# Endodontic Errors During Niti Rotary Mechanical Instrumentation and Root Canal Obturation Process Performed By Dental Students: A Retrospective Study

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#### Abstract

This study aims to evaluate the procedural errors of endodontic treatment that occurred during rotary mechanical instrumentation and root canal obturation process performed by dental students using NiTi rotary instruments. 258 out of 379 dental chart records and radiographic photographs that have completed endodontic treatment during 2014 and 2019 by using a rotary instrument, performed by undergraduate students at the College of Dental Medicine, Rangsit University were included. The digital periapical radiograph of pre-treatment and post-treatment were evaluated by setting criteria. The procedural errors were defined as void, underfill root canal filling material, overfill root canal filling material, ledge formation, perforation, fracture instrument, and miss canal. The sample included 83 anterior teeth and 175 posterior teeth (32%, and 68% respectively). The types of teeth consisted of 83 incisor and canine teeth (31.78%), 73 premolar teeth (28.29%), and 102 molar teeth (39.93%). The prevalence of overall procedural errors was 31.78%. In terms of the anterior position, there were 83 root canals. The prevalences of void detection, underfill root canal filling material, overfill root canal filling material, and ledge formation were 4.82%, 2.41%, 4.82%, and 7.23%, respectively. For the posterior position, there were 444 root canals. Posterior teeth exhibited prevalences of void detection, underfill root canal filling material, overfill root canal filling material, fracture instrument, perforation, and ledge formation were 9.46%, 4.05%, 3.15%, 1.13%, 1.58%, and 6.31%, respectively. There were no significant differences between tooth position and all procedural errors. The overall procedural error rate of endodontic treatment performed by undergraduate students using rotary instruments was 31.78%. Most of the cases occurred during the root canal obturation process. These present data of procedural errors could be a benefit for improving both pre-clinical and clinical curriculum, as well as endodontic skills of undergraduate students.

Keywords: Dental students, Endodontic treatment, Procedural errors, Retrospective studies, Root canal obturation, Rotary instrument

#### 1. Introduction

The evaluation of root canal quality and procedural errors are important in improving the undergraduate dental school program. The previous study in a laboratory by Spanish dental students has shown a total of 561 premolar and molar extracted teeth prepared using nickel-titanium rotary files or manual instrumentation, which were then filled with gutta-percha by 4th-grade undergraduate students. The percentage of technical success was 44% (Román-Richon, Faus-Matoses, Alegre-Domingo, & Faus-Llácer, 2014). The other study of the quality of 200 endodontically treated teeth from patients who had canal obturation performed by undergraduate dental students at Saveetha Dental College and Hospitals, India, demonstrated that the percentage of adequate length was 89% of the teeth, and the percentage of the density of root filling was about 34% of the teeth (Sundahnath, 2015). These pieces of evidence implied that the quality of root canal filling performed by the undergraduate student varies.

Conventional stainless-steel hand files (ss-file) were the standard equipment for the mechanical instrument that was primarily taught to undergraduate students. However, the limitation of ss-file was found in some degrees of canal curvature, which may lead to procedural errors such as ledging, zipping, and perforation. A part of these errors depended on the stiffness of the ss-file (Hartmann, Barletta, Camargo Fontanella, & Vanni, 2007). Later on, the Nickel-titanium (NiTi) hand file was developed to reduce procedural errors on the mechanical instrumental process because its flexibility can be well-controlled in the curve root canal (Baumann, 2004). Currently, NiTi rotary instruments are being widely developed due to their efficacy. Root canal shaping by NiTi rotary instrument is mainly used since it can maintain flexibility, but at the same time, it increases the taper of the canal. It is commonly accepted that the use of this technique gives satisfactory

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results with good centering, diminish debris extrusion, and allows for less preparation time (Kandaswamy, Venkateshbabu, Porkodi, & Pradeep, 2009).

Nowadays, there are many trends that NiTi rotary technique is started to teach at the undergraduate level in dental schools. In 13 out of the 16 dental schools in France, students could use rotary NiTi techniques for canal preparation under supervision (Arbab-Chirani & Vulcain, 2004). France (Arbab-Chirani & Vulcain, 2004) and Jordan (Abu-Tahun, Al-Rabab'ah, Hammad, & Khraisat, 2014) announced a consensus on the need for rotary devices to be used in undergraduate education. Currently, Thailand has no consensus in teaching rotary instruments to undergraduate students. Therefore, the techniques and instruments being used in endodontic treatment for the mechanical instrumentation process are heterogeneous.

In Thailand, a study by Sivavetpikul, Wisithphrom, and Puapichartdumrong (2019) evaluated success and failure rates of initial endodontic treatment performed by dental students, as well as the factors that influenced the result at the Faculty of Dentistry, Naresuan University. During treatment, 19 teeth encountered the following complications: 17 root perforations (4 coronal and 12 apical), 1 ledge, and 1 transportation. The success rate for teeth with complications was 68.4% (Sivavetpikul, Wisithphrom, & Puapichartdumrong, 2019). Yanpiset, Chivatxaranukul, and Jantarat (2006) presented an evaluation of the outcome and influencing conditions affecting the outcome of standard endodontic treatment based on clinical signs and symptoms, as well as radiographic reports of 379 endodontically treated teeth performed by Mahidol University undergraduate and graduate dental students. Nonetheless, the percentage of each type of procedural error is not distributed. They reported that the presence of underfilling, errors occurring during the treatment period had a negative effect on the treatment outcomes (Yanpisat, Jantarat, & Chivatxaranukul, 2006). Similar to another study from Khon Kaen University pointed at the success and failure rates of endodontically treated teeth in the anterior and premolar teeth. This study revealed that the quality of root canal filling significantly influenced treatment outcomes (Samaksamarn et al., 2014). However, in all these previous studies in Thailand, dental students did not employ the NiTi rotary instrument.

To the best of the author's knowledge, there has been no study conducted in Thailand that focuses on the procedural errors performed by dental students at the clinical level before. Rotary instruments were not used or assessed by previous studies performed particularly by undergraduate students.

The College of Dental Medicine of Rangsit University (RSU) has permitted undergraduate students to use rotary instruments based on case selection. Since the opening of the College of Dental Medicine in 2009 until the present but procedural errors, which performed by undergraduate students employing rotary instrument have not been assessed before. Thus, this study aims to evaluate the procedural errors of endo-dontic treatment that occurred during NiTi rotary mechanical instrumentation and root canal obturation process performed by dental students.

#### 2. Objective

To evaluate the procedural errors of endodontic treatment that occurred during mechanical instrumentation and root canal obturation process performed by dental students using rotary instruments.

Hypothesis: Position of tooth-related with procedural errors

H0: There is a difference between the position of the tooth and procedural errors.

H1: There is no difference between the position of the tooth and procedural errors.

#### 3. Materials and Methods

The protocol was approved by the RSU-ERB research ethics committee on March 19, 2020 (COA. No. RSUERB2020-029). The population was recruited from the patients who attended RSU dental clinic from 2014 to 2019. The dental chart records that have completed endodontic treatment by the undergraduate students were collected between those years, as well and each tooth had to fulfill the following conditions: Inclusion criteria:

1) Teeth that required non-surgical root canal treatment

2) Teeth that use Mtwo rotary instrument for mechanical instrumentation technique

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Exclusion criteria:

- 1) Teeth that use a combination of hand instrument and rotary instrument for mechanical instrumentation
- 2) Missing dental records or radiographic records

Root canal treatment protocol:

All cases were performed by undergraduate dental students under the supervision of experienced endodontists with the same treatment steps. All of the cases were handled aseptically with the use of a rubber dam. After access preparation was completed, the working length was determined by inserting SSfile in each root canal using an apex locator (Root ZX mini, J. Morita Mfg. Cooperation). The digital periapical radiograph was taken to confirm that the working length was set at 0.5-1 millimeters (mm) from the radiographic apex. All root canals were mechanical instrumentation with the same brand of NiTi rotary instrument (M-two rotary, VDW GmbH.). 2.5% NaOCl was used as an irrigation solution. Calcium hydroxide paste (Endo Cal<sup>TM</sup> Mahidol University, Thailand) was used as an intra-canal medicament between appointments. When the teeth had normal clinical signs and symptoms, root canals were filled with gutta-percha cones and conventional Zinc oxide eugenol root canal cement. Whether the warm vertical compaction of cold lateral compaction techniques will be used are depending on the case selection. The final restoration was performed either direct composite fillings or indirect restoration (post and core with crowns) depended on the individual treatment plan. Information in all cases included clinical signs and symptoms, diagnosis of the specific tooth, and procedural errors that had occurred were recorded in the dental chart and were approved by endodontists. Every case was recalled 6-month, 12-month, 24-month and 36-month to evaluate the success and failure of endodontic treatment by using clinical signs and .radiographic images following standard criteria and approved by endodontists

Data collection :

The data from dental chart records were review and collected of tooth position and procedural errors. The digital periapical radiographs of pre-treatment and post-treatment were evaluated for procedural errors and density of root canal filling by the research team under the endodontist supervisor who was the principal investigator. All digital periapical radiographs were interpreted by the SOPRO program in Dell Optiplex 760, 1600x900 pixels, color quality: highest 32-bit screen. The operational definition of procedural errors modified from the previous studies (Barrieshi-Nusair, Al-Omari, & Al-Hiyasat, 2004; Khabbaz, Protogerou, & Douka, 2010) were used as seen in Table 1.

Procedural errors	Definition
Void	Non-homogeneous root filling, poor condensation, or voids present in the radiograph.
Under-filled	Root filling terminating $\geq 2$ mm from the radiographic apex.
Over-filled	Root filling extending beyond the radiographic apex.
Ledge formation	Gutta-percha is the final radiograph that deviated from the original curvature com- pared with the working-length radiograph.
Perforation	Extrusion of materials was detected in any area of the root (lateral wall or the apical foramen of the root).
Fracture instrument	The separation of instrument that observed through the final radiograph and according to the radiopacity between the filling material and fractured instrument.
Miss canal	Identifying missed canal from dental chart record

Table 1 T	he criteria	to record	information	from rad	iographs a	and dental	l chart rec	ords (Mo	dified fr	om (Bar-
rieshi-Nus	sair et al., 2	2004; Kha	ıbbaz et al., 2	2010))						

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All data were collected and entered into the Microsoft Excel version 16.15 (180709). The categorical data were described as a frequency and percentage of the types of the tooth, position of the tooth, age, gender, and procedural errors. The ratio of teeth position and procedural errors were calculated with Fisher's Exact test with the statistical significance was set at 0.05.

# 4. Results and Discussion

### 4.1 Results

A total of 379 teeth had undergone complete endodontic treatment with undergraduate students by using the rotary instruments between 2014 and 2019. Two hundred and fifty-eight teeth (68%) were included in the analyses, of which 121 teeth were excluded. The reasons for exclusion were 1) dental chart records of 27 teeth were lost, 2) radiographs of 32 teeth were missing from the system, 3) recall data of 29 teeth were not found, 4) 11 teeth were extracted during endodontic treatment, and 5) 22 teeth were re-treatment cases. The sample size consisted of 113 males and 145 females, which is 44% and 56%, respectively. The age of the sample ranged from 14 years to 80 years. The mean age was 42.5 and the standard deviation (S.D.) was 15.7. The sample included 83 anterior teeth and 175 posterior teeth, which were calculated as 32%, and 68% respectively. The types of the tooth were 83 incisor and canine teeth (31.78%), 73 premolar teeth (28.29%), and 102 molar teeth (39.93%).

The prevalence of overall procedural errors was 31.78%. It was estimated from the number of procedural errors of 82 out of 258 teeth. The numbers of overall procedural errors defined by the types of teeth were 16 incisor and canine teeth, 24 premolar teeth, and 42 molar teeth while these prevalence were 6.20%, 9.30%, and 16.28%, respectively.

The sub-group analyses of types of procedural errors defined by the position of teeth were calculated. In terms of the anterior position, there were 83 root canals. The prevalence of void detection, underfill root canal filling material, overfill root canal filling material, and ledge formation was 4.82%, 2.41%, 4.82%, and 7.23%, respectively. For the posterior position, there were 444 root canals. Posterior teeth exhibited prevalence of void detection, underfill root canal filling material, overfill root canal filling material, overfill root canal filling material, fracture instrument, perforation, and ledge formation were 9.46%, 4.05%, 3.15%, 1.13%, 1.58%, and 6.31%, respectively. Perforation and fracture instruments were not found in anterior teeth whereas a missed canal was not seen in both anterior and posterior teeth as seen in Table 2.

The ratio of procedural errors between anterior and posterior teeth was seen in Table 3. The procedural errors were found mostly in posterior teeth than in anterior teeth, however, there were no significant differences between tooth position and all procedural errors.

				Type of procedural errors n (%)				
R	oot canal	Void	Underfilled	Overfilled	Missed canal	Fractured instrument	Perforated	Ledged
Position	of teeth							
•	Anterior (n=83)	4 (4.82)	2 (2.41)	4 (4.82)	0	0	0	6 (7.23)
•	Poste- rior(n=444)	42 (9.46)	18 (4.05)	14 (3.15)	0	5 (1.13)	7 (1.58)	28 (6.31)

Table 2 Number and percentage of types of procedural errors defined by the position of teeth

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Anterior: Posterior	Fisher's Exact test	
1:10.5	0.5	
1:9	0.5	
1:3.5	0.5	
0:0	n/a	
0:5	0.5	
0:7	0.5	
1:4.7	0.5	
	Anterior: Posterior 1 : 10.5 1 : 9 1 : 3.5 0 : 0 0 : 5 0 : 7 1 : 4.7	

Table 3 Ratio of types of procedural errors defined by the position of teeth (anterior: posterior)

### 4.2 Discussion

The instrumentation of the root canal system is a challenging operation. Complications sometimes lead to endodontic mishaps that can potentially affect the treatment outcome (Lin, Rosenberg, & Lin, 2005) (Pettiette, Delano, & Trope, 2001). In the development of the teaching and learning curriculum, evaluating the procedural errors of root canal treatment performed by undergraduate dental students is important to improve their clinical skills. In the present study, the prevalence of overall procedural errors was 31.78%, which is similar to the previous studies. For students in Pakistan (Yousuf, Khan, & Mehdi, 2015), the prevalence of total procedural error was 32.8%, while the percentage of root canal treatment was 31.1% in the College of Dentistry, Taibah University, Saudi Arabia (AlRahabi, 2017).

A previous study demonstrated that procedural errors occur more frequently in posterior teeth rather than anterior teeth (AlRahabi, 2017), which is similar to the present study. In this study, the procedural errors were found mostly in posterior teeth than in anterior teeth; these prevalences were 25.58% and 6.20%, respectively. This result may be related to the anatomical complexity of posterior teeth that is greater than anterior teeth. Besides, the undergraduate students have inadequate clinical skills and experience so they may find it difficult to access teeth in the posterior region and to manipulate multiple root canal.

The major error in this study was void occurring in root canal filling, which accounts for 16.69%. The detection of void represents the quality of root canal filling. In general, a radiographic photograph was used to evaluate the density of the root canal filling. The previous study concluded the periapical health was associated with adequate root canal obturation (Kielbassa, Frank, & Madaus, 2017). Although the present study did not determine the success rate of endodontic treatment, this issue is concerning and there should be further investigation.

One of the procedural errors in this study was overfilled root canal filling material. The percentage of this error detected at the anterior teeth was 4.82%, while at the posterior teeth was 3.15%. Yousuf et al. (2015) presented discrepancy results of the most prevalent error rate that was overfilled root canal filling by 22.7% (Yousuf et al., 2015). It was shown that underfill decreased the success rate by merely 68% (Kerekes and Tronstad, 1979). In parallel, overfilling also leads to failure and has been shown to reduce the success rate to as low as 76% (Kerekes & Tronstad, 1979; Sjogren, Hagglund, Sundqvist, & Wing, 1990). There are many reasons why the failure occurred in the overfilled root canal. For example, it may be a lack of awareness of working length, over instrumentation, or errors in obturation technique (Siqueira, 2001). Hence, clinicians and undergraduate students should increasingly consider their techniques for preparation and root canal obturation.

Moreover, ledge formation and broken instruments are common errors that happen due to improperly using NiTi rotary instruments caused by a lack of clinical experience. In the present study, the percentage of the ledge was 7.33% and the fractured instrument was only 1.13%. In the authors' opinion, these amounts were acceptable so the use of NiTi rotary instrument is safe under supervision with the endodontist.

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The advantage of shaping the root canal with NiTi rotary files has been broadly reported. The implementation of rotary instruments with NiTi provides well-tapered root canal preparations, thus minimizing the risk of root canal transportation (Mamede-Neto et al., 2017). Mamede-Neto et al. (2017) examined the transportation ability of 9 different brands of NiTi rotary instruments. They concluded that only one of the 9 brands had the tendency of canal transportation. The Ni-Ti instruments could provide the centering ability of root canal shape, maintain the canal curvature, and reduce the risk of procedural errors (Guelzow, Stamm, Martus, & Kielbassa, 2005).

The European Endodontics Society (ESE) has recently published articles to guide the endodontics undergraduate curriculum to develop the theoretical and clinical training of dental premolar and molar teeth, which undergraduate students must undergo preclinical and clinical practices (Çelik et al., 2019). Recently, there are many trends of NiTi rotary techniques being taught at the undergraduate level in dental schools, with a document of the clinical performance of NiTi file used by the undergraduate student showing up. Interestingly, nowadays, based on available evidence in Thailand, dental school programs provide NiTi rotary instruments only in laboratory practice in some institutions. Moreover, the College of Dental Medicine at RSU has allowed undergraduate students to use NiTi rotary instruments on their patients since 2009, while other institutions have not allowed using NiTi rotary instruments in the clinical practice. These present data of procedural errors could be a benefit for improving both pre-clinical and clinical curriculums, as well as endodontic skills of undergraduate students. Besides, the present study could be a novel evident base for consideration of using NiTi rotary instruments in the clinical students.

### 5. Conclusion

The prevalence of overall procedural error rate of endodontic treatment performed by undergraduate students using rotary instruments between 2014 to 2019 was 31.78%. The procedural errors were found mostly in posterior teeth than in anterior teeth, however, there were no significant differences between tooth position and all procedural errors. The majority of these errors happened during the root canal obturation procedure. Further improvement of obturation technique is needed in clinical undergraduate training.

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