Original Article

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A retrospective study of periapical microsurgery outcome

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Objectives: To evaluate treatment outcomes and prognostic factors on the success of periapical microsurgery.
Materials and Methods: Patients who were treated with periapical microsurgery at Endodontic Clinic of Dental Hospital and Endodontic Clinic of Golden Jubilee Medical Center, Faculty of Dentistry, Mahidol University, Thailand, from January 2005 to December 2015, were recruited. The outcomes were assessed clinically and radiographically with a recall period of at least one year after the endodontic microsurgery. All radiographic images were scanned and analysed using Image J software, to measure sizes of periapical radiolucency. Modified Friedman's criteria was employed to classify the outcome as healed, healing, or disease. Pre-operative, intra-operative, and post-operative factors were taken into consideration, and analysed using logistic regression in order to identify any significant factors.
Results: Of all 175 teeth in 154 patients, one-hundred and twenty-nine teeth were recruited. The recall rate was 83.7% (108 teeth) with a mean recall period of 30.8 months (ranging from 12 to 108 months). The outcomes were 86 teeth healed (79.6%), 20 teeth healing (18.5%) and 2 teeth diseased (1.9%). Multivariate logistic regression analysis showed that quality of the pre-operative root canal filling was a significant prognostic factor ($P \leq 0.05$). Teeth with inadequate root canal fillings had six times higher chance of 'disease' than teeth with adequate quality fillings.
Conclusion: The healed rate in this study was 79.6%. Inadequate quality of pre-operative root canal filling was the significant negative prognostic factor of the outcomes.

Keywords: endodontic microsurgery, prognostic factors, retrospective study, root-end filling, success and failure, treatment outcome.

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Introduction

Periapical surgery is an alternative treatment to preserve teeth in the failed non-surgical root canal treatment or retreatment. In the past, due to the limitations of techniques, equipment, and materials; non-microscopic endodontic surgery was performed with large osteotomy size, 45°–60° root-end bevel. The root-end was prepared with a bur and filled with amalgam [1], which resulted in 43.5–62.5% success rate [2-4]. Since the introduction of dental operating microscope into the endodontic field in the 1990s, the endodontic surgery has been transformed with modern microscopic technique, which made it more practicable by the enhancement of the visibility by magnification and illumination [1,5]. The development of microsurgical instruments, ultrasonic devices, and biological root-end filling materials also improved the success outcome [1,5]. The combined healing rates of endodontic surgery with non-microscopic and microscopic surgery techniques were 73.1–74.0% [6–8], while the predicted successful outcome of endodontic microsurgery ranged from 78.5–94.3% [9-15]. Several prognostic factors affecting the outcome of surgery were tooth type [12],

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pre-operative pain [16], pre-operative lesion size [6,16], surgical crypt size [7], quality of root canal filling [12], type of root-end filling materials [16], root resection without root-end filling, absence of labial cortical bone and post-operative periodontal pocket [8].

The outcomes of endodontic surgery varied depending on the criteria of assessment. Generally, clinical signs and symptoms and radiograph are evaluated. If signs and symptoms are present, the result of the treatment is evaluated as failure [17]. The assessment criteria of Rud et al. [18] and Molven et al. [19] correlated histologic morphology and radiographic appearance and classified healing into four categories, namely, complete, incomplete, uncertain, and unsatisfactory healing. These criteria were more practical and widely used by several studies [8,10,12]. Combining clinical and radiographic assessments, Friedman [17] proposed clearly and easily understandable terms; "healed", "healing" and "disease" for periapical evaluation.

Follow-up period must be long enough for the evaluation of healing. Periapical surgery studies reported follow-up periods from 6 months to 23 years [20,21]. For short-term recall, i.e., six months, the outcome tended to present a higher rate of incompletely healed (healing), and recurrence of a periapical lesion might be missed. The complete healing process is commonly detected within the first year after surgery [17]. Many clinical studies showed similar outcomes of 1 year and 3–5 years recall periods [17,20,22]. Therefore, a one-year follow-up was practical as the minimum period in outcome study [17,19,20].

A retrospective study of endodontic apical surgery outcome at Mahidol University during the years 2000–2010 reported 73.1% healed rate. During the first decade of the 21st century, traditional apical surgery was transformed into microsurgery, and a better outcome could be anticipated. Therefore, the purposes of this study were to assess the treatment outcome and prognostic factors of apical endodontic microsurgery at the Faculty of Dentistry, Mahidol University.

Materials and Methods

The study protocol was given the ethics approval COA No. MU-DT/PY-IRB 2017/032.1605 by the Faculty of Dentistry/Faculty of Pharmacy, Mahidol University, Institutional Review Board (MU-IRB). Data were collected from records and radiographs of patients who were treated with periapical microsurgery at Endodontic Clinic of the Dental Hospital and Endodontic Clinic of Golden Jubilee Medical Center, Faculty of Dentistry, Mahidol University, Thailand, from January 2005 to December 2015.

Data Collection

Inclusion criteria: All the included patients had been treated with the endodontic microsurgery technique by postgraduate endodontic students or endodontic faculty. Surgical procedure was performed under dental operating microscope with dissimilar conditions of magnification/illumination. The microinstrument such as, micromirror and microplugger, and ultrasonic retropreparation tip were used. The root-end preparation was apicoectomy or apicoectomy and root-end filling with super EBA or MTA. Other requirements were a recall period of at least one year, complete records of clinical information and treatment procedures, and radiographs of good quality were required.

Exclusion criteria were the teeth that had vertical root fracture or crack line detected during a surgical procedure.

The collected data were divided into:

Pre-operative factors that included the operator, age, gender, tooth type, signs and symptoms, mobility, periodontal involvement, previous root canal retreatment or apical surgery, size of the periapical lesion, circumscribed or

diffused periapical lesion, quality of root canal filling (adequate: 0–2 mm within radiographic apex without voids, or inadequate: shorter than 2 mm from radiographic apex or overextend or with voids), quality of coronal restoration (clinically and radiographically adequate or inadequate), type of coronal restoration (temporary or permanent restoration), and presence or absence of post.

Intra-operative factors included, the type of procedure (apicoectomy or apicoectomy and root-end filling), type of root-end filling material (MTA or Super EBA), quality of root-end filling material (adequate: ≥ 3 mm depth of material without voids, and inadequate: < 3mm depth of material or with voids), presence or absence of labial marginal bone, the use of guided tissue regeneration membrane and bone graft.

Post-operative factors included the type and quality of the coronal restoration.

Clinical and Radiographic Evaluations

Clinical signs and symptoms were reviewed from dental chart records for the following indicators: pain, tenderness to percussion or palpation, presence of sinus tract, periodontal pocket, and signs of swelling.

The pre-operative, post-operative and recall radiographs were imported to Image J Software (version 1.47; National Institutes of Health, Bethesda, Maryland, USA) to measure the size of periapical lesions. TurboReg plugin software was also used to adjust the horizontal angles of radiographs before measurement.

Twenty radiographic images were randomly selected and blindly interpreted using Molven's criteria by one investigator in a two-week interval. Intra-examiner reliability was assesed with Cohen's kappa coefficient test.

Outcome Assessment

The outcomes were evaluated based on both clinical and radiographic information. The criterion was from Friedman [17] assessment as follows:

Healed: A combined clinical (no signs and symptoms) and radiographic(no residual radiolucency) normaly. Included in this classification is the strictly defined, typical appearance of a scar (Figure. 1).

Healing: Reduced radiolucency combined with clinical normalcy, in follow-up periods shorter than 4 years (Figure. 2).

Diseased: Persistence of radiolucency with or without clinical signs and symptoms, or presence of symptoms even when the radiographic appearance is normal (Figure. 3).

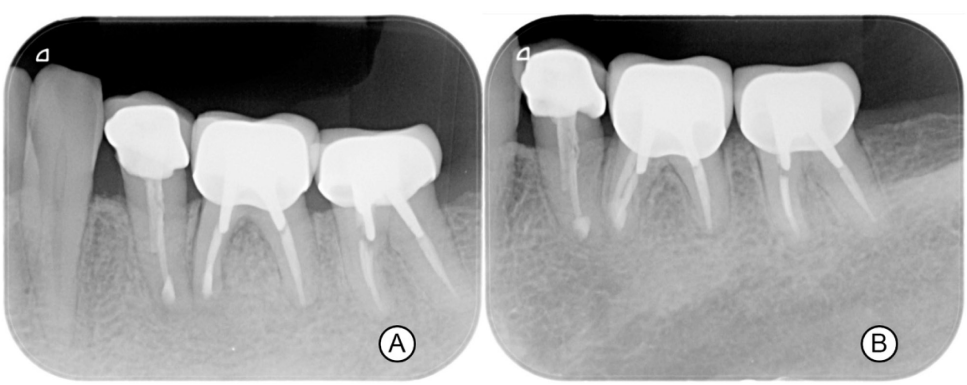

Figure 1 Periapical radiographs of tooth no. 35, 36. (a) Post-surgical radiograph (b) Healed apical tissue without symptom of 24 months follow-up period.

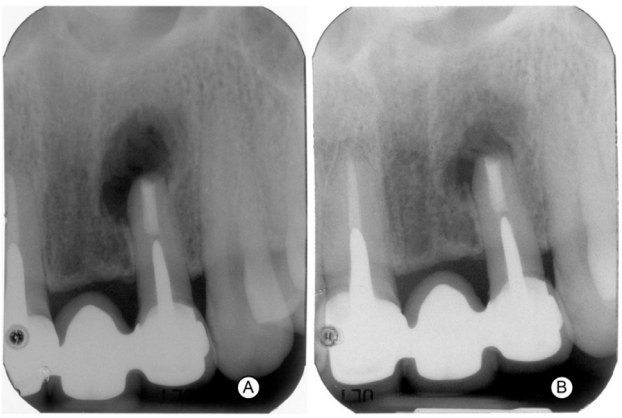

Figure 2 Periapical radiographs of tooth no. 22. (a) Post-surgical radiograph (b) Healing apical tissue that rarefaction reduced without any symptoms of 24 months follow-up period.

Figure 3 Periapical radiographs of tooth no. 21. (a) Post-surgical radiograph (b) Diseased apical tissue that rarefaction was unchanged without any symptoms of 83 months follow-up period.

Statistical Analysis

Descriptive analysis was used to describe data of the outcomes that were classified as healed, healing, and diseased. Statistical analysis of the predisposing factors, dependent variables of Friedman's strict criteria [17], was healed and diseased, where the diseased variable was a combination of healing and diseased. Association between variables and treatment outcomes were assessed using simple logistic regression. The variables which had *P*-value ≤ 0.25 [24] were further evaluated with multiple logistic regression to identify any significant outcome predictors at 5% significant level ($P \leq 0.05$). All data were processed and analyzed with PASW Statistics 18.0 (SPSS Inc., Chicago, IL, USA).

Results

Cohen's kappa value was 0.83, which indicated an almost perfect agreement [25]. A total of 175 teeth of 154 patients underwent endodontic microsurgery. Forty-six teeth were excluded from the study. Of these 23 teeth were excluded due to incomplete radiographic data, 13 teeth for recall time less than a year, and vertical root fractures were detected in ten teeth during a surgical procedure. Of 129 teeth, twenty-one teeth did not attend recall. The attending samples of 108 teeth represented a recall rate of 83.7% with an average recall period of 30.8 months (12–108 months).

Of 108 teeth that were assessed, healed teeth numbered 86 (79.6%), healing—20 teeth (18.5%), and diseased—2 teeth (1.9%) (Table 1). Of the two diseased teeth, one had a sinus tract opening with a deep narrow pocket at 82-month follow-up, and the recorded cause of failure was a traumatic occlusion. The other diseased tooth had no clinical signs and symptoms, but the lesion size was unchanged after the 83-month follow-up period.

Table 1 Numbers of teeth and percentages of outcomes of endodontic microsurgery.

Outcomes	No. of teeth	Percentage
Healed	86	79.6
Healing	20	18.5
Disease	2	1.9
Total	108	100%

From the pre-operative factors (Table 2) the number of male and female patients were 34 and 74, respectively. Patients' ages ranged from 15–72 years (average of 44.7 years). The numbers and types of teeth were 79 anterior teeth (73.1%), 20 premolars (18.5%) and 9 molars (8.4%) (Table 2). Most teeth were maxillary teeth (84.3%). Seventy-three teeth were treated by postgraduate endodontic students (67.6%), and 35 teeth were treated by endodontic faculty (32.4%). Ninety teeth received an initial treatment (89.1%), while 11 teeth underwent nonsurgical root canal retreatment. There were 12 instances of resurgery (11.1%), and 96 teeth (88.9%) had undergone primary apical surgery. Lesion sizes of 56 teeth (51.9%) were within a 5 mm diameter, and 52 teeth (48.1%) had lesion sizes more than 5 mm. The quality of root canal filling, 45 teeth (41.7%) was adequate, and in the case of 63 teeth (58.3%), it was inadequate. The outcomes among the adequate root canal fillings were 41 (91.1%) healed teeth and four (8.9%) diseased teeth, in the inadequate root canal filling group were 45 (71.4%) healed teeth, 16 (25.4%) healing teeth, and two (3.2%) diseased teeth. The coronal restorations of 107 teeth (99.0%) were adequate, and posts were presented in 87 teeth (80.6%).

Table 2 Univariate logistic regression for the association between pre-operative factors and endodontic microsurgery outcome using strict criteria.

Factors	Teeth		Outcome				P-value	Cruded Odd ratios (95% CI)
			Healed		Disease			
	n	(%)	n	(%)	n	(%)		
Operator								
Endodontist	35	32.4	27	77.1	8	22.9	0.66	1
Postgraduate student	73	67.6	59	80.8	14	19.2		0.86 (0.33-2.27)
Age								
≤ 45 years old	58	53.7	42	72.4	16	27.6	0.05*	2.79 (1.00-7.82)
> 45 years old	50	46.3	44	88.0	6	12.0		1
Gender								
Male	34	31.5	26	76.5	8	23.5	0.58	1.32 (0.49-3.52)
Female	74	68.5	60	81.1	14	18.9		1
Tooth type								
Anterior	79	73.1	63	79.7	16	20.3	0.54	1.44 (0.38-5.52)
Premolar	20	18.5	17	85.0	3	15.0		1
Molar	9	8.4	6	66.7	3	33.3		2.83 (0.45-18.04)
Tooth position								
Maxilla	91	84.3	75	82.4	16	17.6	0.10*	1
Mandible	17	15.7	11	64.7	6	35.3		2.56 (0.83-7.93)
Sign and symptoms								
Absence	17	15.7	17	100	0	0	N/A	N/A
Presence	91	84.3	69	75.8	22	24.2		
Mobility								
Absence	86	79.6	67	77.9	19	22.1	0.39	0.56 (0.15-2.08)
Presence	22	20.4	19	86.4	3	13.6		1

Table 2 Univariate logistic regression for the association between pre-operative factors and endodontic microsurgery outcome using strict criteria.

Factors	Teeth		Outcome				P-value	Cruded Odd ratios (95% CI)
			Healed		Disease			
	n	(%)	n	(%)	n	(%)		
Periodontal involvement								
No periodontal involvement	95	88.0	75	78.9	20	21.1	0.64	1.47 (0.30-7.16)
With periodontal involvement	13	12.0	11	84.6	2	21.4		1
Previous treatment								
Initial treatment	90	89.1	69	76.7	21	23.3	0.30	3.04 (0.37-
Retreatment	11	10.9	10	90.9	1	9.1		25.18)
								1
Previous apical surgery								
No	96	88.9	78	81.3	18	18.8	0.27	1
Yes	12	11.1	8	66.7	4	33.3		2.17 (0.59-7.99)
Lesion size								
≤ 5 mm	56	51.9	48	85.7	8	14.3	0.11*	1
> 5 mm	52	48.1	38	73.1	14	26.9		2.21 (0.84-5.82)
Characteristics of lesion								
Diffuse	17	16.2	14	82.4	3	17.6	0.72	1
Circumscribe	88	81.7	69	78.4	19	21.6		1.29 (0.33-4.94)
Quality of root canal filling								
Adequate	45	41.7	41	91.1	4	8.9	0.09*	1
Inadequate	63	58.3	45	71.4	18	28.6		2.87 (0.84-9.85)
Quality of Coronal restoration								
Adequate	107	99.0	86	80.4	21	19.6	N/A	N/A
Inadequate	1	1.0	1	100.0	0	0		
Post								
Absence	21	19.4	18	85.7	3	14.3	0.44	1
Presence	87	80.6	68	78.2	19	21.8		1.68 (0.45-6.30)

* variables considered potential prognostic factors ($P \leq 0.25$), N/A = Not applicable, disease = healing+disease

The intra-operative factors (Table 3), apicoectomy in combination with root-end filling were performed on 106 teeth (98.1%). MTA was retrofilled in 85 teeth (78.7%), and three teeth (2.7%) were orthofilled before apicoectomy, while 17 teeth (15.7%) were filled with Super EBA. Eighty teeth (74.1%) had an adequate quality of root-end filling. Six teeth (5.6%) absent of labial cortical bone. Five (4.3%) of these teeth were applied with guided tissue regeneration membrane and bone graft in the surgical procedure.

From the post-operative factors (Table 4), coronal restorations of 105 (97.2%) teeth were permanent, the other three teeth (2.8%) had temporary restoration. The quality of coronal restoration in 107 teeth (99.1%) was adequate, and only one tooth was found to be inadequately restored.

Table 3 Univariate logistic regression for the association between intra-operative factors and endodontic microsurgery outcome using strict criteria.

Factors	Teeth		Outcome				P-value	Cruded Odd ratios (95% CI)
			Healed		Disease			
	n	(%)	n	(%)	n	(%)		
Procedure								
Apicoectomy	2	1.9	1	50.0	1	50.0	N/A	N/A
Apicoectomy and root end filling	106	98.1	85	80.2	21	19.8		
Root end filling materials								
MTA	88	81.5	70	79.5	18	20.5	0.79	1.20 (0.31-4.63)
Super EBA	17	15.7	14	82.4	3	17.6		1
Quality of root end filling								
Adequate	80	74.1	66	82.5	14	17.5	0.22*	1
Inadequate	28	25.9	20	71.4	8	28.6		1.89 (0.69-5.14)
Cortical bone plate								
Absence	6	5.6	4	66.7	2	33.3	0.43	2.05 (0.35-11.99)
Presence	102	94.4	82	80.4	20	19.6		1
Bone graft and membrane								
Yes	5	4.6	4	80.0	1	20.0	N/A	N/A
No	103	95.4	82	79.6	21	20.4		

* variables considered potential prognostic factors ($P \leq 0.25$), N/A = Not applicable, disease = healing+disease

Table 4 Univariate logistic regression for the association between post-operative factors and endodontic microsurgery outcome using strict criteria.

Factors	Teeth		Outcome				P-value	Cruded Odd ratios (95% CI)
			Healed		Disease			
	n	(%)	n	(%)	n	(%)		
Type of restoration								
Permanent	105	97.2	86	81.9	19	18.1	N/A	N/A
Temporary	3	2.8	0	0	3	100.0		
Quality of coronal restoration								
Adequate	107	99.1	85	79.4	22	20.6	N/A	N/A
Inadequate	1	0.9	1	100.0	0	0		

N/A = Not applicable, disease = healing+disease

The collected data were subjected to univariate analysis. Age, tooth position, lesion size, quality of the root canal filling, root-end filling, and absence of labial cortical bone ($P \leq 0.25$) were identified as significant factors affecting on treatment outcome (Table 2, 3).

In multivariate analysis, the only significant factor was the quality of pre-operative root canal filling. The adjusted odds ratio for the presence of periapical disease after surgery in teeth with inadequate quality of root canal filling were 6.32 times higher than those of adequate root canal filling (P =0.01; adjusted OR=6.32) (Table 5).

Table 5 Multivariate logistic regression for the association between factors and endodontic microsurgery outcome.

Factors	Teeth	P-value	Adjusted odd ratios	95% CI
Age				
≤ 45 years old	58	0.33	1.74	0.57-5.31
> 45 years old	50		1	
Tooth position				
Maxilla	91	0.13	1	
Mandible	17		2.96	0.73-11.96
Lesion size				
≤ 5 mm	56	0.09	1	
> 5 mm	52		2.50	0.86-7.30
Quality of root canal filling				
Adequate	45	0.01*	1	
Inadequate	63		6.32	1.61-24.81
Quality of root end filling				
Adequate	80	0.47	1	
Inadequate	28		1.56	0.46-5.29

* statistically significant ($P \leq 0.05$)

Discussion

The recall rate of this retrospective study was 83.7%, which is considered as a high level of evidence [17]. The Image J Software and TurboReg plugin software used for radiographic evaluation that proved to be more reliable and accurate than subjective evaluation.

The outcomes of this study were 79.6% healed, 15.5% healing and 1.9% diseased. The combined rate of the healed and healing teeth amounted to a success rate of 98.1% was higher than the success rate found in other previous studies (78.5–94.3%) [9-15]. This variation in success rate is attributed to the patient selection, follow-up periods, healing evaluation criteria, the treatment protocols, and the experience of the surgeons. The strict criteria were set, complete healing alone counted as a successful outcome and was not subjected to further observation [17]. The teeth that were found to be incompletely healed needed further investigation to be classified as healed or diseased. Under strict evaluation criteria, the healed rate in this study was 79.6% [12] and was higher than that of 73.1% in the previous study at Mahidol [8]. The result matched with other studies, which ranged from 71.0 to 80.0% [9,10,26]. This study collected only the microsurgery cases, while the former study [5,8] combined the results of traditional surgery and microsurgery.

The assessment criteria of Rud et al. [18] and Molven et al. [19] were classified healing into four categories, complete, incomplete, uncertain, and unsatisfactory healing which several studies [8,10,12] were used. The category of 'incomplete healing' was often misused to describe reduced lesions rather than the typical scar. To promote effective communication within operators and with patients, the outcome of apical surgery was related to healing. Besides, the criterion of Rud et al. [18] and Molven et al. [19] were also meant to

healing, but were referred to represent 'success' and 'failure' [17]. To clearly describe the outcome, Friedman [17] proposed terms; 'healed', 'healing' and 'disease' for periapical evaluation, which was used in this study.

Evaluation time for this study was at least one year after surgery because one-year follow-up was long-enough to predict long-term outcome [17,19,20]. Friedman's criteria [17], define the term "healing" a reduced size of radiolucency in combination with clinical normalcy within a follow-up period shorter than four years. There were 20 healing teeth (18.5%) in this study with an average recall period of 19.6 months. If a longer follow-up period were to be chosen, the healing teeth would tend to shift to "healed" teeth and result in a higher success rate.

After multivariate logistic regression analysis, the pre-operative quality of root canal filling was the only significant factor that affected the healed rate. The adjusted OR (6.32) indicated that the proneness of teeth with an inadequate root canal filling to disease six times higher than teeth with adequate root canal filling. The result agreed with the study of Zhou et al. [12]. The tooth with inadequate root canal filling, that root canal filling was shorter than 2 mm / with voids or overextended, might still contain significant residual infection, and orthograde retreatment in combination with surgery might be needed. If orthograde retreatment is not practicable, the apical approach to clean and disinfection apical root should be archeived as much as possible [21, 27].

The healed rate in patients older than 45 years were 86.3%, and among the younger patients, it was 72.4%. There was no significant difference among the ages, and this was consistent with several studies[6,16,20,21]. However, Barone et al. [7] showed that patients older than 45 years showed a significantly better outcome than younger patients. Among the types of teeth, molar teeth tended to have a lower success rate than others because of the inconvenience of accessibility, complex root anatomy, and difficult operative procedure[12,16]. Tooth type in this study was not a significant factor because molars were few as compared with the anterior and premolar teeth.

The pre-operative radiographic lesions size up to 5 mm, and more than 5 mm were not significantly different. Healed rate of small lesions tended to be higher than the large lesions [6,16]. The small lesions can be totally eliminated to enhance the healing of surrounding bone. In contrast, a large lesion might not be wholly healed and may need longer time to heal and often appear as scar tissue healing, which was difficult to interpret in the radiographs [16,17].

Regarding retrograde materials, some studies reported that the healed rate of MTA was higher than Super EBA [28]. *In vitro* studies showed that Super EBA had inferior biocompatibility than MTA, due to eugenol component, which had a cytotoxic effect on human osteoblasts and inhibited cell proliferation [29–31]. However, clinical studies have shown the success of both MTA and Super EBA to be similar [8,11,32]. This finding was consistent with our study that the healed rates of MTA and Super EBA were not significantly different. Disregarding of root-end filling materials, depth and density of retrograde filling must be of greater concern for the successful treatment outcome.

Gagliani et al. [33], and von Arx et al. [16] reported lower resurgery success because resurgery was performed in the negative cases in which surgery had failed previously and may have different etiologies that delay the healing [16]. However, the healed rate of primary surgery (80.4%) in this study was not significantly higher than that of resurgery (66.7%), probably because fewer resurgery cases featured in this study.

When teeth lacked cortical bone plate, the formation of a junctional epithelium on the denuded root surface caused the communication between periapical tissue and the oral environment and affected the surgical outcome [8,34]. Pecora

et al. [35] and Kim et al. [36] demonstrated that bone grafting technique improved the clinical outcome in such cases. Absence of cortical bone in this study was not a significant factor because membrane and bone graft were applied in the case of five teeth, which resulted in four teeth healed and one tooth healing.

The limitations of this study were, the small sample size for statistical analysis, paucity of information on some variables such as pre-operative signs and symptoms, pre- and post-operative quality of coronal restoration, type of restoration, endodontic microsurgery procedure. The number of cases with bone graft application were too small. There is a need for better dental information records, and radiographs collection for more accurate and powerful of statistical analysis.

Conclusion

The outcomes of the study were 79.6% healed, 18.5% healing, and 1.9% diseased. Pre-operative inadequate quality of root canal filling was the only significant factor that decreased the healed rate of this study.

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