

Treatment Outcome and Prognostic Factors of Initial Root Canal Treatment Performed by Undergraduate Dental Students: A Retrospective Study

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Research Article

Abstract

This study aimed to evaluate the outcomes and survival rates of initial root canal treatments performed by undergraduate dental students at the Faculty of Dentistry, Mahidol University. Additionally, this study aimed to identify prognostic factors influencing the treatment outcome and survival rate. A total of 1,768 teeth treated between 2015 and 2018 were analyzed, with 406 teeth included in the survival analysis and 397 teeth in the treatment outcome analysis. Clinical and radiographic data were collected, and descriptive statistics were used to report treatment outcomes and survival rates. Multivariable logistic regression and multivariable Cox regression were used to identify significant factors. The median follow-up time was 2.6 years. The overall healing rate was 82.1% (326 out of 397 teeth). Multivariable analysis revealed five significant factors negatively impacting the outcome, which included being male (OR=2.698), presence of a sinus opening (OR=2.641), pre-operative radiolucency (OR=3.620 and 5.991 for size <5 mm and ≥5 mm, respectively), inadequate root canal filling quality (OR=2.964), and inadequate restoration quality (OR=9.417). The survival rate was 97.8% (397 out of 406 teeth), with the only significant factor affecting the survival rate being cracked teeth (OR=16.067). The survival from fracture rate was 95.8%, with four significant factors found to negatively impact this rate: mandibular teeth (HR=5.653), teeth that lost more than two surfaces (HR=4.895), intra-operative complications (HR=8.049), and teeth that did not receive definitive restoration (HR=13.777). The majority of fractured teeth did not receive definitive restoration, and most incidence were fractured within 3.3 years (40 months). In conclusion, the healing rate of initial root canal treatment performed by undergraduate dental students at the Faculty of Dentistry, Mahidol University was 82.1%. Male gender, presence of a sinus opening, pre-operative radiolucency, inadequate root canal filling quality, and inadequate restoration quality were significant prognostic factors for the healed rate. The survival rate was 97.8%, with cracked teeth being the only significant factor negatively impacting the survival rate.

Keywords: Root canal treatment/ Retrospective/ Undergraduate dental student/ Prognosis/ Treatment outcome/ Survival rate

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Introduction

The purpose of root canal treatment is to prevent and treat apical periodontitis, which is caused by infection. The procedure aims to eliminate the infection and prevent reinfection through adequate root canal obturation and coronal seal.¹⁻³ Studies on the outcomes of root canal treatment have shown varying success or survival rates, attributable to differences in assessment criteria and study designs.^{2,4,5} In fact, the terms "success" and "failure" do not fully capture the healing dynamics of the disease. Thus, the outcome of endodontic treatment should be assessed based on clinical and radiographic examinations after a certain follow-

up period, ideally at least one year⁶, using terminology that reflects the biological process as "healed," "healing," "disease," or "functional retention".⁷

Moreover, numerous factors have been evaluated for their effects on the outcome. Research on treatment outcomes provides clinical evidence to prognosticate the future of a root canal-treated tooth and aids in communication between patients and clinicians. However, there has been no study on the outcomes of root canal treatments performed by undergraduate students in Thailand. Therefore, this study aimed to assess the treatment outcomes and survival rates

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after initial root canal treatment performed by undergraduate dental students at the Faculty of Dentistry, Mahidol University, and to explore potential factors associated with treatment outcomes.

Materials and Methods

The protocol for the present retrospective study was approved by the Institutional Review Board (MU-DT/PY-IRB) of the Faculty of Dentistry/Faculty of Pharmacy, Mahidol University (2020/DT013). Study data of root canal treatment cases were collected from endodontic and hospital charts between the years 2015 and 2018 from the undergraduate clinic at the Faculty of Dentistry, Mahidol University.

Root canal treatment procedure

Treatment was performed by undergraduate dental student year 5 and 6, without experience of root canal treatment in patients under the supervision of endodontists. Instrument was sterile according to standard of dental hospital. The treatment was performed under rubber dam isolation. The working length determination was aided by an electronic apex locator (RootZX, J Morita Co) and confirmed by radiograph. Mechanical instrument was performed with hand files (K-file or H-file), canals were rinse with 2.5% NaOCl during preparation by syringe irrigation with needle guage 25 and final rinse, 17% EDTA was used after finished preparation. In some case, 2% chlorhexidine might be used as an additional irrigant. Root canals were medicated with calcium hydroxide freshly mixed with sterile water or ready mixed calcium hydroxide (Ultracal) and carried into root canals by lentulo spiral. In between treatment session, the teeth were coronal sealed with temporary filling such as Cavit™ and IRM®. Root canals were obturated with gutta percha and zinc oxide eugenol sealer with lateral compaction technique then the teeth were intermediate restored with resin composite or glass ionomer cement before referring for final restore at Restorative or Prosthodontic clinic.

Inclusion Criteria:

1. Primary root canal treatment for a single or multi-rooted mature permanent tooth.

2. Treatment undertaken by a 5th-6th year undergraduate student under the supervision of a staff of Endodontic division between 2015 and 2018.

3. Complete endodontic records and radiograph information.

Exclusion Criteria:

1. Absence of follow-up data for at least one year.
2. Teeth referred to the postgraduate dental clinic.
3. Poor-quality radiographs that lack interpretive accuracy.
4. Teeth referred to extract were excluded from the treatment outcome analysis.

Based on earlier study, pre-operative, intra-operative, and follow-up information was collected and recorded.

Clinical and Radiographic Examination:

All radiographic interpretations were conducted by one examiner (B.W.), a general dentist who was calibrated with a Thai-board of endodontist (O.L.). The inter-examiner calibration achieved an almost perfect agreement, as determined by Cohen's kappa coefficients. Data were interpreted twice, at two-week intervals, with an intra-examiner level of agreement considered almost perfect ($\kappa=0.81-0.99$).

Outcome Evaluation:

The treatment outcome was assessed based on clinical and radiographic examination according to Friedman and Mor criteria.⁷ The outcome was categorized as follows:

1. Healed: Both clinical and radiographic findings are normal.
2. Healing: Radiolucency is reduced, combined with a normal clinical presentation.
3. Disease: Radiolucency either emerges or persists without change, regardless of a normal clinical presentation, or clinical signs or symptoms are present, even if the radiographic presentation is normal.

These criteria were applied to each root canal-treated tooth. For multi-rooted teeth, the root with the worst outcome determined the overall outcome for the tooth. The size of periapical lesions was measured in millimeters, based on the largest diameter and its perpendicular measurement.

Subsequently, the outcome for each tooth was dichotomized as healed or healing/disease. Functional retention was defined as the presence of an asymptomatic, endodontically treated tooth in the oral cavity. Survival referred to the presence of an endodontically treated tooth in the oral cavity, while survival from fracture was defined as the absence of fracture in either the tooth structure or restoration.

Statistics:

The treatment outcomes were described using frequency and percentage for each tooth unit. To identify prognostic factors affecting the outcome of root canal treatment, both univariable and multivariable logistic regression analyses were employed. Additionally, the rates of survival and survival from fracture were assessed using Kaplan-Meier statistics and log-rank tests. Univariable and multivariable Cox regression analyses were also conducted to evaluate the impact of various variables. All tests were interpreted at the 5% significance level. These analyses were performed using SPSS software, version 18.0.

Result

From January 2015 to December 2018, 1,768 teeth met the inclusion criteria, but 18 teeth were excluded. These exclusions were due to referrals to the postgraduate dental clinic because of perforations (8 teeth), complex root canal anatomy (5 teeth), separated instruments (2 teeth), and low

patient compliance (3 teeth). Additionally, 1,344 teeth were unreachable or declined the recall, resulting in a recall rate of 23%. Consequently, 406 teeth were analyzed for survival rate and survival to fracture. Of these, 9 were extracted and excluded, leaving 397 teeth for treatment outcome analysis (Figure 1). Due to the low recall rate, a response bias analysis was conducted. Using Chi-square analysis. Result showed that the only one factor was identified: fewer anterior teeth in the study sample compared to the lost follow-up.

The characteristics of the study sample for the treatment outcome analysis were documented, showing a mean follow-up time of 2.6 ± 1.4 years (range 1.0-5.5 years). The overall healed rate was 82.1% (326 out of 397 teeth), with the remaining 17.9% (71 out of 397 teeth) classified as healing/diseased. In the healing/diseased group, the apical radiolucent area was smaller in 48 teeth (indicating healing) and larger in 23 teeth (indicating disease) compared to the initial radiograph.

Univariable analysis identified significant pre-operative factors including sex, presence of sinus opening, tooth mobility, and pre-operative radiolucency. The significant intra-operative factor was root canal filling quality, while post-operative factors affecting the treatment outcome included type of restoration, restoration quality, and post-placement as detailed in Table 1.

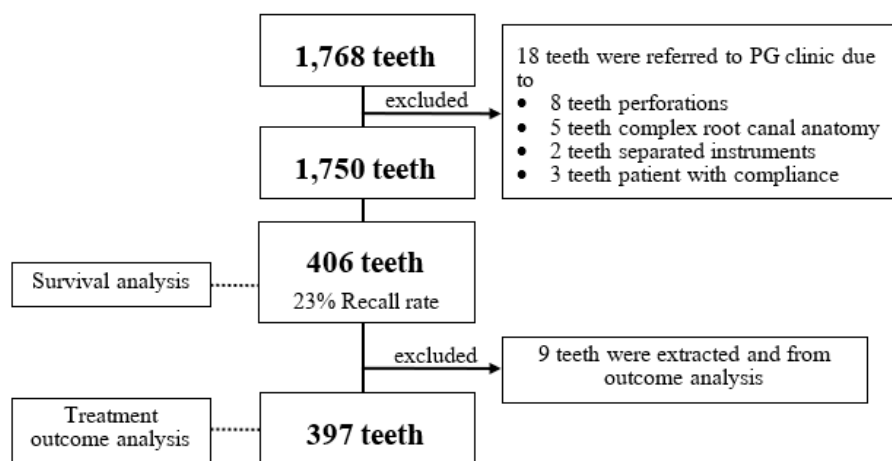


Figure 1 Flow chart of study sample.

Table 1 Univariable distribution and characteristics of the study samples for treatment outcome analysis

Variables	Study sample	Healed (%)	P-value	Cruded OR
Demographic data				
Age				
≤45 years	178	82.6	0.826	1
>45 years	219	81.7		1.060
Sex				
Female	254	86.6	0.002	1
Male	143	74.1		2.259
Systemic disease				
No	279	83.2	0.407	1
Yes	118	79.7		1.260
Preoperative data				
Tooth type				
Anterior	100	84.0	0.761	11.271
Premolar	159	80.5		1.105
Molar	138	82.6		
Arch				
Maxilla	216	85.2	0.083	1
Mandible	181	78.5		1.579
Cause				
Caries	317	83.9	0.063	1
Non-caries	80	75.0		1.739
Preoperative pain				
No	332	83.1	0.234	1
Yes	65	76.9		1.479
Traumatic occlusion				
No	387	81.9	0.518	1
Yes	10	90.0		1.987
Soft tissue swelling				
No	390	82.3	0.457	1
Yes	7	71.4		1.861
Intraoperative data				
Flare-up				
No	389	82.5	0.161	1
Yes	8	62.5		2.832
File				
Hand file	386	82.1	0.979	1
Rotary file	11	81.8		1.021
Complication				
No	366	82.2	0.824	1
Yes	31	80.6		1.111
Root canal filling extent				
Adequate	356	83.4	0.142	1
Short	21	71.4		2.014
Long	20	70.0		2.157
Root canal filling quality				
Adequate	337	84.3	0.009	1
Inadequate	60	70.0		2.296

Variables	Study sample	Healed (%)	P-value	Cruded OR
Sinus tract opening				
Absent	363	84.6	<0.001	1
Present	34	55.9		4.328
Percussion				
No	177	80.2	0.379	1.260
Yes	220	83.6		1
Cracked				
No	385	80.2	0.517	1
Yes	12	83.6		1.554
Mobility				
No	333	84.4	0.008	1
Yes	64	70.3		2.282
Periodontal involvement				
No	385	82.6	0.168	2
Yes	12	66.7		2.373
Preoperative radiolucency				
No	109	93.6	<0.001	1
<5 mm	198	82.2		3.021
≥5 mm	90	66.7		7.286
Adjacent teeth				
0-1 contact	347	82.4	0.349	1
2 contacts	50	80		1.299
Terminal tooth				
No	359	82.2	0.928	1
Yes	38	81.6		1.041
Occluded tooth				
No	37	81.1	0.863	1
Yes	360	82.2		1.079
Surface loss of tooth structure				
1-2 surfaces	284	83.5	0.272	1
>2 surfaces	113	78.8		1.360
Postoperative data				
Restoration type				
Resin composite	304	79.9	0.044	2.084
Crown	93	89.2		1
Use as abutment				
No	386	82.1	0.979	1
Yes	11	81.8		1.021
Definitive restoration				
Not received	140	85.0	0.270	1
Received	257	80.5		1.369
Restoration quality				
Adequate	382	83.5	0.001	1
Inadequate	15	46.7		5.787
Post				
No	323	80.2	0.041	2.365
Yes	74	90.5		1
Univariable analysis logistic regression				
Bold letter indicate significance (p<0.05)				

For teeth without pre-operative radiolucency, 93.6% (102/109 teeth) healed, showing no significant factors. Among teeth with pre-operative radiolucency, 77.8% (224/288 teeth) healed. Stratified univariable analysis highlighted significant pre-operative factors related to treatment outcome, including sex, cause of endodontic treatment, presence of sinus opening, tooth mobility, and lesion size. The significant intra-operative factor was root canal filling quality, and the post-operative factor was restorative quality.

Multivariable analysis identified five significant predictors affecting the treatment outcome are shown in Table 2. Pre-operative factors were male gender (OR=2.698; CI 1.442-5.046), presence of sinus opening (OR=2.641; CI 1.039-6.711), and pre-operative radiolucency (OR=3.620; CI 1.391-9.422 and OR=5.991; CI 2.060-17.423 for lesion size <5 mm and ≥5 respectively). Intra-operative and post-operative factors were inadequate root canal filling quality (OR=2.964; CI 1.333-6.589) and inadequate restoration quality (OR=9.417; CI 2.642-33.561), respectively.

A stratified multivariable analysis for teeth with pre-operative radiolucency identified five significant outcome predictors are displayed in Table 3: male gender

(OR=3.512; CI 1.734-7.112), cause of endodontic treatment (OR=2.597; CI 1.101-6.125), presence of sinus opening (OR=2.829; CI 1.049-7.626), inadequate root canal filling quality (OR=2.800; CI 1.110-7.067), and inadequate restoration quality (OR=5.017; CI 1.053-23.902).

Survival analysis

Survival rate

The characteristics and distribution of the study sample for survival analysis are detailed in Table 4. The survival rate at 2.6 years was 97.8% (397 out of 406 teeth), with all surviving teeth being symptomless, resulting in a functional retention rate of 97.8%. The cause of all extracted teeth was unrestorable tooth fractures.

Univariable Cox proportional hazards regression models revealed three significant factors affecting the survival outcome: the presence of cracks, tooth mobility, and teeth that lost structure on more than two surfaces. The multivariable Cox proportional hazards regression models demonstrated that the presence of cracks was the only significant factor influencing the survival outcome ($p=0.014$, HR=16.067; CI 1.756-146.604).

Table 2 Multivariable analysis of the significant predictors of outcome

Predictors	Adjusted OR	95% CI	P-value
Demographic data			
Sex			
(0=female; 1=male)	2.698	1.442-5.046	0.002
Preoperative data			
Sinus opening			
(0=absent; 1=present)	2.641	1.039-6.711	0.041
Preoperative radiolucency			
(0=no)			0.004
1=Size < 5 mm	3.620	1.391-9.422	0.008
2=Size ≥ 5 mm	5.991	2.060-17.423	0.001
Intraoperative data			
Root canal filling quality			
(0=adequate; 1=inadequate)	2.964	1.333-6.589	0.008
Postoperative data			
Restoration quality			
(0=adequate; 1=inadequate)	9.417	2.642-33.561	0.001
Multivariable analysis logistic regression			

Table 3 Stratified multivariable analysis of the significant predictors of outcome in teeth with preoperative radiolucency

Predictors	Adjusted OR	95% CI	P-value
Demographic data			
Sex			
(0=female; 1=male)	3.512	1.734-7.112	<0.001
Preoperative data			
Cause			
(0=caries; 1=non-caries)	2.597	1.101-6.125	0.029
Sinus opening			
(0=absent; 1=present)	2.829	1.049-7.626	0.004
Intraoperative data			
Root canal filling quality			
(0=adequate; 1=inadequate)	2.800	1.110-7.067	0.029
Postoperative data			
Restoration quality			
(0=adequate; 1=inadequate)	5.017	1.053-23.902	0.043
Multivariable analysis logistic regression			

Table 4 Univariable distribution and characteristics of the study samples for survival analysis

Variables	Study sample	Survival (%)	P-value	Cruded HR
Demographic data				
Age				
≤45 years	181	98.3	0.425	1
>45 years	225	97.3		1.759
Sex				
Female	260	97.7	0.920	1
Male	146	97.9		1.074
Systemic disease				
No	284	98.2	0.342	1
Yes	122	96.7		1.891
Preoperative data				
Tooth type				
Anterior	102	98.0	0.921	1
Premolar	163	97.5		1.365
Molar	141	97.9		1.315
Arch				
Maxilla	219	98.6	0.240	1
Mandible	187	96.8		2.299
Cause				
Caries	323	98.1	0.237	1
Non-caries	83	96.4		2.314
Preoperative pain				
No	340	97.6	0.567	1
Yes	66	98.5		1.835
Traumatic occlusion				
No	395	98.0	0.224	1
Yes	11	90.9		3.634
Soft tissue swelling				
No	399	97.7	N/A	N/A
Yes	7	100.0		N/A
Intraoperative data				
Flare-up				
No	398	97.7	N/A	N/A
Yes	8	100.0		N/A
File				
Hand file	395	97.7	N/A	N/A
Rotary file	11	100.0		N/A
Complication				
No	373	98.1	0.158	1
Yes	33	93.9		3.104
Root canal filling extent				
Adequate	365	97.5	N/A	N/A
Short	21	100.0		N/A
Long	20	100.0		N/A
Root canal filling quality				
Adequate	345	97.9	0.888	1
Inadequate	61	96.6		1.161

Variables	Study sample	Survival (%)	P-value	Cruded HR
Sinus tract opening				
Absent	372	97.6	N/A	N/A
Present	34	100.0		N/A
Percussion				
No	179	98.9	0.230	1
Yes	227	96.9		2.623
Cracked				
Absent	392	98.2	0.003	1
Present	14	85.7		11.375
Mobility				
No	338	98.5	0.020	1
Yes	68	94.1		4.793
Periodontal involvement				
No	393	98.0	0.212	1
Yes	13	92.3		3.771
Preoperative radiolucency				
No	112	97.3	0.612	1
<5 mm	201	98.5		0.656
≥5 mm	93	96.8		1.472
Adjacent teeth				
0-1 contact	355	97.6	0.601	1
2 contacts	51	98.3		1.521
Terminal tooth				
No	367	97.8	0.928	1
Yes	39	97.4		1.100
Occluded tooth				
No	37	100	N/A	N/A
Yes	369	97.6		N/A
Surface loss of tooth structure				
1-2 surfaces	287	99.0	0.037	1
>2 surfaces	119	95.0		4.375
Postoperative data				
Restoration type				
Resin composite	312	97.1	N/A	N/A
Crown	94	100		N/A
Use as abutment				
No	386	100.0	N/A	N/A
Yes	11	100.0		N/A
N/A (extracted)	9	0		N/A
Definitive restoration				
Not received	140	100.0	N/A	N/A
Received	266	96.6		N/A
Restoration quality				
Adequate	387	98.7	N/A	N/A
Inadequate	15	100.0		N/A
N/A (extracted)	4	0		N/A
Post				
No	324	100	N/A	N/A
Yes	73	100		N/A
N/A (extracted)	9	0		N/A

Bold letter indicate significance (p<0.05).
N/A = Not applicable

Survival from fracture

The distribution and characteristics of the study sample for the analysis of survival from fracture are shown in Table 5. The rate of survival from fracture was 95.8% (389 out of 406 teeth). Of the 17 fractured teeth, 17.6% (3 out of 17 teeth) were restorable, while 82.4% (14 out of 17 teeth)

were not restorable. The Cox proportional hazards regression models identified several significant factors for survival from fracture: the mandibular arch, the presence of cracks, tooth mobility, intra-operative complications, and teeth that did not receive a definitive restoration as significantly impacting the outcome.

Table 5 Univariable distribution and characteristics of the study samples for survival from fracture analysis

Variables	Study sample	Survival from fracture (%)	P-value	Cruded HR
Demographic data				
Age				
≤45 years	181	96.7	0.353	1
>45 years	225	95.1		1.597
Sex				
Female	260	96.2	0.560	1
Male	146	95.2		1.332
Systemic disease				
No	284	96.5	0.275	1
Yes	122	94.3		1.706
Preoperative data				
Tooth type				
Anterior	102	97.1	0.855	1
Premolar	163	96.3		1.028
Molar	141	94.3		1.337
Arch				
Maxilla	219	98.2	0.015	1
Mandible	187	93.0		3.684
Cause				
Caries	323	96.0	0.554	1
Non-caries	83	95.2		1.402
Preoperative pain				
No	340	95.3	0.171	1
Yes	66	98.5		3.721
Traumatic occlusion				
No	395	95.9	0.600	1
Yes	11	90.9		1.707
Soft tissue swelling				
No	399	95.7	0.523	20.919
Yes	7	97.1		1

Variables	Study sample	Survival from fracture (%)	P-value	Cruded HR
Sinus tract opening				
Absent	372	95.7	0.949	1
Present	34	97.1		0.949
Percussion				
No	179	96.6	0.527	1
Yes	227	95.2		1.381
Cracked				
Absent	392	96.2	0.018	1
Present	14	85.7		5.038
Mobility				
No	338	96.7	0.012	1
Yes	68	91.2		3.318
Periodontal involvement				
No	393	95.9	0.561	1
Yes	13	92.3		1.806
Preoperative radiolucency				
No	112	95.5	0.568	1
<5 mm	201	96.5		0.901
≥5 mm	93	88		1.471
Adjacent teeth				
0-1 contact	355	96.5	0.382	1
2 contacts	51	94.1		1.537
Terminal tooth				
No	367	96.5	0.156	1
Yes	39	89.7		2.212
Occluded tooth				
No	37	97.3	0.919	1
Yes	369	95.7		1.111
Surface loss of tooth structure				
1-2 surfaces	287	97.2	0.058	1
>2 surfaces	119	92.4		2.447

Table 5 Univariable distribution and characteristics of the study samples for survival from fracture analysis (Count.)

Variables	Study sample	Survival from fracture (%)	P-value	Cruded HR
Intraoperative data				
Flare-up				
No	398	95.7	N/A	N/A
Yes	8	100		N/A
File				
Hand file	395	95.7	N/A	N/A
Rotary file	11	100		N/A
Complication				
No	373	96.5	0.033	1
Yes	33	87.9		3.216
Root canal filling extent				
Adequate	365	95.3	N/A	N/A
Short	21	100		N/A
Long	20	100		N/A
Root canal filling quality				
Adequate	345	95.7	0.915	1.084
Inadequate	61	96.7		1
Postoperative data				
Restoration type				
Resin composite	313	94.6	N/A	N/A
Crown	93	100		N/A

Variables	Study sample	Survival from fracture (%)	P-value	Cruded HR
Use as abutment				
No	386	97.9	N/A	N/A
Yes	11	100		N/A
N/A(extracted)	9	0		N/A
Definitive restoration				
Not received	140	99.3	0.003	1
Received	266	94.0		11.695
Restoration quality				
Adequate	387	97.2	0.065	1
Inadequate	15	86.7		4.396
N/A (extracted)	4	0		76.131
Post				
No	324	97.5	N/A	N/A
Yes	73	100		N/A
N/A (extracted)	9	0		N/A
Bold letter indicate significance (p<0.05).				
N/A = Not applicable				

Multivariable Cox regression analysis, as detailed in Table 6, revealed significant predictors for survival from fracture: mandibular teeth (HR = 5.653; CI 1.224-26.107), teeth that lost more than two surfaces (HR = 4.895; CI 1.331-18.005), intra-operative complications (HR = 8.049; CI 1.428-45.359), and teeth that did not receive a definitive restoration (HR = 13.777; CI 1.522-124.683). Notably, 91.1% (16 out of 17 teeth) of the fractured teeth had not received a definitive restoration, and most fractures occurred within 40 months (Figure 2).

Table 6 Multivariable Cox regression analysis of the significant factors effect survival from fracture

Predictors	HR	95% CI	P-value
Preoperative data			
Arch	5.618	1.115-28.295	0.036
(0=Maxilla; 1=Mandible)			
> 2 surfaces loss	5.679	1.395-23.118	0.015
(0=no; 1=yes)			
Intraoperative data			
Complication	9.583	1.52-60.413	0.016
(0=no; 1=yes)			
Multivariable Cox regression			

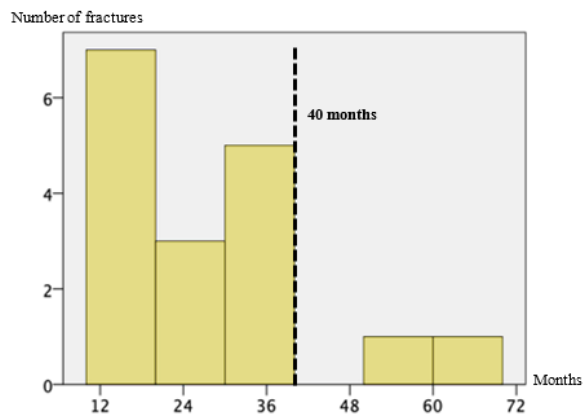


Figure 2 Frequency of tooth fracture and time range.

In a subgroup analysis focusing on the survival from fracture among teeth that did not receive a definitive restoration, the Cox proportional hazards regression model was applied to 266 teeth. This analysis identified significant predictors for survival from fracture: the mandibular arch ($p=0.018$) and tooth mobility ($p=0.004$). Further, the multivariable Cox regression analysis, as detailed in Table 7, highlighted three significant factors affecting the survival from fracture in this subgroup: the mandibular arch ($p=0.036$), teeth that lost more than two surfaces ($p=0.015$), and intra-operative complications ($p=0.016$).

Table 7 Multivariable Cox regression analysis of the significant factors effect survival from fracture in teeth that not receive definitive restoration

Predictors	HR	95% CI	P value
Preoperative data			
Arch (0=Maxilla; 1=Mandible)	5.653	1.224-26.107	0.026
> 2 surfaces loss (0=no; 1=yes)	4.895	1.331-18.005	0.017
Intraoperative data			
Complication (0=no; 1=yes)	8.049	1.428-45.359	0.018
Postoperative data			
Definitive restoration (0=received; 1=not received)	13.777	1.522-124.683	0.020
Multivariable Cox regression			

Discussion

The healing rate of endodontically treated teeth varies across studies, ranging from 68-85%, according to systematic reviews.^{8,9} Population-based cohort studies indicate that treatments performed in general clinics tend to have lower success rates compared to those in specialist clinics and institutes.¹⁰ The healing rates also significantly differ based on the provider's experience, with endodontists reporting 77-84.1%^{11,12}, postgraduate students or general dentists reporting 82.8-88.6%¹³⁻¹⁶, and undergraduate students reporting 73.5-78%^{17, 18}. At the Faculty of Dentistry, Mahidol University, approximately 500 teeth receive root canal treatment annually at the undergraduate clinic. This study aimed to investigate the outcomes of treatments performed by undergraduate dental students under supervision and identify prognostic factors to aid clinical decision-making.

A retrospective observational study allows evaluation of a large dataset with some limitations, such as the inability to control the treatment regimen and incomplete data recording. However, the academic setting ensures a standardized treatment protocol, organized records, and high-quality radiographs, enhancing the reliability of the obtained information.

The low recall rate (23%) might be influenced by the COVID-19 pandemic, yet a response bias analysis was conducted. Although the tooth type varied between the study sample and those lost to follow-up, it's unlikely to affect the study's result because the tooth type is not a factor that influences the treatment outcome, making the study's results representative of the population.

The healed rate in this study was 82.1%, aligning with rates reported by other studies on undergraduate student treatments^{2,17-19} and even comparable to those by specialists.^{11,12} The high healed rate observed may be attributed to careful case selection and comprehensive supervision (student: supervisor=4:1). Notably, patients with intra-operative complications were referred to postgraduate clinics and excluded them from the study.

For preoperative factors affecting root canal treatment outcomes, the study highlights several key points. While sex showed a significant impact on treatment outcomes in this study, a systematic review found no such influence.^{9,20} Preoperative radiolucency is a well-known predictor of outcome, with a lower healed rate observed in teeth with preoperative radiolucency compared to those without.^{2,9,13, 14,21} The size of the periapical lesion also influences the outcome, with smaller lesions associated with higher healed rates^{11,14,15,21}, though the impact of lesion size might diminish over longer follow-up periods.^{2,9} Since the median follow-up time of this study was 2.6 years, the size of the lesion might not affect the outcome in a longer follow-up time. The presence of a sinus opening, indicative of chronic infection and inflammation. Some studies have explained that the sinus tract may allow bacteria in the oral cavity to colonize the periapical area and increase the risk of extraradicular infection^{14, 22, 23} and may have a negative impact on treatment outcomes.¹⁰ The etiology of endodontic treatment has emerged as a factor influencing outcomes, with non-carious causes, including 36 teeth with non-carious cervical lesions, 6 fractured teeth, 1 cracked tooth, and 14 teeth affected by trauma, associated with lower healing rates. The impact of treatment etiology on outcomes has not been extensively studied before, underscoring the need for further investigation.

The quality of root canal filling, especially its homogeneity and length, critically affects the healing rate.^{9,18,19,24,25} The present study is consistent with previous studies, showing that the quality of root canal filling significantly influences the treatment outcome. Among the 397 teeth included in this study, 60 teeth (15.1%) had inadequate root canal fillings, primarily due to the length of the fillings. The length of a root canal filling reflects the quality of disinfection; thus, inadequate filling length significantly impacts the treatment outcome in teeth with preoperative radiolucency. A systematic review and meta-analysis have shown that adequate root canal filling and high-quality restoration contribute to favorable treatment

outcomes.²⁶ The results of this study align with previous studies.

Survival analysis indicated a high rate (97.8%), which was higher than earlier studies (85.1-93%).^{12,16,27,28} This higher rate can be attributed to the selection of cases, effective treatment protocols, and the exclusion of cases with serious complications. In the final multivariable Cox regression model, presence of crack emerged as the only significant predictor. A crack can serve as a pathway for bacteria to enter and cause infection and increased risk of fracture. With delayed placement of a crown, the tooth will have a lower survival rate if a crack is present.

All non-surviving teeth were attributed to unrestorable fractures. Previous research has identified tooth fracture as the most common reason for the extraction of endodontically treated teeth.^{29,30} The survival from fracture rates reported in earlier studies ranged from 84.1% to 86.2%^{31,32}, which is lower than the 95.8% observed in this study. The reasons are not entirely clear, but may be related to the selection criteria for undergraduate students. Previous studies showed that teeth with less severe structural loss, the employment of composite resin for intermediate restoration, or the relatively short follow-up duration demonstrated higher survival outcome.

Furthermore, the timing of the definitive restoration is crucial. Previous studies have demonstrated that delayed definitive restoration significantly increases the risk of tooth fracture^{30,33}, with recommendations suggesting that such restorations should be completed within four months post-endodontic treatment.³⁰ It's important to note that the delay in crown placement observed in this study was largely due to the service setting of dental school, where patients may face waiting periods up to 3-4 years. Regular monitoring is vital to mitigate the risk of unrestorable tooth fractures.

Our study confirms the necessity of definitive coronal restoration following root canal treatment. Ideally, the definitive restoration should be applied as promptly as possible, particularly for mandibular teeth with more than two surfaces loss of tooth structure.

Conclusions

Undergraduate dental students at Faculty of Dentistry, Mahidol University's had an 82.1% healed rate for their first root canal treatments. Significant predictors influencing this rate included sex, preoperative radiolucency, the presence of a sinus opening, the quality of root canal filling, and quality of restoration. The overall survival rate was 97.8%, with tooth cracks identified as a significant negative predictor this outcome. The survival rate from fracture was 95.8%, with significant factors lowering this outcome being the tooth located in the mandibular arch and the tooth that lost more than two surfaces of its structure.

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ผลการรักษาและปัจจัยที่พยากรณ์ผลการรักษาในการรักษาคลองรากฟันครั้งแรกโดยนักศึกษาทันตแพทย์

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บทความวิจัย

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อรายงานผลสำเร็จในการรักษาคลองรากฟัน และอัตราการคงอยู่ในช่องปากของฟันที่ได้รับการรักษาคลองรากฟันโดยนักศึกษาทันตแพทย์ คณะทันตแพทยศาสตร์ มหาวิทยาลัยมหิดล รวมทั้งศึกษาปัจจัยที่ส่งผลต่อผลการรักษา โดยในปี ค.ศ. 2015 ถึง 2018 มีฟันที่ได้รับการรักษาโดยนักศึกษาทันตแพทย์จำนวน 1,768 ซี่ เมื่อนำข้อมูลมาคัดกรองผ่านเกณฑ์การคัดเข้าและออก ทำให้มีฟันจำนวน 397 ซี่ถูกนำมาวิเคราะห์ผลสำเร็จในการรักษาคลองรากฟัน และ 406 ซี่ถูกนำมาวิเคราะห์อัตราการคงอยู่ในช่องปาก หลังจากเก็บข้อมูลทางคลินิกและภาพรังสี และวิเคราะห์ทางสถิติโดยใช้การวิเคราะห์การถดถอยโลจิสติก พบว่าที่ระยะการติดตามผลเฉลี่ย 2.6 ปี พบอัตราการหายของโรคร้อยละ 82.1 (326/397 ซี่) โดยมีปัจจัยที่ส่งผลเสียต่อการหายคือ เพศชาย การมีตุ่มหนอง การมีรอยโรคทางภาพรังสีก่อนการรักษา คุณภาพการอุดคลองรากฟันที่ไม่เหมาะสม และคุณภาพของการบูรณะฟันที่ไม่เหมาะสม ส่วนอัตราการคงอยู่ในช่องปากพบว่ามีฟันคงอยู่ที่ร้อยละ 97.8 (397/406 ซี่) โดยการมีรอยร้าวเป็นปัจจัยเดียวที่ส่งผลต่อการคงอยู่ในช่องปากของฟันที่ได้รับการรักษาคลองรากฟันแล้ว อัตราการรอดจากการแตกหักของฟันอยู่ที่ร้อยละ 95.8 โดยมีปัจจัยที่ส่งผลกระทบต่ออัตราการรอดจากการแตกหักคือ การเป็นฟันล่าง การสูญเสียเนื้อฟันมากกว่า 2 ด้าน การมีภาวะแทรกซ้อนต่อการรักษา และฟันไม่ได้รับการบูรณะถาวร โดยพบว่าฟันที่ไม่ได้รับการบูรณะถาวรมักแตกในช่วงระยะเวลา 40 เดือนหลังการรักษา อัตราการหายของโรคของฟันที่ได้รับการรักษาคลองรากฟัน โดยนักศึกษาทันตแพทย์ มหาวิทยาลัยมหิดล อยู่ที่ร้อยละ 82.1 อัตราการคงอยู่ในช่องปากอยู่ที่ร้อยละ 97.8 และอัตราการรอดจากการแตกหักของฟันอยู่ที่ร้อยละ 95.8

คำไวยุทธ: การรักษาคลองรากฟัน/ การศึกษาย้อนหลัง/ นักศึกษาทันตแพทย์/ พยากรณ์โรค/ ผลการรักษา/ อัตราการหาย

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