion of a follow-up examination between 1 and 2 years postoperatively.

The exclusion criteria for this study were as follows:

1. Cases involving a second molar or palatal root of a maxillary molar.Tooth extraction for reasons not associated with endodontic problems.

2. Cases involving resurgery after the failure of a previous endodontic surgery.

3. Crack or root perforation.

All cases that required surgical intervention or tooth extraction due to endodontic problems before the 1-year follow-up visit were considered failures.

2. Surgical Procedures

All surgical procedures were performed using microsurgical techniques with an operating microscope (OPMI pico; Carl Zeiss, Göttingen, Germany) except for incisions, flap elevation, and suturing. Under local anesthesia, flap reflection followed the sinus tract or detected it with a thin explorer tip, and osteotomy was performed. After curettage of granulation tissue, a tapered fissure bur was used to resect 2–3 mm of the root tip with a 0-10 ° bevel angle under copious water irrigation. The resected root surfaces were then inspected with micromirrors (Obtura Spartan, Fenton, MO, USA) at 20-26 x magnification with methylene blue staining. Root-end cavity preparation was performed using KiS ultrasonic tips (ObturaSpartan) driven by a piezoelectric ultrasonic unit (Spartan MTS, ObturaSpartan), 3 mm into the root canal space parallel to the long axis of the root. For root-end filling materials, IRM, Super-EBA, or MTA were used as selected by the operators. After root-end filling and cleaning of the root surface, primary wound closure was performed with 5-0, 6-0 Vicryl (polyglactin 910, Ethicon, Inc., Somerville, New Jersey, USA), or 4-0 silk (Mersilk, Ethicon, Inc., New Jersey, USA). A postoperative radiograph was taken for an immediate examination of the surgical site. The wound site stitches were removed 4-10 days later. Endodontic surgery was performed by referring to the actual surgical records at the Department of Conservative Dentistry, Yonsei University Dental Hospital (Figure 1).

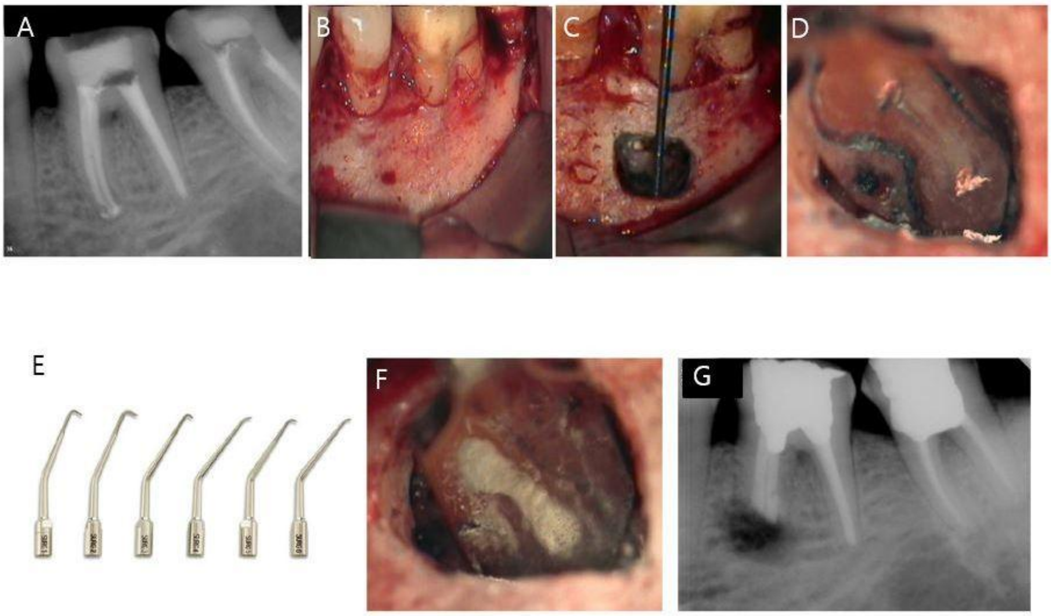

Figure 1. The procedures of endodontic surgery

(A) Preoperative periapical radiograph. **(B)** Elevation and reflection of the full-thickness flap. **(C)** Osteotomy, curettage, and apicoectomy were performed. **(D)** Magnification of the resected root surface after root-end resection (25 X). **(E)** An ultrasonic instrument for root-end cavity preparation. **(F)** Picture of root-end filling. **(G)** Postoperative periapical radiograph. Endodontic surgical procedures were schematically determined by referring to the actual surgical records at the Department of Conservative Dentistry, Yonsei University College of Dentistry and Dental Hospital.

3. Evaluation factors

Each case was assessed for preoperative, intraoperative, and postoperative evaluation factors (Table 1), in accordance with previous clinical studies (Song, Jung, et al. 2011; Song et al. 2013).

The preoperative factors included the patient's age, gender, tooth type (anterior tooth, premolar, or molar), presence of signs and symptoms, type of periapical radiolucency (none, demarcated, or diffuse), quality of root canal filling, density and length, history of apical surgery, presence of post, and type of lesion. The preoperative signs and symptoms included pain, swelling, or sinus tract. The type of periapical radiolucency was categorized as none (intact lamina dura), demarcated (well-defined boundary), or diffuse (vague boundary). In terms of root canal filling density, those with uniform radiopacity without voids were considered adequate. Root canal filling length was considered adequate when canal obturation was completed within 2 mm of the radiographic apex. The type of lesion was divided into isolated endodontic lesions (classes A, B, and C) and endodontic-periodontal combined lesions (classes D, E, and F) as classified by Kim and Kratchman (2006). The intraoperative factors were operator (faculty or resident) and root-end filling material (MTA, Super-EBA, or IRM). The postoperative factors included the type of restoration at the follow-up visit (temporary or permanent restoration) and the presence of post.

Table 1. Preoperative, intraoperative, and postoperative evaluation factors for cases that underwent endodontic surgery

	Evaluation factors
Preoperative	Age
	Gender (male or female)
	Tooth type (anterior tooth, premolar, or molar)
	Signs and symptoms
	Type of periapical radiolucency (none, demarcated, or diffuse)
	Quality of root canal filling—density and length (adequate or inadequate)[1]
	Presence of post
	Type of lesion (isolated endodontic lesion or combined endodontic-periodontal lesion)[2]
Intraoperative	Operator (faculty or resident)
	Root-end filling material (MTA, Super-EBA, or IRM)
Postoperative	Type of postoperative restoration (temporary or permanent)
	Presence of post

[1] The canal filling quality was considered adequate when the obturation had an appropriate density and finished within 2 mm of the apex on a periapical radiograph.

[2] According to the criteria proposed by Kim and Kratchman (2006), classes A, B, and C represent isolated endodontic lesions, and classes D, E, and F represent combined endodontic-periodontal lesions.

4. Outcome assessment

The outcome for each case was determined based on clinical records and periapical radiographs obtained at the follow-up visit between 1 and 2 years after microsurgery. Clinical evaluations included assessing signs and symptoms, loss of function, tenderness on percussion or palpation, subjective discomfort, tooth mobility, periodontal pocket formation, and sinus tract formation. Radiographic healing was independently evaluated by two examiners according to the evaluation criteria proposed by Rud et al. (1972) and Molven et al. (1987):

1. Complete healing – reformation of a periodontal space with normal width and lamina dura to be followed around the apex. Slight increase in the width of the apical periodontal space but less than twice the width of non-involved parts of the root. Tiny defects in the lamina dura (maximum 1 mm) adjacent to the root filling. Complete bone repair where the bone bordering the apical area does not have the same density as the surrounding non-involved bone. No apical periodontal space was discerned.

2. Incomplete healing – the rarefaction has decreased in size or remained stationary with recognizable bone structure within the rarefaction. The rarefaction has an irregular periphery and is demarcated by a compact bone border. The rarefaction was located asymmetrically around the apex, with an angular connection between the rarefaction and the periodontal space.

3. Uncertain healing – the rarefaction decreased in size with a size larger than twice the width of the periodontal space and lamina-dura-like bone structures around the border. A circular or semi-circular peripheral-symmetric location around the apex is a funnel-shaped extension of the periodontal space. The bone structure was discernible within the bony cavity, a collar-shape in the width of the lamina dura coronal to the radiolucency.

4. Unsatisfactory healing – the rarefaction has enlarged or remained unchanged. If the patient still demonstrated "uncertain healing" 4 years postoperatively, the treatment should be considered a failure.

Two examiners standardized the evaluation criteria before evaluation. In case of any disagreement, the two examiners reached an agreement after a discussion. The outcome was based on the findings of the clinical and radiographic evaluations and was classified as a success or failure as follows:

1. Success – the absence of clinical signs and symptoms and radiographic evidence of complete or incomplete healing.

2. Failure – the presence of any clinical signs and symptoms or radiographic evidence of uncertain or unsatisfactory healing.

The classification was based on cases conducted at the Department of Conservative Dentistry, Yonsei University Dental Hospital (Figure 2).

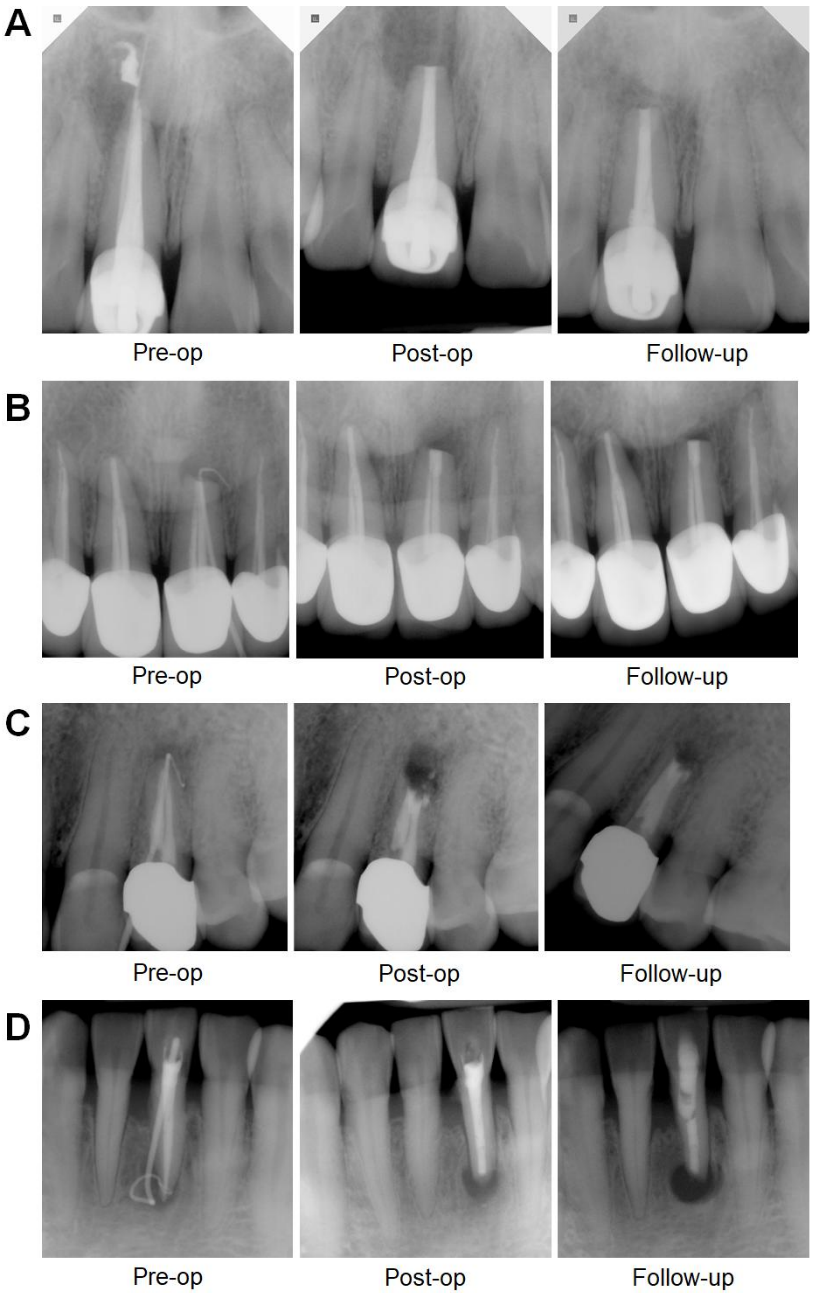

Figure 2. Representative clinical cases of each category. **(A)** Complete healing. **(B)** Incomplete healing. **(C)** Uncertain healing. **(D)** Unsatisfactory healing.

5. Statistical Analysis

All statistical analyses were conducted using R (version 3.1.0; R Foundation for Statistical Computing, Vienna, Austria) and SPSS 23 software (IBM Corp., Armonk, NY, USA).

Agreement between the two examiners who performed the radiographic evaluations at the final follow-up visit was assessed using Cohen's kappa statistic. The interpretation of the agreement was made according to the standards of Landis and Koch (1977).

Univariate analyses using t-tests, chi-squared tests, or Fisher's exact tests were performed to examine differences in the variables based on the outcome. All variables were subjected to multivariate logistic regression analysis followed by a stepwise method to investigate the prognostic factors influencing the outcome of endodontic microsurgery.

III. RESULTS

A total of 5,806 cases of endodontic microsurgery were identified from 2004 to 2017, and follow-up records were available for 3,215 cases. Among these, 2,021 cases were included in the study according to the inclusion and exclusion criteria. The kappa value for agreement in radiographic evaluations between the two examiners was 0.54 (95%CI = 0.49-0.59), which indicated a moderate correlation. The overall success rate for endodontic surgery was 84.0% (1,697/2,021). The total number of operators was 77, 15 faculty members conducted 1,530 cases (75.7%), and 62 residents conducted 491 cases (24.3%).

The baseline characteristics and results of the univariate analyses for all cases are summarized in Table 2. Univariate analysis showed that significant factors included age, gender, tooth type, preoperative symptoms, periapical radiolucency, preoperative post, lesion type, and retrofilling material (Table 3). Logistic regression analysis identified age, gender, tooth type, lesion type, and retrofilling material as significant factors affecting the outcome (Table 4). Older age (odds ratio [OR] = 0.98, 95%CI = 0.97-0.99), male gender (OR = 0.71, 95%CI = 0.55-0.91), molar tooth (OR = 0.49, 95%CI = 0.37-0.66), premolar tooth (OR = 0.65, 95%CI = 0.47-0.90), endodontic-periodontal combined lesion (OR = 0.48, 95%CI = 0.35 to 0.67), and MTA retrofilling material (OR = 1.62, 95%CI = 1.14 – 2.29) were significantly associated with the outcome of endodontic microsurgery ($p < 0.05$). The results showed that preoperative factors are significantly associated with microsurgery outcomes, except for retrofilling materials.

Table 2. Baseline characteristics and distribution of cases

Evaluation factors	Number of cases (Total N = 2,021)
Age (Mean 40.7 ± 16.0)	
- 0-19	99 (4.9%)
- 20-29	498 (24.6%)
- 30-39	497 (24.6%)
- 40-49	337 (16.7%)
- 50-59	267 (13.2%)
- 60-69	212 (10.5%)
- 70+	111 (5.5%)
Gender	
- Female	1206 (59.7%)
- Male	815 (40.3%)
Tooth type	
- Anterior	924 (45.7%)
- Molar	641 (31.7%)
- Premolar	456 (22.6%)
Operator	
- Faculty	1530 (75.7%)
- Resident	491 (24.3%)
Preoperative symptom	
- Asymptomatic	399 (19.7%)
- Symptomatic	1622 (80.3%)
Periapical radiolucency	
- Demarcated	1017 (50.3%)
- Diffuse	893 (44.2%)
- None	111 (5.5%)
Canal filling density	
- Good	1128 (55.8%)
- Poor	893 (44.2%)
Canal filling length	
- Good	1192 (59.0%)
- Poor	829 (41.0%)
Preoperative post	
- Absent	1387 (68.6%)
- Present	634 (31.4%)
Lesion Type	
- Endo	1776 (87.9%)
- Endo-Perio	245 (12.1%)
Retrofilling material	
- Super-EBA	277 (13.7%)
- IRM	262 (13.0%)
- MTA	1482 (73.3%)
Postoperative restoration	
- Permanent	1965 (97.2%)
- Temporary	56 (2.8%)
Postoperative post	
- Absent	1336 (66.1%)
- Present	685 (33.9%)

Table 3. Results of univariate analysis of prognostic factors influencing the outcomes of endodontic surgery

Evaluation factors	Failure (N = 324)	Success (N = 1697)	*p*-value[1]
Age	45.3 ± 16.0	39.9 ± 15.9	< 0.001
Gender			0.005
- Female	170 (14.1%)	1036 (85.9%)	
- Male	154 (18.9%)	661 (81.1%)	
Tooth type			< 0.001
- Anterior	105 (11.4%)	819 (88.6%)	
- Molar	139 (21.7%)	502 (78.3%)	
- Premolar	80 (17.5%)	376 (82.5%)	
Operator			0.010
- Faculty	264 (17.3%)	1266 (82.7%)	
- Resident	60 (12.2%)	431 (87.8%)	
Preoperative Symptom			0.028
- Asymptomatic	49 (12.3%)	350 (87.7%)	
- Symptomatic	275 (17.0%)	1347 (83.0%)	
Periapical radiolucency			0.036
- Demarcated	152 (15.0%)	865 (85.0%)	
- Diffuse	161 (18.0%)	732 (82.0%)	
- None	11 (9.9%)	100 (90.1%)	
Canal filling density			0.166
- Good	169 (15.0%)	959 (85.0%)	
- Poor	155 (17.4%)	738 (82.6%)	
Canal filing length			0.416
- Good	184 (15.4%)	1008 (84.6%)	
- Poor	140 (16.9%)	689 (83.1%)	
Preoperative post			0.025
- Absent	240 (17.3%)	1147 (82.7%)	
- Present	84 (13.2%)	550 (86.8%)	
Lesion type			< 0.001
- Isolate endodontic	254 (14.3%)	1522 (85.7%)	
- Endo-perio combined	70 (28.6%)	175 (71.4%)	
Retrofilling material			< 0.001
- Super-EBA	52 (18.8%)	225 (81.2%)	
- IRM	65 (24.8%)	197 (75.2%)	
- MTA	207 (14.0%)	1275 (86.0%)	
Postoperative restoration			0.199
- Permanent	319 (16.2%)	1646 (83.8%)	
- Temporary	5 (8.9%)	51 (91.1%)	
Postoperative post			0.067
- Absent	229 (17.1%)	1107 (82.9%)	
- Present	95 (13.9%)	590 (86.1%)	

[1] *p*-value as per t-tests, chi-square tests, or Fisher's exact tests

Table 4. Findings of multivariate logistic regression analysis

(A) Initial model

	Odds ratio	95% confidence interval	*p*-value[1]
Age	0.98	0.97-0.99	< 0.001
Gender			
- Female			
- Male	0.70	0.54-0.90	0.005
Tooth type			
- Anterior			
- Molar	0.70	0.37-0.66	< 0.001
- Premolar	0.50	0.47-0.91	0.011
Operator			
- Faculty			
- Resident	1.22	0.89-1.69	0.235
Preoperative Symptom			
- Asymptomatic			
- Symptomatic	0.73	0.51-1.01	0.065
Periapical radiolucency			
- Demarcated			
- Diffuse	0.88	0.68-1.13	0.317
- None	1.67	0.89-3.44	0.130
Canal filling density			
- Good			
- Poor	0.79	0.61-1.02	0.065
Preoperative presence of post			
- No post			
- Post	1.31	0.98-1.76	0.069
Lesion type			
- Isolate endodontic			
- Endodontic-periodontal combined	0.49	0.35-0.67	< 0.001
Retrofilling material			
- Super-EBA			
- IRM	0.80	0.52-1.22	0.302
- MTA	1.56	1.09-2.22	0.013
Postoperative restoration			
- Permanent			
- Temporary	2.01	0.85-5.91	0.150

(B) Final model after stepwise method

	Odds ratio	**95% confidence interval**	***p*-value[1]**
Age	0.98	0.97-0.99	< 0.001
Gender			
- Female			
- Male	0.71	0.55-0.91	0.006
Tooth type			
- Anterior			
- Molar	0.49	0.37-0.66	< 0.001
- Premolar	0.65	0.47-0.90	0.009
Preoperative Symptom			
- Asymptomatic			
- Symptomatic	0.72	0.51-1.01	0.061
Periapical radiolucency			
- Demarcated			
- Diffuse	0.89	0.69-1.14	0.358
- None	1.67	0.89-3.44	0.130
Canal filling density			
- Good			
- Poor	0.78	0.60-1.01	0.059
Preoperative presence of post			
- No post			
- Post	1.32	0.99-1.78	0.060
Lesion type			
- Isolate endodontic			
- Endodontic-periodontal combined	0.48	0.35-0.67	< 0.001
Retrofilling material			
- Super-EBA			
- IRM	0.79	0.51-1.21	0.285
- MTA	1.62	1.14-2.29	0.007
Postoperative restoration			
- Permanent			
- Temporary	2.01	0.85-5.92	0.150

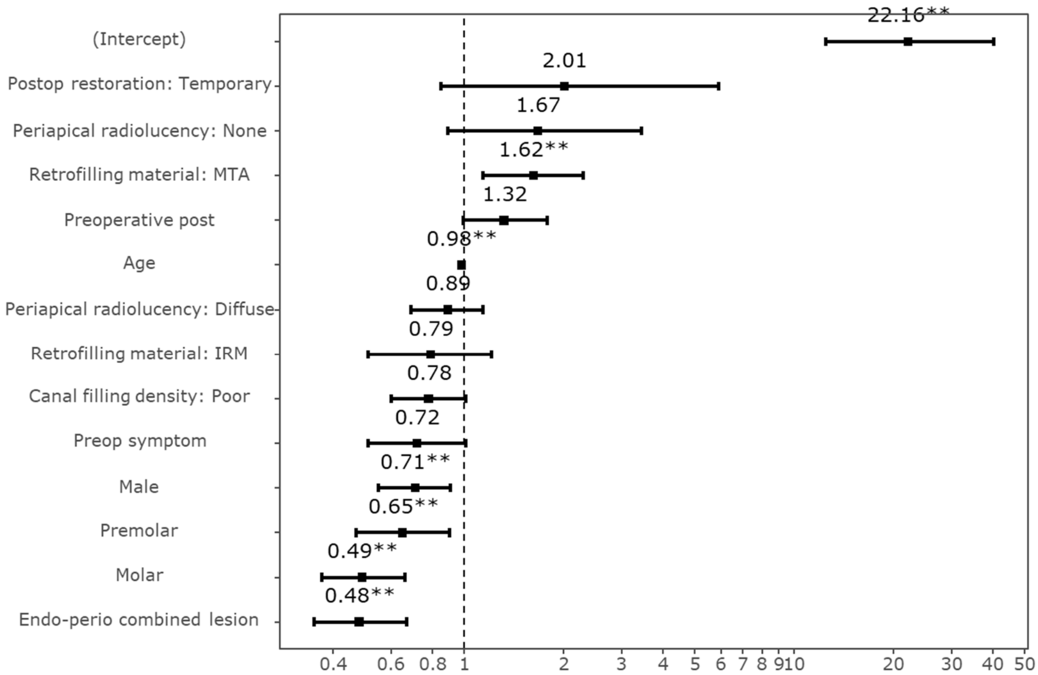

Figure 3. Odds ratio plot for the final model of multivariate logistic regression analysis

Figure 3 expresses the multivariate logistic regression as an OR plot. The OR of postoperative restoration (temporary), periapical lesions (none), and preoperative post are one or more, but point estimation includes one within the 95% confidence interval, which means these are not significant positive factors. Likewise, periapical radiolucency (diffuse), retrofilling material (IRM), canal filling density (poor), and preoperative symptoms are odds ratios of one or less, but point estimation includes one within a 95%CI, so it is difficult to recognize it as a significant negative factor. Postoperative restoration (temporary) and periapical radiolucency (none) had a relatively wide confidence interval due to the small sample size. Therefore, it is difficult to predict where the population's mean will lie.

Finally, the logistic regression final model's result is that significant negative factors include age (old), gender (male), tooth type (premolar and molar), lesion type (endo-perio combined lesion), and the significant positive factors are shown as retrofilling MTA (Table 4).

IV. DISCUSSION

In a similar period as the cases conducted at the Department of Conservative Dentistry, Yonsei University Dental Hospital, Song et al. (2014)'s study, including 115 samples, showed a success rate at 1-year follow-up of 91.3%. Rubinstein and Kim (1999), Halse et al. (1991), and von Arx et al. (2014) showed success rates of 91.5, 87.2, and 87.7%, respectively at 1-year follow-up. This study showed a relatively low success rate of 84%. Because it included a significantly larger cohort compared to the previous studies, it is expected that a large number of endodontic periodontal combined lesions were also included, which influenced the results. This study evaluated the factors that can affect the success and failure of endodontic surgery. As a result, age, gender, tooth type, lesion type, and retrofilling material had a statistically significant influence on surgical outcomes.

In this study, the evaluators reached an agreement on the evaluation after repeated discussions to reach a consensus. The kappa value for agreement in radiographic evaluations between the two examiners was 0.54 (95%CI = 0.49-0.59), which indicated a moderate correlation. In particular, uncertain healing was a category with low concordance among the examiners.

Most of the previous studies were evaluated based on the Rud and Molven criteria (Molven et al. 1987; Rud et al. 1991) at 2 years and at least 1 year. Song et al. (2012) reported that following up on surgical cases for as long as possible is important for accurately assessing complete and sustained healing. However, this requires patient cooperation, which is challenging to maintain. A large number of treated patients were not available for contact during the follow-up period. Even when patients were successfully contacted, if they had become symptom-free after treatment, there was a reduced incentive for them to return for follow-up. Loss to follow-up is intrinsic to most long-term clinical studies, and this loss diminishes the scientific validity of some findings. von Arx et al. (2012) suggested that the 5-year prognosis after apical microsurgery was 8% poorer than that assessed at 1 year. In previous longitudinal studies in which treatment was not consistent with apical microsurgery (Setzer et al. 2010), the 1-year assessment predicted the 5-year prognosis with an accuracy of 91% (Halse et al. 1991) and 95% (Jesslen et al. 1995), which is similar to the 95% predictive accuracy reported in a current 6-9-year study (Yazdi et al. 2007). Kvist and Reit (1999) reported that healing tends to occur more quickly with surgical retreatment than with nonsurgical retreatment. The most significant information about healing was obtained 1 year after surgery (Chong et al. 2003). Many studies on the clinical outcomes of surgical endodontics tend to report outcomes after a follow-up period of approximately 1 year.

Jesslen et al. (1995) reported that the result of a 1-year follow-up was valid in more than 95% of cases. Rubinstein and Kim (1999) followed up the cases classified as healed at the 1-year follow-up for an additional 5-7 years and reported a highly maintained success rate of 91.5% based on the long-term follow-up. This is consistent with the findings of a recent study (Song et al. 2012), which showed a highly maintained success rate of 93.3% for more than 6 years. Only seven cases were considered failures.

Song et al. (2014) reported no significant difference in the clinical outcomes after endodontic microsurgery when comparing 1-year follow-up periods with longer follow-up periods. On that basis, a success rate of 87.8% was observed at the long-term follow-up, with a success rate of 91.3% at the 1-year follow-up, and the success rate reduction was only 3.5%, which was not statistically significant. Failure of endodontic surgery can be caused by vertical root fractures or prosthetic problems and periodontal problems not related to the surgery. While the present study showed a success rate of 84%, Song et al.'s study showed a success rate of 91.3% at 1-year follow-up. The reason for this conjecture is that there were more number of molar and premolar cases (54.3%) than that of anterior tooth cases (45.7%). On the other hand, in the study by Song et al., 55.7% of anterior teeth and 44.3% of molar and premolar cases were included among 115 cases.

Age

Rubinstein and Kim (1999), Wang et al. (2004), Zuolo et al. (2000) found that there was no statistical significance between endodontic microsurgery outcomes and age, but Barone et al. (2010) evaluated it as a positive factor. In this study, age was a factor influencing the outcome of surgery, and as age increased, the success rate of surgery decreased. This relationship between surgical outcomes and age could be related to periodontal problems and postoperative healing potential (von Arx et al. 2010). Song and Kim (2012) reported that the highest success rate was reported in patients aged < 20 years and tended to decrease with age ($p < 0.05$). In this study, the success rate began to decrease in people over the age of 30 years. As age increased, the proportion of endo-perio combined lesions increased, which might be the cause of the lower success rate.

Gender

In this study, men had a lower endodontic surgical success rate than women. There are not many papers on the correlation between gender and the outcomes of endodontic apical surgery. Studies have shown that gender is associated with periodontal disease; Desvarieux et al. (2004) reported that men were more susceptible to periodontal infection than women, and according to a study by McAbee et al. (2012), male mice showed more pathological endodontic bone loss in a mouse study. A study found that smoking is a potential cause of failure in endodontic microsurgery. Song and Kim (2012) reported that men had a poorer success rate than women. In the literature, it has been shown that males are more prone to periodontal infection than females.

Additionally, W-Dahl and Toksvig-Larsen (2004) and Duncan and Pitt Ford (2006) reported that the smoking rate was significantly higher in men and lowered the healing potential after surgery. Truschnegg et al. (2020) reported that the surgical success rates for smokers and non-smokers were 33.3 and 80.4%, respectively. Tawil et al. (2015) reported that smoking affects root dentinal defects, and the success rate of surgery in smokers was 31.5%, was and 97.3% in non-smokers. The side effects of smoking on endodontic microsurgery include postoperative complications, such as the delayed healing of hard and soft tissues, widening of suture sites, and infection problems at the surgical site (Castillo et al. 2005; Chang et al. 1996; Wang et al. 2004).

Operator

Lustmann et al. (1991) found that the surgical outcomes depended on the operator, which was not due to surgical experience, but because of individual differences. Song et al. (2013) showed that there was no significant effect of the operator on the outcomes of endodontic surgery. Rahbaran et al. (2001) compared the outcomes of periapical surgery performed in the endodontic and oral surgery departments in a dental hospital and showed that the rate of complete healing in patients treated in the endodontic unit was significantly higher (37.4%) than that for patients treated in the oral surgery unit (19.4%). In the present study, residents' success rates were higher than those of faculty members. Wang et al. (2004) also reported that the success rate of residents was higher than that of faculty members and concluded that case screening was the main cause.

Previous study showed that the surgical success rate between the faculty and the residents who have undergone appropriate education and training at the Department of Conservation at Yonsei University will not be significantly different (Song and Kim 2011). This result might be due to the difference in case selection and case allocation between the faculty and residents. In this study, 682 anterior teeth, 490 molars, and 358 premolars were assigned to 15 faculty members, and 242 anterior teeth, 151 molars, and 98 premolars were assigned to 62 residents.

Tooth type

In this study, the proportion of anterior teeth, molars, and premolars was 45.7, 31.7, and 22.6%, respectively (Table 2). The surgical success rate of this study shows an OR of 0.7 for molars and 0.5 for premolars, compared to anterior teeth. We found that the factors lowering the success rate of the posterior teeth included the difficulty of access, inaccurate root-end preparation, periodontal combined lesions, and thick buccal bone. The factors that decrease the success rate of premolars include anatomical problems such as isthmus and poor crown/root ratio (Ricucci et al. 2011; Kim et al. 2016; Song and Kim 2011).

Kim et al. (2016) reported the effect of isthmus on the outcomes of endodontic surgery in the maxillary and mandibular molars. Of the 106 teeth included in the study, 72 had an isthmus, and 34 had no isthmus. The postsurgical survival rate was 61.5 and 87.4% for 4 years when an isthmus was present and absent, respectively. Despite procedural advances such as ultrasonic devices and operating microscopes, root weakening cannot be avoided because of the reduction in the thickness of the remaining dentin after isthmus preparation.

Kim and Kratchman (2006) reported that the anterior teeth tended to have a higher success rate than the other tooth groups, which might be caused by the specific convenience of access and the root’s anatomy (Friedman et al. 1991).

von Arx et al. (2007) reported that maxillary and mandibular anterior teeth showed relatively high estimated healed rates (above 85%), whereas mandibular molars had a low estimated healed rate of 63.7%. The reason that the tooth type is a significant factor is that the anatomical disadvantages of premolar and molar teeth compared to the anterior teeth, for example, isthmus, thick buccal bone, inaccessibility during surgery, and difficulty in maintaining a stable state by the occlusal force at the early healing stage. In the present study, molar and premolar showed significantly lower success rates than anterior teeth, similar to other studies.

Lesion type

The lesion type was classified based on the criteria proposed by Kim and Kratchman (2006) and was divided into an isolated endodontic lesion group (Class A-C) and an endodontic-periodontal combined lesion group (Class D-F). Kim and Kratchman (2006) reported that the lesion type was divided into isolated endodontic lesions and endodontic-periodontal combined lesions; the success rate of isolated endodontic lesions was 95.2%, and the success rate of combined lesions was 77.5%. Based on the results of this study, lesion type was considered to be a significant factor. Kang (2016) reported that lesion type was a significant predictor of the outcome of endodontic microsurgery. Isolated endodontic lesions were significantly associated with a better prognosis of endodontic microsurgery.

In the present study, endodontic-periodontal combined lesions had a lower success rate than isolated lesions. In endodontic-periodontal combined lesions, the loss of alveolar bone makes apical migration of the epithelium and subsequent periodontal reattachment difficult, causing bacteria to enter the sulcus. Thus, it interferes with healing by providing a re-infection pathway to the apex (Barone et al. 2010).

Retrofilling material

The success rate of surgery was remarkably low when amalgam, Glass-ionomer cement(GIC) , and IRM were used in the apical surgery (von Arx et al. 2010). Retrofilling materials include Zinc-Oxide Eugenol (ZOE) materials (IRM, Super-EBA), glass ionomer cement, composite resin, compomer (Geristore), and MTA. Currently, the most popular material is MTA.

In a meta-analysis of endodontic microsurgery, von Arx, Hänni, and Jensen (2010) reported that the success rate of surgery with MTA was higher than with other retrofilling materials. When used as the retrofitting material, the success rates of amalgam, GIC, IRM, and Super-EBA were 57.9, 51.2, 71.6, and 69.8%, respectively. Meanwhile, MTA had a success rate of 91.4%.

In the present study, when MTA was used as a retrofilling material, the surgical success rate was higher than that of Super-EBA or IRM. The most popular advantage of MTA is that it maintains volume stability until hardening, does not decompose by fluid, and induces bacteriostatic effects and osteogenesis (Saunders 2008; Baek et al. 2010; Christiansen et al. 2009).

Due to the nature of MTA, it prevents any further leakage from the canal and provides the opportunity to create an apical seal. In addition, because of the biocompatibility of MTA, osteoblasts and cementoblasts gather at the root resection site, resulting in regenerated bone and regenerated Periodontal ligament (PDL) and increasing the success rate of endodontic surgery (Stropko 1999; Ricucci et al. 2006).

Christiansen et al. (2009) reported a success rate of 52% versus 96% when only smoothing or cold burnishing was performed after cutting, and MTA backfilling was performed. Chong et al. (2003) reported no difference in the success rate according to the retrofilling material. In a prospective clinical study using a randomized design involving single-rooted teeth, Lindeboom et al. (2005) reported that MTA and IRM had the same clinical effectiveness as root-end filling materials.

Song and Kim (2011) reported that MTA and Super-EBA showed similar results in a study comparing MTA, Super-EBA, and IRM, whereas MTA showed a higher success rate than IRM (95% CI, 1.251-4.668, $p = 0.009$). This is thought to be because the eugenol leached from the IRM inhibits healing, and the humid surgical environment reduces the IRM's sealing force. von Arx et al. (2012) reported that the success rate of Super-EBA versus root MTA was 67.3% vs. 86.4%, with a statistically significant difference.

V. CONCLUSION

Within the limitations of this retrospective study, the short-term outcome of endodontic surgery was favorable in a large cohort. Few studies have shown the effect of sample size on the success rate or significant factors affecting the outcomes of endodontic surgery, but through a few papers, we were able to determine the limitations of a small sample size.

The results of this study suggest that age (older), gender (male), tooth type (premolar and molar), and lesion type (endo-perio combined lesion) were negative factors for success rate, and retrofilling material (MTA) was a positive factor for success rate. Therefore, when planning endodontic surgery, clinicians should consider that these factors affect the success rate of endodontic surgery. In addition, clinicians should pay more careful attention during surgery when patients have negative factors.

REFERENCES

Ainsworth, G. 2012. Super-EBA and IRM for retrograde root filing, *Evid Based Dent*, 13: 20.

Baek, S. H., Lee, W. C., Setzer, F. C., and Kim, S. 2010. Periapical bone regeneration after endodontic microsurgery with three different root-end filling materials: amalgam, SuperEBA, and mineral trioxide aggregate, *J Endod*, 36: 1323-5.

Barone, C., Dao, T. T., Basrani, B. B., Wang, N., and Friedman, S. 2010. Treatment outcome in endodontics: the Toronto study--phases 3, 4, and 5: apical surgery, *J Endod*, 36: 28-35.

Çalışkan, M. K., Tekin, U., Kaval, M. E., and Solmaz, M. C. 2016. The outcome of apical microsurgery using MTA as the root-end filling material: 2-to 6-year follow-up study, *Int Endod J*, 49: 245-54.

Castillo, R. C., Bosse, M. J., MacKenzie, E. J., and Patterson, B. M. 2005. Impact of smoking on fracture healing and risk of complications in limb-threatening open tibia fractures, *J Orthop Trauma*, 19: 151-7.

Chang, L. D., Buncke, G., Slezak, S., and Buncke, H. J. 1996. Cigarette smoking, plastic surgery, and microsurgery, *J Reconstr Microsurg*, 12: 467-74.

Chong, B. S., Pitt Ford, T. R., and Hudson, M. B. 2003. A prospective clinical study of Mineral Trioxide Aggregate and IRM when used as root-end filling materials in endodontic surgery, *Int Endod J*, 36: 520-6.

Christiansen, R., Kirkevang, L. L., Hørsted-Bindslev, P., and Wenzel, A. 2009. Randomized clinical trial of root-end resection followed by root-end filling with mineral trioxide aggregate or smoothing of the orthograde gutta-percha root filling–1-year follow-up, *Int Endod J*, 42: 105-14.

Desvarieux, M. s., Schwahn, C., Volzke, H., Demmer, R. T., Ludemann, J., Kessler, C., Jacobs Jr, D. R., John, U., and Kocher, T. 2004. Gender differences in the relationship between periodontal disease, tooth loss, and atherosclerosis, *Stroke*, 35: 2029-35.

Dietrich, T., Zunker, P., Dietrich, D., and Bernimoulin, J. P. 2003. Periapical and periodontal healing after osseous grafting and guided tissue regeneration treatment of apicomarginal defects in periradicular surgery: results after 12 months, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, 95: 474-82.

Duncan, H. F., and Pitt Ford, T. R. 2006. The potential association between smoking and endodontic disease, *Int Endod J*, 39: 843-54.

Fabricius, L., Dahlen, G., Holm, S. E., and Moller, A. J. 1982. Influence of combinations of oral bacteria on periapical tissues of monkeys, *Scand J Dent Res*, 90: 200-6.

Friedman, S., Lustmann, J., and Shaharabany, V. 1991. Treatment results of apical surgery in premolar and molar teeth, *J Endod*, 17: 30-3.

Halse, A., Molven, O., and Grung, B. 1991. Follow-up after periapical surgery: the value of the one-year control, *Endod Dent Traumatol*, 7: 246-50.

Hargreaves, K. M., Cohen, S., and Berman, L. H. 2011. *Cohen's pathways of the pulp* (Mosby Elsevier).

Jesslen, P., Zetterqvist, L., and Heimdahl, A. 1995. Long-term results of amalgam versus glass ionomer cement as apical sealant after apicectomy, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, 79: 101-03.

Johnston, K. M., Lakzadeh, P., Donato, B. M. K., and Szabo, S. M. 2019. Methods of sample size calculation in descriptive retrospective burden of illness studies, *BMC Med Res Methodol*, 19: 9.

Kang, M. 2016. Effect of various prognostic factors on the outcome of endodontic microsurgery: propensity score matching analysis, Graduate School, Yonsei University.

Kim, E., Song, J. S., Jung, I. Y., Lee, S. J., and Kim, S. 2008. Prospective clinical study evaluating endodontic microsurgery outcomes for cases with lesions of endodontic origin compared with cases with lesions of combined periodontal-endodontic origin, *J Endod*, 34: 546-51.

Kim, S., Jung, H., Kim, S., Shin, S. J., and Kim, E. 2016. The Influence of an Isthmus on the Outcomes of Surgically Treated Molars: A Retrospective Study, *J Endod*, 42: 1029-34.

Kim, S., and Kratchman, S. 2006. Modern endodontic surgery concepts and practice: a review, *J Endod*, 32: 601-23.

Kruse, C., Spin-Neto, R., Christiansen, R., Wenzel, A., and Kirkevang, L. L. 2016. Periapical Bone Healing after Apicectomy with and without Retrograde Root Filling with Mineral Trioxide Aggregate: A 6-year Follow-up of a Randomized Controlled Trial, *J Endod*, 42: 533-7.

Kvist, T., and Reit, C. 1999. Results of endodontic retreatment: a randomized clinical study comparing surgical and nonsurgical procedures, *J Endod*, 25: 814-7.

Landis, J. R., and Koch, G. G. 1977. The measurement of observer agreement for categorical data, *Biometrics*, 33: 159-74.

Lindeboom, J. A., Frenken, J. W., Kroon, F. H., and van den Akker, H. P. 2005. A comparative prospective randomized clinical study of MTA and IRM as root-end filling materials in single-rooted teeth in endodontic surgery, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, 100: 495-500.

Lui, J. N., Khin, M. M., Krishnaswamy, G., and Chen, N. N. 2014. Prognostic factors relating to the outcome of endodontic microsurgery, *J Endod*, 40: 1071-6.

Lustmann, J., Friedman, S., and Shaharabany, V. 1991. Relation of pre- and intraoperative factors to prognosis of posterior apical surgery, *J Endod*, 17: 239-41.

Mareschi, P., Taschieri, S., and Corbella, S. 2020. Long-Term Follow-Up of Nonsurgical Endodontic Treatments Performed by One Specialist: A Retrospective Cohort Study about Tooth Survival and Treatment Success, *Int Endod J*, 2020.

McAbee, J., Li, Q., Yu, H., and Kirkwood, K. L. 2012. Genderual dimorphism in periapical inflammation and bone loss from mitogen-activated protein kinase phosphatase-1 deficient mice, *J Endod*, 38: 1097-100.

Molven, O., Halse, A., and Grung, B. 1987. Observer strategy and the radiographic classification of healing after endodontic surgery, *Int J Oral Maxillofac Surg*, 16: 432-9.

Prati, C., Pirani, C., Zamparini, F., Gatto, M. R., and Gandolfi, M. G. 2018. A 20-year historical prospective cohort study of root canal treatments. A Multilevel analysis, *Int Endod J*, 51: 955-68.

Rahbaran, S., Gilthorpe, M. S., Harrison, S. D., and Gulabivala, K. 2001. Comparison of clinical outcome of periapical surgery in endodontic and oral surgery units of a teaching dental hospital: a retrospective study, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, 91: 700-9.

Ricucci, D., Pascon, E. A., Ford, T. R., and Langeland, K. 2006. Epithelium and bacteria in periapical lesions, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, 101: 239-49.

Ricucci, D., Russo, J., Rutberg, M., Burleson, J. A., and Spangberg, L. S. 2011. A prospective cohort study of endodontic treatments of 1,369 root canals: results after 5 years, *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, 112: 825-42.

Rubinstein, R. A., and Kim, S. 1999. Short-term observation of the results of endodontic surgery with the use of a surgical operation microscope and Super-EBA as root-end filling material, *J Endod*, 25: 43-48.

Rud, J., Andreasen, J. O., and Jensen, J. E. 1972. Radiographic criteria for the assessment of healing after endodontic surgery, *Int J Oral Surg*, 1: 195-214.

Rud, J., Munksgaard, E. C., Andreasen, J. O., and Rud, V. 1991. Retrograde root filling with composite and a dentin-bonding agent. 2, *Endod Dent Traumatol*, 7: 126-31.

Sauerland, S., Lefering, R., and Neugebauer, E. A. 2002. Retrospective clinical studies in surgery: potentials and pitfalls, *J Hand Surg Br*, 27: 117-21.

Saunders, W. P. 2008. A prospective clinical study of periradicular surgery using mineral trioxide aggregate as a root-end filling, *J Endod*, 34: 660-5.

Setzer, F. C., Shah, S. B., Kohli, M. R., Karabucak, B., and Kim, S. 2010. Outcome of endodontic surgery: a meta-analysis of the literature--part 1: Comparison of traditional root-end surgery and endodontic microsurgery, *J Endod*, 36: 1757-65.

Song, M., Chung, W., Lee, S.-J., and Kim, E. 2012. Long-term outcome of the cases classified as successes based on short-term follow-up in endodontic microsurgery, *J Endod*, 38: 1192-96.

Song, M., Jung, I. Y., Lee, S. J., Lee, C. Y., and Kim, E. 2011. Prognostic factors for clinical outcomes in endodontic microsurgery: a retrospective study, *J Endod*, 37: 927-33.

Song, M., and Kim, E. 2011. Success and failure of endodontic microsurgery, *J Korean Acad Conserv Dent*, 36: 465-76.

Song, M., and Kim, E. 2012. A prospective randomized controlled study of mineral trioxide aggregate and super ethoxy-benzoic acid as root-end filling materials in endodontic microsurgery, *J Endod*, 38: 875-9.

Song, M., Kim, S. G., Lee, S. J., Kim, B., and Kim, E. 2013. Prognostic factors of clinical outcomes in endodontic microsurgery: a prospective study, *J Endod*, 39: 1491-7.

Song, M., Nam, T., Shin, S. J., and Kim, E. 2014. Comparison of clinical outcomes of endodontic microsurgery: 1 year versus long-term follow-up, *J Endod*, 40: 490-4.

Song, M., Shin, S. J., and Kim, E. 2011. Outcomes of endodontic micro-resurgery: a prospective clinical study, *J Endod*, 37: 316-20.

Stropko, J. J. 1999. Canal morphology of maxillary molars: clinical observations of canal configurations, *J Endod*, 25: 446-50.

Tawil, P. Z., Saraiya, V. M., Galicia, J. C., and Duggan, D. J. 2015. Periapical microsurgery: the effect of root dentinal defects on short- and long-term outcome, *J Endod*, 41: 22-7.

Truschnegg, A., Rugani, P., Kirnbauer, B., Kqiku, L., Jakse, N., and Kirmeier, R. 2020. Long-term Follow-up for Apical Microsurgery of Teeth with Core and Post Restorations, *J Endod*, 46: 178-83.

Tsesis, I., Faivishevsky, V., Kfir, A., and Rosen, E. 2009. Outcome of surgical endodontic treatment performed by a modern technique: a meta-analysis of literature, *J Endod*, 35: 1505-11.

von Arx, T., Hanni, S., and Jensen, S. S. 2014. 5-year results comparing mineral trioxide aggregate and adhesive resin composite for root-end sealing in apical surgery, *J Endod*, 40: 1077-81.

von Arx, T., Jensen, S. S., and Hanni, S. 2007. Clinical and radiographic assessment of various predictors for healing outcome 1 year after periapical surgery, *J Endod*, 33: 123-8.

von Arx, T., Jensen, S. S., Hanni, S., and Friedman, S. 2012. Five-year longitudinal assessment of the prognosis of apical microsurgery, *J Endod*, 38: 570-9.

von Arx, T., Jensen, S. S., Janner, S. F. M., Hanni, S., and Bornstein, M. M. 2019. A 10-year Follow-up Study of 119 Teeth Treated with Apical Surgery and Root-end Filling with Mineral Trioxide Aggregate, *J Endod*, 45: 394-401.

von Arx, T., Penarrocha, M., and Jensen, S. 2010. Prognostic factors in apical surgery with root-end filling: a meta-analysis, *J Endod*, 36: 957-73.

W-Dahl, A., and Toksvig-Larsen, S. 2004. Cigarette smoking delays bone healing: a prospective study of 200 patients operated on by the hemicallotasis technique, *Acta Orthop Scand*, 75: 347-51.

Wang, N., Knight, K., Dao, T., and Friedman, S. 2004. Treatment outcome in endodontics-The Toronto Study. Phases I and II: apical surgery, *J Endod*, 30: 751-61.

Wolcott, J., Ishley, D., Kennedy, W., Johnson, S., Minnich, S., and Meyers, J. 2005. A 5 yr clinical investigation of second mesiobuccal canals in endodontically treated and retreated maxillary molars, *J Endod*, 31: 262-4.

Yazdi, P. M., Schou, S., Jensen, S. S., Stoltze, K., Kenrad, B., and Sewerin, I. 2007. Dentine-bonded resin composite (Retroplast) for root-end filling: a prospective clinical and radiographic study with a mean follow-up period of 8 years, *Int Endod J*, 40: 493-503.

Zhao, X., Dai, X., Wang, S., Yang, T., Yan, Y., Zhu, G., Feng, J., Pan, B., Sunagawa, M., Zhang, X., Qian, Y., and Liu, Y. 2018. Traditional Chinese Medicine Integrated with Chemotherapy for Stage II-IIIA Patients with Non-Small-Cell Lung Cancer after Radical Surgery: A Retrospective Clinical Analysis with Small Sample Size, *Evid Based Complement Alternat Med*, 2018: 4369027.

Zuolo, M. L., Ferreira, M. O., and Gutmann, J. L. 2000. Prognosis in periradicular surgery: a clinical prospective study, *Int Endod J*, 33: 91-8.

Abstract (Korean)

2004-2017 동안 연세대학교 치과대학 보존과에서 시행한 치근단 수술의 후향적 코호트 연구

이현정

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I. 서론

비수술 근관치료의 실패 원인은 다양하다. 그리고 재근관치료가 실패하였거나, 불가할때, 치아를 살 릴 수 있는 마지막 방법은 미세치근단 수술이다. 최근 발표되었던 미세치근단 수술에 관한 논문의 대부분은 약

100 여개의 샘플을 이용한 연구였다. 샘플 숫자는 연구 결과에 많은 영향을 미치는 것으로 알려져 있다.

이에, 본 연구에서는 연세대학교 치과대학 보존과 미세현미경 센터에서 2004 년부터 2017 년까지의 시행된 미세현미경 치근단 수술 증례로 후향적 cohort 를 구축하여 치근단 수술의 성공율과 결과에 영향을 미치는 예후인자를 평가하고자 하였다.

II. 재료 및 방법

치근단 수술이 시행된 5806 개의 증례 중, 결과 평가를 위해 내원한 3215 개의 증례에서 본 연구의 포함 기준에 부합하는 2021 개의 증례로 후향적 cohort 를 구축하여 분석하였다. 평가는 Molven criteria 를 기본으로 차트와 방사선사진을 이용하여 평가하고, 평가자간 불일치한 결과에 대해서는 토론을 통해 일치시켰다.

평가 요소로는 술전,술중,술후로 나누어 분석하여 기록하였고, 그중 유의하게 평가된 요소를 univariated analysis (t tests, chi-squared tests, fisher' s exact tests) 과 multiple-variated analysis (logistic regression, stepwise method) 을 통해 분석하였다.

III. 결과

여러가지 요인 중 나이(많을수록), 성별(남성), 치아 위치(소구치, 대구치) 병변 유형(치수-치주 복합 병소)이 부정적 영향을 미치는 것으로 분석되었다. 반면에 역충전 재료(MTA)가 긍정적인 유의한 요소를 갖는 것으로 분석되었다. 본 연구에 따르면 미세현미경 치근단수술은 역충전 소재를 제외하고 수술 후 요인보다 수술 전 요인이 치유 결과에 더 큰 영향을 미칠 가능성이 높다. 즉, 수술 전 요인들은 성공률에 영향을 미치는 중요한 요인들로 평가되었다.

IV. 결론

본 연구는 미세현미경을 이용한 치근단 수술의 결과에 영향을 미치는 요인과 치유와 실패 사이의 상관 관계를 분석 하였다.

임상의는 치료 관련 요인을 제어할 수 있지만 수술 전 요인은 대개 치과의사의 권한을 벗어난다. 그럼에도 불구하고 치료 대안과 비교하여 수술을 계획하거나 예후를 평가할 때 수술 전 요인을 중요한 예후 결정 요소로 고려해야 한다.

본 연구에서는 다수의 샘플을 확보하여, 치근단 수술의 결과에 영향을 미치는 요인을 분석했다는 점에서 의미가 있다.

핵심되는말 : 미세치근단수술, 치근단절제술, 예후인자, 치유결과