

## The Correlation between Endodontic Mishaps and Single-Visit Treatment in King Saud University

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### Abstract

**Aim:** To our knowledge, the correlation between the incidence of endodontic mishaps and single-visit treatment has not been reported. Therefore, the study's primary objective was to examine the correlation between endodontic mishaps and single-visit treatment using stainless steel files amongst dental students in King Saud University. The secondary objective was to identify risk factors associated with endodontic mishaps.

**Methodology:** Dental records filed between September 2012 and May 2015 was screened for patients who underwent complete endodontic treatment in King Saud University. Data collection included number of visits, tooth type, clinical training duration, preoperative conditions, and endodontic mishaps. Dental records with incomplete documentation or radiographs were excluded. Preoperative conditions included full-coverage restorations, a 10-30° root curvature, and a history of root canal treatment. Mishaps included ledge formation, transportation, perforation, and instrument separation. Risk factors included multiple visits, tooth type, preoperative conditions, and clinical training duration. Two endodontists with intraexaminer reliability >0.75, blinded to the number of visits and operator training duration, identified mishaps in postoperative radiographs. Data were statistically analyzed at a P-value of <0.05.

**Results:** In total, 1328 teeth fulfilled the study criteria. The incidence of mishaps was 7% for teeth treated in a single visit, and the incidence increased significantly to 16.2% and 28.3% for teeth treated in two and three visits, respectively. Single-visit treatment was significantly correlated with fewer mishaps compared to multiple-visit. Multiple visits, tooth type, and preoperative conditions had a significant effect on the incidence of mishaps. Clinical training duration had no significant correlation with incidence of mishaps.

**Conclusion:** Single-visit treatment using stainless steel files decreased the incidence of mishaps. Tooth type, preoperative conditions and multiple visits, are risk factors associated with mishaps.

**Keywords:** Single-visit root canal treatment; Root perforation; Curved canal; Apical transportation; Stainless steel files

### Introduction

Endodontic mishaps are procedural errors that occur during endodontic treatment and include ledge formation [1], apical transportation [2], root perforation [3], and instrument separation [4]. There are several reasons for such errors including inattention to details, and unsuspected aberrations in the root canal anatomy [1]. Among the various anatomical aberrations, root curvature is the most common [5]. Therefore, endodontic mishaps in curved canals cannot be completely avoided, particularly by novice operators [6].

Variations in the root canal morphology are observed more frequently in maxillary and mandibular first molars than in the other teeth [7,8]. Therefore, the American Association of Endodontics (AAE) have acknowledged the effects of the tooth type, the crown morphology, canal and root anatomy, and endodontic treatment history in AAE Case Difficulty Assessment Form and Guidelines. Recently, tooth type and preoperative conditions including crown morphology, root anatomy and endodontic treatment history were shown to have a significant effect on the number of visits and the radiographic quality of root canal treatment performed in King Saud University [9,10]. However, tooth type and preoperative conditions were not recognized as risk factors of endodontic mishaps.

Multiple-visit endodontic treatment is accomplished in two or more dental visits and is widely accepted as a safe and common protocol [11-13]. However, there is growing concern regarding the actual necessity of multiple-visit root canal treatment [14], because no significant difference in the healing rate and incidence of postoperative pain between single-visit and multiple-visit treatment has been reported [15].

In endodontics, using intracanal medicaments between dental visits is a well-known practice due to their antimicrobial effect. However, the extent of intracanal medicament antimicrobial activity is controversial [16,17]. The use of intracanal medicaments was not recommended by the European society of Endodontology for vital teeth [18], and their clinical efficacy was considered unpredictable by the American Association of Endodontists (Colleagues for Excellence, Root canal irrigants and disinfectant, 2011). Therefore, the use of intracanal medicament between dental visits is elective.

To our knowledge, the correlation between endodontic mishaps and single-visit root canal treatment has not been reported. Therefore, the study's primary objective was to examine the correlation between endodontic mishaps and single-visit treatment using stainless steel files amongst dental students in King Saud University. The secondary objective was to identify risk factors associated with endodontic mishaps.

## Materials and Methods

This retrospective study was conducted at King Saud University (KSU), Riyadh, Saudi Arabia. The study design was approved by the ethical committee of the College of Dentistry Research Centre, KSU, and in full accordance with the World Medical Association Declaration of Helsinki (version 2008). Dental records filed between September 2012 and May 2015 were anonymized prior to screening for teeth that received complete endodontic treatment in KSU undergraduate clinics. Included cases were treated under local anesthesia and rubber dam isolation using coronal preflaring, step-back instrumentation with stainless steel files, electronic apex locator for working length measurement, and root canal obturation using the lateral compaction technique. The exclusion criteria were as follows: incomplete documentation and the use of intracanal medicaments. The scheduled treatment sessions in undergraduate clinics were three hours per visit.

## Radiographic Evaluation

Pre- and postoperative radiographs were acquired using Kodak Ultra-speed D films (Carestream Health, Rochester, NY, USA) for teeth treated between September 2012 and August 2014, while digital radiographs (Planmeca, Romexis 3.6.0, Helsinki, Finland) were acquired for teeth treated between September 2014 and May 2015. Conventional radiographs were mounted in cardboard slits to block ambient light from entering the illuminated viewing box (Star X-ray Illuminator; Star X-ray, Amityville, NY, USA) and were examined at a 2 × magnification. Digital radiographs were first printed on transparent sheets (Kodak Premium Transparency Film, Eastman Kodak, Rochester, USA) at 1200 × 1200 DPI using a printer (HP Office Jet Pro 8000, Singapore). The printing dimensions were equal to those of Kodak Ultra-speed D films size 1 for anterior teeth and size 2 for posterior teeth. The printed radiographs were examined using the illuminated viewing box at a 2 × magnification.

Preoperative radiographs were examined for tooth type (anterior/premolar, first, second, or third molar) and for the presence of preoperative conditions, including full-coverage restorations, a 10-30° root curvature, and endodontic treatment history (adopted from the AAE Endodontic Case Difficulty Assess Form). Teeth with two or more preoperative conditions were grouped and compared to those with one or no preoperative condition.

Postoperative radiographs were examined for the presence of mishaps and were assigned binary outcomes (Yes or No). Then teeth with mishaps were evaluated for the type and position of the mishaps. The types of mishaps included transportation (removal of the canal wall structure on the outside curve in the apical half of the canal), ledge formation (root canal filling ending >2 mm short of the radiographic apex), perforation (apical overfilling by >2 mm, midroot or strip perforation, coronal or furcal perforation), and instrument separation. The position of mishaps was classified as apical, middle, or coronal. The documentation of more than one mishap per tooth was permitted.

Radiographic evaluations were performed by two endodontists blinded to the number of treatment visits. The Kappa value for intraexaminer reliability was required to be at least 0.75. Each examiner separately evaluated preoperative radiographs for preoperative conditions and postoperative radiographs for mishaps. In case of disagreement, the case was reevaluated until a consensus was reached.

To determine the intraexaminer reliability, the examiner's evaluation scores were compared with those for a set of 50 periapical radiographs. The time between the first and second reading was three weeks.

## Statistical Analysis

All statistical analyses were performed using SAS 9.3 (SAS Institute, Cary, NC, USA). The following hypotheses ( $H_0$ ) were tested:

- There is no significant correlation between the incidence of endodontic mishaps and single-visit treatment.
- Multiple-visit treatment, tooth type, preoperative conditions, and clinical training have no significant association with the incidence of endodontic mishaps.
- Multiple-visit treatment, tooth type, preoperative conditions, and clinical training have no significant association with the type of endodontic mishaps.

Pearson's correlation analysis was used to examine the correlation between the incidence of endodontic mishaps and the number of dental visits. Logistic regression analyses for repeated categorical response data were used to investigate the relationship between the incidence of mishaps and the following risk factors: multiple-visit, tooth type, preoperative conditions, and clinical training. The logistic regression models for repeated categorical data were fit using generalized estimating equations [19]. A P-value of <0.05 was considered statistically significant. Odds ratio estimates for the independent variables and corresponding 95% confidence intervals were also calculated.

## Results

A total of 1328 teeth met the study criteria. Conventional radiographs documented the treatment of 930 teeth, while digital radiography was used during the treatment of 398. The Kappa values for intraexaminer reliability were 0.86 and 0.88 for examiners 1 and 2, respectively.

One hundred and eighty-five tooth (13.93%) were treated in single visit, including 110 anterior teeth, 52 premolars and 10 molars. Most root canal treatments were performed in anterior (35.09%) and premolar teeth (38.86%) in two to three visits (64.31%). Complete demographic data for the study sample is presented in Table 1.

### The correlation between the incidence of endodontic mishaps and single-visit treatment

The incidence of mishaps was 7% in teeth treated in a single visit, and the incidence increased significantly ( $P < 0.0001$ ) to 16.2% and 28.3% for teeth treated in two and three visits, respectively (Figure 1). Single-visit treatment was significantly correlated with fewer mishaps compared to multiple-visit treatment (Pearson's correlation ( $r_p$ ) coefficient, 0.284).

### The association between multiple visits, tooth type, preoperative conditions, clinical training, and the incidence of endodontic mishaps

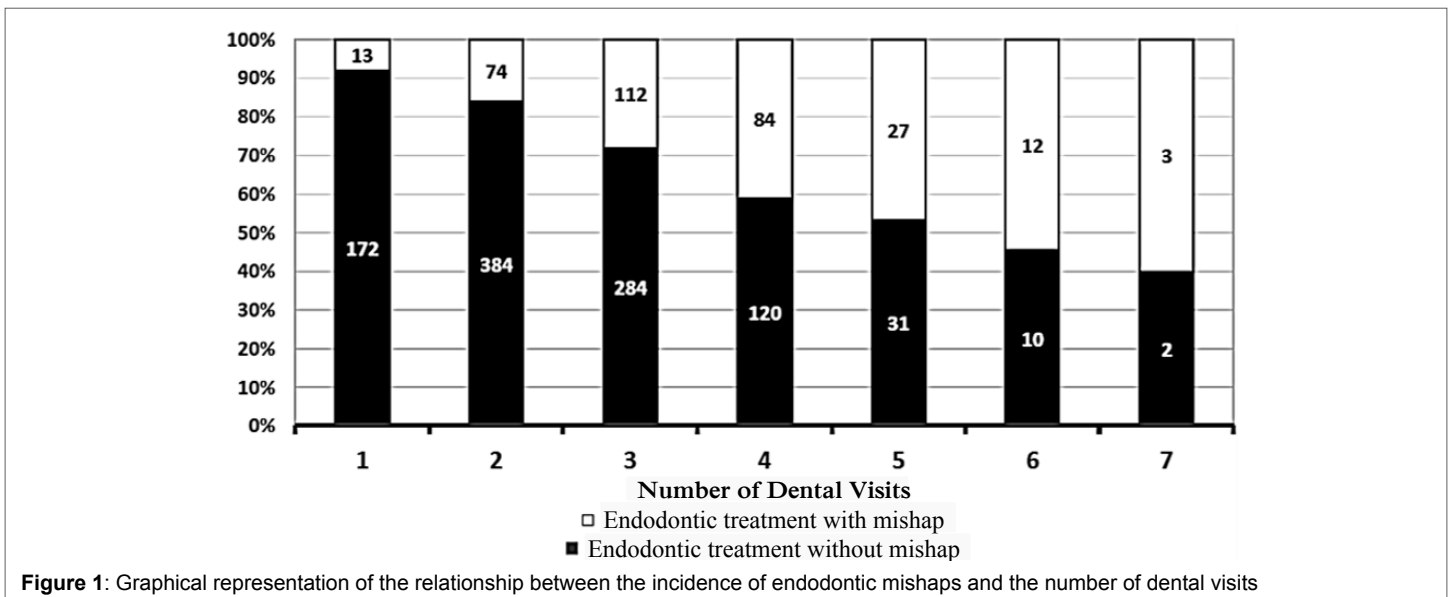
Table 2 demonstrates the significant association between multiple-visit treatment and the incidence of endodontic mishaps in univariate

		Treated Teeth	(%)
Number of dental visits	Single visit	185	13.93
	Two to three visits	854	64.31
	Four or more visits	289	21.76
Tooth type	Anterior/premolar	982	73.9
	First molar	228	17.2
	Second/third molar	118	8.9
Jaw type	Maxillary	818	61.6
	Mandibular	510	38.4
Preoperative conditions	None	471	35.5
	One condition	640	48.2
	Two or more conditions	217	16.3
Clinical Training	1 year	573	43.15
	2 years	755	56.85
Endodontic mishap	No	1003	75.5
	Yes	325	24.5

Table 1: Demographic data for the study sample (n=1328)

	Comparison group	Reference Group	Univariate Analysis		Multivariate Analysis	
			Odd Ratio (95% CI)	P-value	Odd Ratio (95% CI)	P-value
Number of Dental visits	1 visit	More than 4 visits	0.09 (0.05, 0.18)	<0.0001*	0.31 (0.15, 0.63)	0.0009*
	2 to 3 visits	More than 4 visits	0.35 (0.26, 0.48)		0.78 (0.52, 1.17)	
Tooth type	First molar	Anterior/ premolar	9.65 (7.02, 13.28)	<0.0001*	6.45 (4.43, 9.39)	<0.0001*
	Second/third molar	Anterior/ premolar	4.58 (3.08, 6.79)		3.27 (2.06, 5.16)	
Preoperative conditions	One condition	None	5.07 (3.69, 6.97)	<0.0001*	3.36 (2.34, 4.83)	<0.0001*
	Two or more conditions	None	5.07 (3.13, 8.22)		4.75 (2.79, 8.06)	
Clinical Training	1 year	2 years	1.36 (1.06, 1.75)	0.0228*	1.01 (0.74, 1.40)	0.9333

**Table 2:** The effect of multiple-visit, tooth type, preoperative conditions, and clinical training on the incidence of endodontic mishaps  
\*statistically significant at P<0.05



**Figure 1:** Graphical representation of the relationship between the incidence of endodontic mishaps and the number of dental visits

and multivariate analysis. The results of the odds ratio suggested that there were less likely to be mishaps in single-visit treatment compared to multiple-visit.

There was no significant (P=0.543) increase in the incidence of mishaps in premolar teeth compared to anterior teeth when both were treated in multiple visits. However, there was a significant (P<0.0001) increase in the incidence of endodontic mishaps in the first molar and the second/third molar compared to anterior/premolar teeth during multiple-visit treatment. Table 2 illustrates the odds ratio for endodontic mishaps, which were significantly higher in molar teeth compared to anterior/premolar teeth.

The presence of preoperative conditions such as full coronal coverage, root curvature (10-30°), and previous root canal treatment significantly increased the incidence of mishaps. In addition, table 2 shows an increase in the odds ratio when the tooth had a combination of two or more preoperative conditions. Clinical training had no significant effect on the incidence of mishaps in the multivariate analysis (Table 2).

**The association between multiple visits, tooth type, preoperative conditions, clinical training, and the type of endodontic mishaps**

Apical transportation was the most common mishap detected in the study sample. The type and location of the endodontic mishaps is

presented in table 3. The type of mishap was significantly associated with the presence of preoperative conditions (P=0.0002). However, there was no significant association between the type of mishap and multiple visits (P=0.1863), tooth type (P=0.0827), or clinical training (P=0.3861).

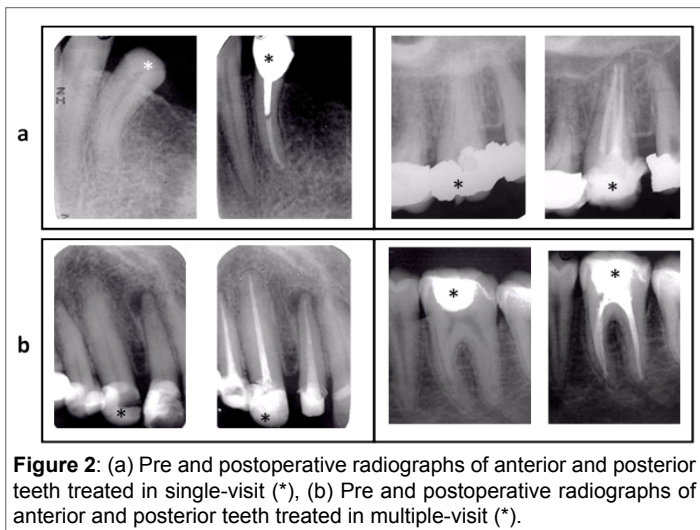
**Discussion**

In this study, endodontic mishaps were less frequent in single-visit treatment using stainless steel files in King Saud University (Figure 2). This retrospective cohort study was conducted in one academic center with a large homogenous sample size, which facilitates studying the correlation between single-visit treatment and endodontic mishaps. Multivariate analysis demonstrated that multiple-visit is statistically a significant risk factor leading to more mishaps while considering tooth type, preoperative conditions, and clinical training as risk factors. There are no previous studies to compare the study findings.

Figure 1 demonstrates the increase of mishaps with the increase in the number of dental visits. However, the correlation coefficient value was 0.284, which is interpreted statistically as a weak positive correlation. The most likely explanation is the presence of other significant risk factors such as tooth type and preoperative conditions. Randomized clinical trials (RCTs) provide the highest level of evidence in evidence-based dentistry

Endodontic Mishap		Frequency	(%)
Location	Furcation or Crown	5	1.5
	Middle	151	45
	Apical	180	53.5
Type	Transportation	131	39
	Ledge Formation	116	34.5
	Perforation	83	24.7
	Instrument Separation	6	1.8

**Table 3:** Types and location of endodontic mishaps (n=336)\*  
\*some teeth were associated with more than one mishap



**Figure 2:** (a) Pre and postoperative radiographs of anterior and posterior teeth treated in single-visit (\*), (b) Pre and postoperative radiographs of anterior and posterior teeth treated in multiple-visit (\*).

[20]. However, RCTs can't answer all clinical questions. Because there are situations where they might not be ethical or feasible [21], for example, with iatrogenic errors such as endodontic mishaps.

Multiple-visit treatment with intra-canal medicament was excluded from the study sample to minimize the confounding variables that might leads to inaccurate working length determination [22].

Tooth type was hypothesized as a risk factor of mishaps. The results showed that the incidence of mishaps was 50% in molars and 16% in premolars treated in multiple visits. In addition, the odds ratio of mishaps was significantly higher in molars compared to premolar/anterior teeth. Which is in agreement with a recent retrospective study reported that molars were associated with more mishaps compared to anterior teeth [23].

The presence of preoperative conditions such as root curvature, extensive coronal restoration, and previous root canal treatment is common clinically [24,25]. Therefore, the effect of preoperative conditions on the incidence of endodontic mishaps was included in the study analysis. The results showed that the type and incidence of mishaps was significantly less in teeth without preoperative conditions, which in agreement with earlier reports [26,27].

The study sample included teeth treated by 233 undergraduates, and the cases were arranged by practitioner and chronologically along two years of clinical training. Therefore, analyzing the effect of clinical training was possible. Theoretically, one would assume that more clinical practice would lead to fewer mishaps. However, the study results showed that clinical training, two years versus one year, had no significant effect on the incidence of mishaps, because tooth type and preoperative conditions had a leading influence compared to clinical training. The positive effect of clinical training on mishaps was not reported in previous studies [28,29].

Whether multiple-visit root canal treatment ensures a better outcome compared with single-visit treatment is one of the most debated topics in

the field of endodontics, assessed using different indices such as periapical healing [15], postoperative pain [30], operator [12] and patient preferences [31]. In this study, single-visit treatment associated with significantly less mishaps compared to multiple-visit treatment.

Single-visit treatment using stainless steel hand files was achievable by novice operators. The duration of dental visits was three hours in KSU undergraduate clinics and is considered adequate for the completion of treatment in one visit [32]. However, only 13.93 % of treatments were completed in a single visit. The most probable explanation was the lack of preclinical training in single-visit root canal treatment in King Saud University.

Recent advances in endodontics, including electronic apex locators, digital radiography, magnification, and the use of rotary nickel–titanium systems, have decreased the time for root canal treatment [33]. Therefore, including recent advances in academic centers would promote the practice of single-visit root canal treatment [11].

In the present study, the frequency of mishaps was lower with single-visit root canal treatment using stainless steel files. This can be explained by the fact that the operator is already oriented with the long axis of the tooth and root curvature during instrumentation and root canal obturation. On the other hand, the repeated use of stainless steel files during multiple treatment sessions might explain the increase in mishaps. Apical transportation was the most common mishap observed in this study. In vitro studies have presented controversial results about the relationship between the use of stainless steel files and canal transportation [2,34].

The use of rotary nickel-titanium (NiTi) files have become popular due its superelastic property [35]. However, there is no clinical data on how the use of NiTi files reduced the number of visit or the incidence of mishaps in comparison to stainless steel files. Moreover, new endodontic instruments are still compared to stainless steel files [36]. The study findings were limited to teeth treated by undergraduates and the use of stainless steel hand files. Therefore, the study findings are limited to academic centers using stainless steel files and future studies should provide information from teeth treated by endodontists and using nickel–titanium files.

In conclusion, single-visit treatment using stainless steel file amongst dental students in King Saud University reduced the incidence of mishaps compared to multiple-visit treatment. Multiple-visit treatment, tooth type and preoperative conditions are risk factors associated with endodontic mishaps. Clinical training did not reduce the incidence of endodontic mishaps.

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### Conflicts of Interest

None

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