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Original Article

The outcome of endodontic treatment performed by dental students: A retrospective study

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Abstract

Background/Objectives: The objectives of this study were to evaluate the success and failure rates as well as factors influencing the outcome of initial endodontic treatment performed by dental students at the Faculty of Dentistry, Naresuan University, Thailand, from 2010 to 2015.

Materials and Methods: Data from the treatment records, clinical signs and symptoms, and radiographic records of 213 endodontically treated anterior teeth and premolar were collected and evaluated. Digital periapical radiographs obtained at pre-operation and the last follow-up period were interpreted independently by two examiners via Periapical index (PAI) score. Treatment outcome was evaluated as success or failure based on clinical signs and symptoms as well as radiographic criteria. Factors influencing the treatment outcome were analyzed using Chi-square test and logistic regression model.

Results: The results showed that the recall rate was 36.3%, ranging from 6 to 64 months, with a mean of 18 months. The overall success rate was 72.8%, the failure rate was 27.2%, and the functional rate was 96.2%. The multivariate analysis identified 2 significant ($p \leq 0.05$) influencing factors: the presence of pre-operative periapical lesion size ≥ 5 mm and the recall period at 24-35 months, with odds ratio of 0.21 and 3.18, respectively.

Conclusions: The overall endodontic success rate was 72.8%, and failure rate was 27.2%. The success of treatment was significantly influenced by the presence of pre-operative periapical lesion and the recall period.

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Keywords: Endodontically treated teeth, failure rate, outcome, root canal treatment, success rate

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Introduction

The main goals of root canal therapy are to maintain the health of the periradicular tissue or treat periapical disease, and to retain the function of the treated tooth. The therapy procedures include cleansing, and disinfecting, followed by filling of the root canal systems (Ng et al., 2008).

Numerous studies on the outcome of endodontic treatment have been published and reported the success rates of root canal treatment range from 73 to 95% (Friedman et al., 2003, Ng et al., 2011a, Ng et al., 2011b, Pirani et al., 2015, Laukkanen et al., 2019). A systematic review showed the weighted pooled success rate of initial root canal treatment based on strict criteria ranges from 68% to 85% (Ng et al., 2007). Therefore, the varied success rate depended on the different study characteristic and criteria used. Many factors that influence the outcome of treatment have been reported, such as, the presence of preoperative periapical lesion, the occurrence of procedural error, apical extent of root canal filling, recall period, and the quality of coronal restoration (Friedman, 2002, Friedman et al., 2003, Yanpiset et al., 2006, Ng et al., 2008). The data related to the treatment outcomes have benefits for clinical decision making, treatment planning, and also informing the patients about the prognosis of the affected tooth (Friedman, 2002, Friedman et al., 2003).

In Thailand, there are few studies on long-term evaluation of the outcome of endodontic treatment performed by dental students. Previous studies used different clinical and radiographic criteria to determine success with varied recall periods. They reported the overall success rate of initial endodontic treatment ranging from 61% to 81% (Pholbungkerd, 1999, Yanpiset et al., 2006, Samaksamarn et al., 2014). A retrospective study evaluating the success and failure rate of endodontic treatments in anterior teeth performed by undergraduate dental students at Chiangmai University, showed the success, uncertain, and failure rate were 81.6%, 6.4%, and 12.1%, respectively. This study also reported that coronal leakage due to an inadequate temporary filling influenced the outcome of root canal treatment (Pholbungkerd, 1999).

Yanpiset *et al.* (Yanpiset et al., 2006) evaluated the clinical signs and symptoms, and the radiographic records of 379 endodontically treated teeth performed by undergraduate and graduate dental students at Mahidol University. This retrospective study showed that the recall rate was 41.6%, ranging from 6 months to 8 years with a mean of 2 years 9 months. The overall success rate was 61.0%, whereas the uncertain and failure rate was 28.0% and 11.0%, respectively. They reported that the presence of a preoperative periapical lesion, short apical extent of root canal fillings, complications occurring during the treatment period, and poor quality of coronal restorations had negative effects on the treatment outcomes (Yanpiset et al., 2006).

Another retrospective study, Samaksamarn *et al.* (Samaksamarn et al., 2014) recalled patients that had previously received endodontic treatment at Khon Kaen University, from 12 months up to 95 months after the completion of treatment, with the mean recall period of 33.10 months. Based on the Gutmann's criteria, they showed that the overall success and failure rates were 80.7% and 19.3%, respectively. The quality of root canal fillings and coronal restorations and the different recall periods significantly influenced treatment outcomes (Samaksamarn et al., 2014).

However, the outcome of endodontic treatment performed by undergraduate dental students at the Faculty of Dentistry, Naresuan University have never been evaluated. The aims of this study were to evaluate the success, failure rates, and the factors influencing the treatment outcomes of initial endodontic treatments that were performed by undergraduate dental students at the Faculty of Dentistry, Naresuan University, from May 2010 to April 2015.

Materials and methods

This retrospective study obtained ethical approval from the Human Research Ethics Committee of Naresuan University (No. 0252/61).

All patients that had endodontic treatment performed on their anterior or premolar teeth by undergraduate dental students from May 2010 to April 2015 at the Endodontic Clinic, Faculty of Dentistry, Naresuan University, Phitsanulok, Thailand, who returned for examination, were selected for this study. A total of 600 teeth received conventional root canal treatment with complete records, including pre and post-operative, and follow-up digital periapical radiographs. Of the 600 teeth, 218 teeth were available for re-examination after at least 6 months of completed treatment to evaluate the endodontic outcomes.

All endodontic treatments were performed by undergraduate dental students under the supervision of experienced endodontists. All cases were treated with aseptic techniques under rubber dam application. After access cavity preparation, the working length was established at 0.5 millimeters (mm) from the radiographic apex. Root canals were cleaned and shaped with a step-back technique using stainless steel K-files and frequently irrigated with 2.5% sodium hypochlorite (NaOCl), then calcium hydroxide was used as an intracanal medicament. When the teeth had normal clinical signs and symptoms, the root canals were obturated after irrigation with 2.5% NaOCl, 17% ethylenediaminetetraacetic acid (EDTA) solution, and 2.5% NaOCl. All root canals were filled with gutta-percha and zinc oxide eugenol-based sealer by the lateral condensation technique. Finally, the teeth were either restored with direct composite filling or indirect restoration; post and core with crowns.

In case of procedural error occurred such as perforation, separated instrument, root canal blockage or transportation, these cases were also included in this study. The perforation defect located at coronal third or middle third of root was repaired under a dental operating microscope by experienced endodontists, using either glass ionomer cement (GIC) or Mineral Trioxide Aggregated (MTA). However, the root canal was filled with either gutta percha or MTA in case of the apical perforation occurred, depending on the apical size.

After treatment completion at least 6 months, the students who were assigned for the recall contacted the patients initially by telephone. The letters were then sent to patients who did not respond to the telephone calls. In case of the patient could not be reached by the letter, there was no additional attempt to approach the patient.

During the follow-up visit, patients were re-examined by undergraduate students who were not the treatment operators. The examinations consisted of history taking, clinical and radiographic examinations. Pain, swelling, palpation, percussion, tooth mobility, periodontal status, and type quality of coronal restoration were recorded on endodontic charts. Periapical radiographs were taken using the paralleling-technique with the aid of a positioning device (RINN XCP®, Dentsply-RINN, PA, USA). In case of any treated teeth had been extracted or patients did not attend the follow-up, this information was recorded on their dental charts.

The following information and treatment records: age of patient, gender, tooth location, tooth type, pulp status, occurrence of complications during treatment, apical extent of root canal filling, recall period, type and quality of coronal restoration, and the presence of any clinical findings were obtained from endodontic charts. The apical extent of root canal filling was classified into 3 categories: 1) adequate: reaching within 2 mm of the radiographic apex, 2) short: more than 2 mm short of the radiographic apex, and 3) long: excess beyond the radiographic apex (Ng et al., 2008).

The types of coronal restoration were classified as intermediate or final restoration. According to the quality of coronal restoration, teeth were categorized as follows: (a) satisfactory restoration: absence of clinical and radiographic evidence of marginal discrepancy, discoloration or recurrent caries at the restoration margin with no history of decementation; and (b) unsatisfactory restoration: fracture or loss of restoration, presence of clinical and radiographic evidence of marginal discrepancy, discoloration or recurrent caries at the restoration margin with history of decementation (Hoskinson et al., 2002).

Data regarding the pre-operative and follow-up periapical status were obtained from radiographic interpretations. Before the beginning of radiographic interpretation, three examiners were calibrated for using periapical index (PAI) score. The intra-examiner and inter-examiner reliability were evaluated using Cohen kappa statistics. All pre-operative and the final follow-up radiographs were interpreted independently by two examiners. The widest diameter of pre-operative radiolucency was recorded in millimeters. Periapical status was defined by PAI score, and then classified as absence/healed (PAI < 3) or presence/disease (PAI ≥ 3) of apical periodontitis (Ørstavik et al., 1986, Friedman et al., 2003). Multirooted teeth were given one score, which is the highest for any of them. In case of disagreement, two examiners conferred to get a conclusion. If the two examiners still disagreed on any case, the opinion of a third examiner would be taken as the final decision.

Treatment outcome was evaluated as success or failure based on both clinical and radiographic findings. The success of treatment was considered when the teeth had no pain or tenderness to palpation and percussion with no evidence of sinus tract and soft tissue swelling as well as normal tooth mobility. The radiographic findings showed that the absence of, or a healed periapical lesion (PAI ≤ 2) was considered a success. The treatment outcome was judged as failure with a PAI score of ≥ 3, or if there were clinical signs or symptoms of pain, swelling, sinus tract, tooth mobility, and extraction. Moreover, the teeth were recorded as "functional" when the absence of any signs or symptoms was noted, regardless of the PAI score.

The various factors that may influence the treatment outcome were also analyzed including the age of the patients, gender, tooth location, tooth type, pulp status, pre-operative periapical status, occurrence of complications during treatment, apical extent of root canal filling, recall period, type of restoration, and quality of coronal restoration.

The data was coded and converted into Microsoft Excel format, then analyzed using the statistical package version 23.0 (SPSS). All statistical tests were performed as two-tailed and interpreted at a 5% significance level. The univariate description of the data was performed using percentage frequencies. The bivariate associations between the factors and treatment outcome (success or failure) were tested using the Chi-square test. The logistic regression model was used for multivariate analysis to evaluate associations among various factors.

Results

According to radiographic interpretation, the results of the intra-examiner agreement of the three examiners were 0.857, 0.783, and 0.857, respectively. Inter-examiner agreement of examiner 1 and 2, 1 and 3, 2 and 3 were 0.737, 0.733, and 0.737, respectively. These Kappa scores indicated substantial agreement.

Of the 600 treated teeth, 382 teeth were excluded as patients declined to follow-up. Of the responding samples, comprising of the 218 remaining teeth, 5 dropped out due to incomplete treatment records or an incomplete set of digital radiographs. Two hundred and thirteen teeth were subjected to statistical analysis.

The analyzed samples were characterized according to general and pre-operative, intra- and post-operative, and follow-up variables in Table 1.

In this study, the recall rate was 36.33%, and the mean of the recall periods was 18.45 months, ranged from 6 to 64 months. The mean age of the patients was 38.43 years, ranging from 14 to 76 years. At the follow-up visit, there were 205 teeth with normal clinical signs and symptoms (96.2%), 2 extracted teeth (0.9%), and 6 with clinical signs or symptoms of failure (2.8%), including 3 with sinus tract, 1 with pain, 1 tenderness to palpation, and 1 grade 3 tooth mobility. From the data of this study, the overall success rate of 213 teeth was 72.8% (155 teeth), whereas the failure rate was 27.2% (58 teeth). Of the 213 treated teeth, 205 teeth had normal clinical signs and symptoms, regardless of the radiographic findings, and the functional rate of treated teeth was 96.2%.

During treatment periods, 19 teeth had the following complications: 17 root perforations (4 at the coronal, and 12 at the apical), 1 ledge, and 1 transportation. The success rate in teeth with complications was 68.4%, and without complications, the success rate was 73.2%.

The bivariate analysis (Table 1) revealed significant associations between the treatment outcome and two variables: pulp status (p=0.020) and pre-operative periapical status (p=0.000). The factors that did not affect the treatment outcome were age (p=0.532), gender (p=0.268), tooth location (p=0.190), tooth type (p=0.136), the occurrence of complications (p=0.655), apical extent of root filling (p=0.896), recall period (p=0.202), types of restoration (p=0.570), and quality of restoration (p=0.821). According to the pulp status, there were 151 teeth (70.9%) with nonvital pulp, and 62 (29.1%) with vital pulp, and the success rate was 68.2%, and 83.9%, respectively. The success rate according to the periapical status were 85.0% in teeth without pre-operative periapical lesion, 76.4% in teeth with pre-operative periapical lesion size less than 5 mm (< 5 mm), and 57.7% in teeth with pre-operative periapical lesion size greater than or equal to 5 mm (≥ 5 mm), as shown in Table 1.

The confounding factors that may have affected the results were eliminated by using the multiple logistic regression analysis. The particular factors and magnitude of their effects on success, presented by adjusted odds ratios (OR) as shown in Table 2. The logistic regression analysis identified two factors that significantly influenced the outcome of treatment were the presence of pre-operative periapical lesion size ≥ 5 mm and the recall period at 24-35 months, with odds ratio of 0.21 and 3.18, respectively. The probability of success in teeth with pre-operative periapical lesion (≥ 5 mm) was 0.21 that of teeth with no lesion (p=0.000), and probability of success in teeth that recalled at 24-35 months was 3.18 that of teeth recalled less than 12 months (p=0.041).

Table 1 Frequency distribution of data and successful outcome by tooth

Factor		Total		Success (healed)		
		n	%	n	%	p-value[a]
General and pre-operative						
Age	< 60	186	87.3	134	72.0	0.532
	≥ 60	27	12.7	21	77.8	
Gender	Female	116	54.5	88	75.9	0.268
	Male	97	45.5	67	69.1	
Tooth location	Maxilla	159	74.6	112	70.4	0.190
	Mandible	54	25.4	43	79.6	
Tooth type	Anterior	145	68.1	101	69.7	0.136
	Premolar	68	32.9	54	79.4	
Pulp status	Vital	62	29.1	52	83.9	0.020*
	Nonvital	151	70.9	103	68.2	
Pre-operative periapical status	No lesion	80	37.6	68	85.0	0.000*
	< 5 mm	55	25.8	42	76.4	
	≥ 5 mm	78	36.6	45	57.7	
Intra-, and post-operative						
Complications	Absence	194	91.1	142	73.2	0.655
	Presence	19	8.9	13	68.4	
Apical extent of root filling	Adequate	190	89.2	138	72.6	0.896
	Short	0	0	0	0	
	Long	23	10.8	17	73.9	
Follow-up						
Recall period	6-11 months	71	33.3	49	69.0	0.202
	12-23 months	84	39.4	58	69.0	
	24-35 months	34	16.0	29	85.3	
	36-47 months	16	7.5	14	87.5	
	≥ 48 months	8	3.8	5	62.5	
Type of restoration	Intermediate	65	30.5	49	75.4	0.570
	Final	148	69.5	106	71.6	
Quality of restoration	Satisfactory	189	88.7	138	73.0	0.821
	Unsatisfactory	24	11.3	17	70.8	
Clinical findings	Absent	205	96.2			
	Present	6	2.8			
	Extracted	2	0.9			

[a]Chi-square tests

* Indicates a statistical significance ($p<0.05$)

Table 2 The results of multivariate analysis of the particular factors effecting on the treatment outcome (N=213)

Factors (n)	Success (N=155)		Failure (N=58)		Cruded OR [95% CI]	p-value of cruded OR	Adjusted OR [95% CI]	p-value of Adjusted OR
	n	%	n	%				
Pulp status								
Vital (62)	52	33.5	10	17.2	ref		ref	
Nonvital (151)	103	66.5	48	82.8	0.41 [0.19-0.88]	0.020*	0.90 [0.35-2.34]	0.826
Pre-operative periapical lesion								
No lesion (80)	68	43.9	12	20.7	ref		ref	
< 5 mm (55)	42	27.1	13	22.4	0.57 [0.24-1.37]	0.208	0.53 [0.22-1.28]	0.158
≥ 5 mm (78)	45	29.0	33	56.9	0.24 [0.11-0.52]	0.000*	0.21 [0.10-0.46]	0.000*
Complication								
Absence (194)	142	91.6	52	89.7	ref		ref	
Presence (19)	13	8.4	6	10.3	0.79 [0.29-2.20]	0.656	0.93 [0.31-2.79]	0.898
Apical extent of root canal filling								
Adequate (190)	138	89.0	52	89.7	ref		ref	
Long (23)	17	11.0	6	10.3	1.07 [0.40-2.86]	0.896	1.28 [0.44-3.78]	0.653
Recall period								
6-11 months (71)	49	31.6	22	37.9	ref		ref	
12-23 months (84)	58	37.4	26	44.8	1.00 [0.51-1.98]	0.996	0.92 [0.45-1.89]	0.819
24-35 months (34)	29	18.7	5	8.6	2.60 [0.90-7.62]	0.081	3.18 [1.05-9.67]	0.041*
36-47 months (16)	14	9.0	2	3.5	3.14 [0.66-15.03]	0.151	3.32 [0.66-16.66]	0.144
≥ 48 months (8)	5	3.2	3	5.2	0.75 [0.16-3.41]	0.708	0.72 [0.15-3.58]	0.691
Type of restoration								
Final (148)	106	68.4	42	72.4	ref		ref	
Intermediate (65)	49	31.6	16	27.6	1.21 [0.62-2.37]	0.570	1.08 [0.47-2.46]	0.862
Quality of restoration								
Satisfactory (189)	138	89.0	51	87.9	ref		ref	
Unsatisfactory (24)	17	11.0	7	12.1	0.90 [0.35-2.29]	0.821	0.77 [0.28-2.14]	0.621

*Indicates a statistical significance ($p < 0.05$)

OR = Odds ratio

CI = Confidence interval

Discussion

Many studies reported that there are always disagreements when the same radiograph is interpreted by different examiners (Goldman et al., 1972, Reit and Hollender, 1983). In this study, we controlled this factor by calibrating the 3 examiners before the beginning of the study, therefore, the inter-examiner agreement averaged 0.73, which indicated substantial agreement.

This was a retrospective study based on data collection and analysis from chart records and digital radiographs of teeth. Previous studies reported the recall rates varied from 20 to 100% (Murphy et al., 1991, Selden, 1999, Chugal et al., 2001, Chugal et al., 2003). The recall rate in Thai dental schools ranged from 21 to 41% (Yanpiset et al., 2006, Samaksamarn et al., 2014). In this study, the recall rate was 36.33%. Most of the dental patient population in Naresuan University were transient. Therefore, relocation was one of the major reasons of the low recall rate. In addition to the relocation, the reasons that patients were not available for follow-up in this study were nonresponding (patients can be contacted but declined for recall because of inconvenient time or travel) and unreachable (patients cannot be contacted). Due to lack of control variables, some cases with either incomplete treatment records, and or incomplete sets of radiographs from unknown errors, were also excluded from the study, which further decreased the sample size.

Strict clinical and radiographic criteria were used in this study for dichotomous outcomes either as "success" or "failure", with a success rate of 72.8%. The radiographic criteria for success included the PAI score of 1 or 2 which showed an absence of or healed periapical lesion. However, if only the clinical criteria were used, 96.2% of the teeth were asymptomatic and considered to be functional. These results agreed with previous studies that reported the healed rate was 74% - 78% (Weiger et al., 2000, Peters and Wesselink, 2002, Friedman et al., 2003, Samaksamarn et al., 2014), and the functional rate was 94% - 97% (Weiger et al., 2000, Peters and Wesselink, 2002, Friedman et al., 2003).

Among the 58 teeth classified as failure, most of teeth presented radiographic failures according to the strict criteria used as discussed above. Six teeth (2.8%) showed clinical signs or symptoms at the follow-up: 3 had sinus tract, 1 had pain, 1 had tenderness to palpation, and 1 had grade 3 mobility. Two extracted teeth were noted in the treatment records that fractures were the reason of extraction before placement of permanent restorations. The possible explanation of the clinical failure of endodontically treated teeth could be either prosthetic, periodontal, or endodontic origins (Vire, 1991). The prosthetic origin was related to the failure of restoration or ability to further restore the tooth. The largest group of prosthetic failures were deemed unrestorable due to the locations of the fractures. The second reason was the periodontal origin, which showed extensive bone loss. These teeth with severe mobility were considered unable to bear a prosthetic load. The third reason was endodontic origin, which included vertical root fractures, root resorption, and instrumentation error. Therefore, the failure teeth in this study might be associated with either prosthetic, periodontal, or endodontic origins.

Numerous studies demonstrated that many factors influenced treatment outcomes, including the presence of preoperative periapical lesion (Friedman et al., 2003, Stoll et al., 2005, Ng et al., 2010, Polyzos et al., 2018), the occurrence of procedural error (Kerekes and Tronstad, 1979, Marquis et al., 2006, de Chevigny et al., 2008), apical extent of root canal filling (Yanpiset et al., 2006, Pirani et al., 2015, Polyzos et al., 2018), recall period (Ørstavik, 1996, Samaksamarn et al., 2014), and the quality of coronal restoration (Ray and Trope, 1995, Tronstad et al., 2000, Gillen et al., 2011, Craveiro et al., 2015).

In bivariate analysis, the two factors significantly associated with treatment outcomes were pulp status, and pre-operative periapical status. According to pulp status, there were statistically significant differences of success between teeth with vital pulp and nonvital pulp ($p = 0.020$). Similarly, Hoskinson *et al.* reported that the outcome was better in teeth with vital than those with necrotic pulp (Hoskinson et al., 2002). In teeth with necrotic pulp, there are more infections and a greater risk of bacteria remaining after treatment, that may cause persistent periapical inflammation (Smith et al., 1993). Whilst the bivariate analysis showed significant association of pulp status with the outcome, the multivariate analysis did not identify any significant predictor of success, possibly because of the low number of vital pulps.

Large numbers of studies demonstrated that the success rate of root canal treatment was significantly influenced by the presence or absence of pre-operative periapical lesion. Teeth with periapical lesion had lower success rate than those without lesion (Sjögren et al., 1990, Chugal et al., 2001, Hoskinson et al., 2002, Dammaschke et al., 2003, Friedman et al., 2003, Stoll et al., 2005, Ng et al., 2008, Ng et al., 2010, Polyzos et al., 2018). In this study, 133 teeth (62.4%) with pre-operative periapical lesion and 80 teeth (37.6%) without lesion revealed the success rate of 65.4% and 85%, respectively. This large proportion of teeth with pre-operative periapical lesion may lower the overall success rate, which also reported in several reports (Friedman et al., 2003, Farzaneh et al., 2004, de Chevigny et al., 2008). Moreover, the multivariate analysis in our study also confirmed the presence of pre-operative periapical lesion as the predictor of outcome in initial endodontic treatment.

The size of periapical lesions also influenced the treatment outcomes. In this study, the success rate of 76.4% for teeth with periapical lesion size less than 5 mm, was significantly higher than larger periapical lesions (57.7%), as shown in many studies (Matsumoto et al., 1987, Hoskinson et al., 2002, Ng et al., 2008). In addition, a systematic review pooled the data of lesion size, showed that teeth with small periapical lesion (< 5 mm) had a higher success rate than those with large lesion (≥ 5 mm) (Ng et al., 2008). In consistent with our multivariate analysis, which also identified the presence of pre-operative periapical lesion size greater than or equal to 5 mm significantly influenced the outcome of treatment, with odds ratio of 0.21. These results can be explained by larger lesions required a longer duration to heal than the smaller lesions (Selden, 1974, Sjögren et al., 1990).

Samaksamarn *et al.* reported the different follow-up periods that had an influence on treatment outcome (Samaksamarn et al., 2014), which was consistent with our study shown by the logistic regression analysis. Murphy *et al.* stated the importance of the length of follow-up. When recall at least 12 months after treatment, 70.6% of the lesions showed complete healing, while only 17.6% showed complete healing at the recall 6 months or less (Murphy et al., 1991). In this study, the success rate at the 6-11 months recall was the same as the 12-23 months recall (69.0%) but increased at the 24-35 months recall (85%). This could be explained by the high proportion of teeth with pre-operative periapical lesion in all recall period groups. The presence of the periapical lesion is required the longer duration for the complete healing, which may result the higher success rate in the long recall period. Therefore, our results emphasized that a short recall period less than 1 year might not be enough to evaluate the outcome of treatment in teeth with periapical lesions (Wu et al., 2011). However, we included the 6 months recall period, which was the routine of the dental student recall. This recall period is the initial follow-up to examine the clinical signs and symptoms, and the restoration after the endodontic treatment.

In this study, 72.7% of the patients came back for recall at 6-11 months (33.3%) and 12-23 months (39.4%). Most of the patients in this study were transient, therefore they might be interested in follow-up only a certain period because of inconvenient time or travel. These results emphasized the importance of the long-term follow-up to determine the healing process, especially in teeth with periapical lesion. Moreover, the dental students should encourage the patients to attend follow-up after endodontic treatment to assess the outcome, even if they are asymptomatic.

At more than 48 months, only 8 teeth were recalled, 5 teeth classified as success and 3 teeth classified as failure. Of 3 failure teeth, 1 with large pre-operative periapical lesion had reduction in lesion size. This failure depended on the strict definition of success, while the lenient criteria were classified as healing. The other 2 failure teeth had extruded root canal filling with new periapical lesion. Teeth with under/over root canal filling had a significantly lower success rate than teeth with satisfactory root canal filling (Pirani et al., 2015, Polyzos et al., 2018).

The apical extent of root canal filling had been reported as a prognostic factor of endodontic treatment outcome (Sjögren et al., 1990, Ørstavik and Horsted-Bindslev, 1993, Smith et al., 1993, Yanpiset et al., 2006), contradicting to this study. Only 11% (n=23) of teeth were over filled with 73.9% success rate and 89% (n=190) of teeth were filled within 2 mm of the apex with success rate 72.6%. Therefore, the small sample size of the under/over filled root canal (n=0 and 23, respectively) might affect the statistical power. The endodontic treatment performed by dental students was closely supervised by the experienced endodontists, which contributed to the adequate root canal filling (89.2%) and the absence of complication (91.1%) in most of the cases.

The procedural error is also an important factor influencing outcome of treatment (Kerekes and Tronstad, 1979, Marquis et al., 2006, de Chevigny et al., 2008). Our study showed the success rate in teeth with and without complications was 68.4% and 73.2%, respectively, which were not statistically significant. This insignificance due to the small number of teeth with complication (n=19, 8.9%).

Of the 19 teeth with complications, 1 had ledge, 1 had transportation, and 17 had perforations; 5 with coronal perforation and 12 with apical perforation. Teeth with ledge and transportation were filled root canal with gutta percha. Twelve teeth that had apical perforation due to over-instrumentation with apical size ≤ MAF #80 were filled with gutta-percha. However, the recent study suggested that the other sealing materials, such as MTA, should be used instead of gutta percha when the apex size exceeds 60 (Silvestrin et al., 2016). Of 5 teeth with coronal perforation, 4 were repaired using GIC, and 1 using MTA.

In those with complication, the treatment outcome was successful in 13 teeth (68.4%), and failure in 6 teeth (31.6%). Of 6 teeth with failure, 2 were coronal perforation using GIC as a repaired material, and 4 were apical perforation using gutta percha as a root canal filling material.

Among 6 teeth classified as failure, 1 coronal perforation and 2 apical perforation showed reduction in size of existing periapical lesion. The recall period of these 3 teeth was 7-27 months, which is too short to judge a tooth as 'failure' (Ørstavik, 1996, Ørstavik et al., 2004). One coronal perforation repaired with GIC had a sinus tract at the 17 months follow-up. The prognosis of perforation depends on the location and size of the perforation, time lapse between the occurrence of the perforation and repair (Tsesis and Fuss, 2006), as well as the repair materials (Main et al., 2004, Marquis et al., 2006, de Chevigny et al., 2008). GIC have been reported the biocompatibility

and the sealing ability comparable with MTA (Tselnik et al., 2004, Kakani et al., 2015). However, MTA, as a repair material showed more success rate than GIC (Marquis et al., 2006, de Chevigny et al., 2008). Considering the location of the perforation in this case, a perforation in the cervical third of the root had poor prognosis because of the possibility of bacterial contamination from the oral environment along the gingival sulcus (Main et al., 2004, Tsesis and Fuss, 2006). Another failed tooth with apical perforation showed a new rarefied area around the extruded sealer. Overfilling may impair the prognosis of treatment as a result of a foreign body reaction, cytotoxicity of root filling material, and or possibly related to a deficient apical seal (Ricucci et al., 2016). The last failed tooth with apical perforation had clinical symptom. At 6 months recall, the intermediate restoration fully dislodged, which may lead to the recontamination.

Quality of coronal restoration is also determining factor affecting the outcome, which positively correlated with the prognosis of endodontic treatment (Ray and Trope, 1995, Tronstad et al., 2000, Gillen et al., 2011, Craveiro et al., 2015). However, this study was unable to demonstrate an association between the quality of coronal restoration and treatment outcome, which could be attributed to the small proportion (10.4%) of unsatisfactory restorations. Similarly, the types of coronal restoration were not significantly associated with treatment outcomes in this study. However, many studies (Vire, 1991, Stavropoulou and Koidis, 2007, Ng et al., 2010) suggested that teeth with crowns had greater longevity than ones without. It is important to note that the type and quality of coronal restorations can affect the survival rate of endodontically treated teeth (Abitbol, 2001, Stavropoulou and Koidis, 2007, Ng et al., 2008, Ng et al., 2010, Gillen et al., 2011).

This study was limited by its retrospective nature, relatively small sample size and lack of control over variables. The results are potentially clinically useful for patient information, clinician consideration, and prognosis assessment. Importantly, an understanding of influencing factors helps the clinicians as well as patients decide the appropriate treatment procedures, especially in higher-risk conditions such as teeth with large periapical lesion, for higher success rate. Moreover, the importance of the long-term follow-up should be highlighted to the dental students, dentists, as well as patients for determining healing process.

Conclusions

The overall endodontic success rate in this study was 72.8%, whereas the failure rate was 27.2%, and the functional rate was 96.2%. The factors that influenced the outcomes of endodontic treatment found in this study were the pre-operative periapical status and the recall period.

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