



## Frequency of Procedural Errors during Root Canal Treatment Performed by Interns

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### Authors' contributions

This work was carried out in collaboration between all authors. Author SAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors FAS, ZK and ABS managed the analyses of the study. Authors SN, SR and MSZ managed the literature search. All authors read and approved the final manuscript.

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### ABSTRACT

**Aims:** Chemo-mechanical preparation continues to be one of the most challenging steps in root canal treatment procedures. The aim of this study was to examine the frequency of procedural errors during root canal treatment performed by interns.

**Study Design:** Cross sectional descriptive study.

**Methodology:** A total of 200 patients scheduled for root canal treatment in the permanent first molar were selected and pre-operative radiographs were taken before the procedure. After achieving a straight line access, the interns performed conventional step back technique to prepare the canals and irrigation was done using 2.5% sodium hypochlorite solution. After completion of the instrumentation procedure, two experienced endodontists evaluated the cases both clinically and radiographically.

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**Results:** Results showed that a total of 78 (39%) cases received procedural errors, and the remaining cases received appropriate instrumentation procedures. Apical Transportation (12%) presented the highest percentage for procedural errors followed by ledge formation (10%), strip perforation (5%), apical perforation (5%), instrument separation (4%) and perforation during access (3%).

**Conclusion:** The present study suggests a high frequency of procedural errors 39% in all cases performed by interns. This reflects the amount of clinical knowledge and skill possessed and applied by operator during the course of the treatment.

*Keywords: Procedural errors; radiographs; interns; endodontic training.*

## 1. INTRODUCTION

The root canal is a complex system composed of a meshwork of canals encased in the radicular dentine. Root canal treatment (RCT) is essentially a surgical procedure [1] with the aim of removal of the vital pulp or dead tissues, elimination of microorganisms, their sub-products and infected dentine both mechanically and chemically. According to Schilder [2] this process creates a telescopic form from the coronal access to the apex, producing a surgical space that favors the complete sealing of the root canal system. The complex morphology of the root canal system varies among individuals and populations [3,4]. A clear understanding of the variation of root canal anatomy is an important prerequisite for a successful endodontic procedure involving cleaning and shaping of root canals [2,5,6]. During RCT procedures, the clinician can encounter unforeseen circumstances or mishaps' commonly known as "Procedural Errors", which can tamper the prognosis of RCT.

Recent advances have resulted in using nanotechnology [7-9], lasers [10] and tissue engineering approaches [11] for various dental applications. Endodontics along with other disciplines of dentistry has undergone a paradigm shift in the recent decades while the basic principles of instrumentation and obturation procedures essentially remain the same. Edward Maynard has been credited with the development of the first endodontic hand instruments. Notching a round wire (in the beginning watch springs, later piano wires) he created small needles for extirpation of pulp tissue [12,13]. In 1915, the K-files were introduced. Although standardization of instruments was proposed in 1929 by Trebitsch and by Ingle in 1958, ISO specifications for endodontic instruments were not published until 1974 [14]. The stainless steel files have certain drawbacks like file sizes larger than # 25 become stiffer therefore, it is difficult to

keep the larger files centered in a curved canal. Their lack of flexibility results in apical transportation, ledges, apical canal blockage, and extrusion of canal debris through the apex. To overcome these problems the endodontic files were developed from a super elastic alloy, nickel-titanium, with a low-modulus of elasticity [15]. Walia, et al. [15] reported that #15 nickel-titanium files have two to three times more elastic flexibility and superior resistance to torsional fracture when compared with #15 stainless steel files manufactured by the same process. These properties give nickel-titanium endodontic files a greater ability to negotiate curved canals; reduce the tendency of straightening, zipping, ledging, or perforating curved canals and allow larger apical preparations of curved root canals while maintaining the original canal path [16-18]. Examples of nickel-titanium rotary endodontic file systems are Pro Taper by Dentsply and Mtwo by VDW Dental.

The biomechanical preparation of the root canal system is based on the cervical reverse-tapering [16], crown-down [19] or step-down technique [20]. The crown down technique starts in the cervical third extending to the apical third, thus minimizing the risk of procedural errors during RCT [21]. Schilder [2] suggested the 'concept of flow' allowing both removal of tissue and appropriate space for filing. In order to estimate the root canal length and apex location, radiographic techniques [22-24] are of great benefit and minimizing the chances of procedural errors. However, regardless of the instrument or technique used, procedural accidents still occur such as ledge formation, strip and apical perforation, apical transportation, and instrument separation. Canal systems can be evaluated *in vitro* before and after preparation by means of micro-computed tomography (CT) [25] and more precise detection of procedural accidents [23]. *In vivo*, less precise methods are generally applied, with the two-dimensional (2-D) radiographic representation of the root canal [26]. The use of

Cone Beam Computerized Tomography (CBCT) and Optical Microscope are also used for evaluation [3,4].

In 1995, Esposito and Cunningham [18] suggested the difference between stainless steel and nickel-titanium groups became statistically significant with instruments larger than size #30. In the study, nickel-titanium files were more effective in maintaining the original canal anatomy of curved root canals when the apical preparation was enlarged beyond size #30. However, in a study from a biological perspective, rotary instrumentation does not seem to have produced significant real advantages over hand instrumentation [27].

A number of factors can affect the perception, clinical efficiency and performance of students and interns [28-30]. The procedural errors can be avoided by a clinician by relying on his knowledge, intuition, and patience during the course of the treatment. In our Institution the students are taught the traditional step-back technique with stainless steel files. During the final year, the students are given extracted teeth to perform root canal treatment in order to familiarize the students to endodontic therapy, after graduation during the house job period the interns start working on patients, using traditional step-back technique with stainless steel files. Several challenges are present at the house job [internship] level resulting in procedural accidents. Hence, different studies, etiology and management of these errors can help our operators develop improving programs. The aim of this study was to find the frequency of procedural accidents during root canal treatment in patients performed by interns and to evaluate the accidents and determine factors leading to such procedural errors.

## 2. MATERIALS AND METHODS

This study was conducted at the Department of Endodontics, Fatima Jinnah Dental hospital, Karachi. Practitioners responsible for carrying out the root canal treatment were all interns working independently in the department. Non-probability purposive sampling technique was used to select a total of 200 patients referred to the department of Endodontics for RCT of permanent first molars. All consecutive patients aged between 15-60 years of either gender were included in this study. The patients with need of re-treatment, periodontal conditions, endo-perio

lesions, any contraindicative medical condition, mobile teeth, patients younger than 15 years and older than 60 years of age, and patients requiring root canal treatment in teeth other than first permanent molars were excluded from the study. Pre-Operative radiographs were taken prior to RCT. After achieving a straight line access opening using a No. 4 round carbide bur or No. 557 carbide bur in a high speed hand piece with air-water spray cooling and a rubber dam was placed. The canal patency was checked using a patency file, working length was taken 0.5-1 mm short of the radiographic apex with #15 or #20 K-file (K-type file, DENTSPLY Malleifer, USA), a working length radiograph was taken. Conventional step back technique was used to prepare the canals and 2.5% sodium hypochlorite was used for irrigation. The types of Procedural accidents like ledging, strip perforation, apical perforation, instrument separation, apical transportation, and perforation during access preparation were assessed on the basis of clinical and radiographic assessment, by two independent and experienced endodontists. The radiographs were evaluated at three different levels, Pre-Operative, Working length, and after completion of the instrumentation procedure. The results were recorded separately by each endodontists. In case of different results for the same case, a third endodontist was referred to give an opinion about the type of procedural accident. A student t-test was carried to deduce the statistical significance of the results.

## 3. RESULTS AND DISCUSSION

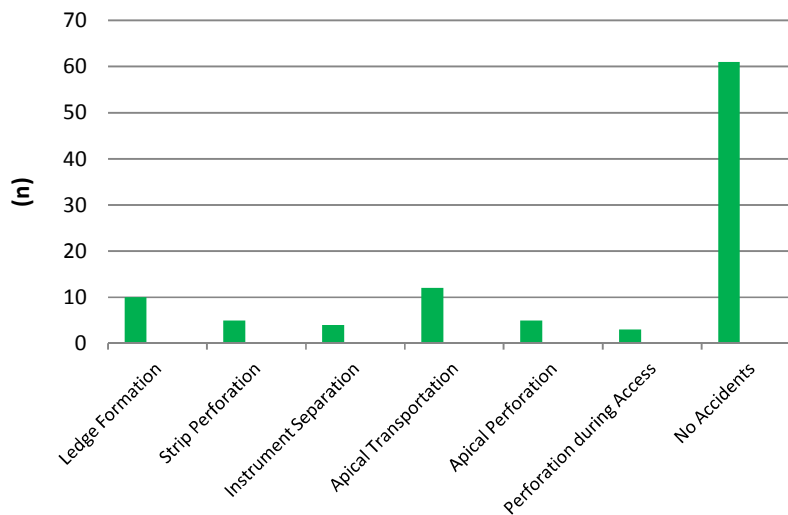
In the light of this study, it was observed that out of 200 patients, a total of 78 teeth (39%) received various procedural errors. The highest incidence was of apical transportation 24 cases (12%) followed by 20 cases (10%) of ledge formation. The prevalence of other procedural errors is listed in Table 1. Statistically, ledge formation and apical transportation were the two most prevalent procedural accidents ( $P < 0.05$ ).

An assessment of the clinical outcomes of the root canal therapy carried out by interns could suggest the need for a critical re-evaluation of teaching methods and philosophy. The study reported in this article was conducted to assess the technical quality of root canal treatment in patients performed by interns and to determine the reasons for the procedural errors during the preparation.

**Table 1. A tabular representation of the frequency (n) of each type of procedural accident occurring during root canal therapy performed by interns**

Type of procedural accident	Number (n)	Percentage (%)
Ledge formation	20	10 <sup>a</sup>
Strip perforation	10	5 <sup>b</sup>
Instrument separation	8	4 <sup>b</sup>
Apical transportation	24	12 <sup>a</sup>
Apical perforation	10	5 <sup>b</sup>
Perforation during access	6	3 <sup>b</sup>
Teeth with accidents	78	39 <sup>c</sup>
Teeth without accidents	122	61 <sup>d</sup>

Same letters in superscript denote no statistical difference, different letters denote statistical difference ( $P < 0.05$ )

**Fig. 1. The frequency (n) of each type of procedural accident during root canal therapy performed by interns**

According to the data collected, 40.7% and 37.8% of maxillary and mandibular first molars, respectively (Table 2), received procedural errors, and 36.3% of males and 40.2% of females received procedural accidents (Table 3). The most commonly affected tooth was the right mandibular first permanent molar. The frequency of treatment varied between men and women. Females received 67 percent of the endodontic treatment in this study. This is consistent with the findings of Boucher et al. [31] who reported that 62 percent of the treated individuals were women. Dental Schools all around the world face the challenge of providing knowledge to the undergraduate dental students to perform endodontic therapy without any procedural accidents, yet accidents occur regardless of the technique and type of instrument used. Sonntag et al. [30] observed that inexperienced operators achieved better canal preparation using rotary

NiTi instruments compared to hand stainless steel instruments.

Tu et al. [32] and Gekelman [33] found that receiving structured training sessions and following the preparation sequence carefully allowed undergraduate students to shape canals successfully employing rotary instruments. The most frequent procedural error in the present study was apical transportation 24 cases (12%), 20 cases of ledge formation (10%), 10 cases (5%) of apical perforation. Javaheri and Sameri [34] showed that 25% of apical transportation, 30% of ledge formation, 55.5% of apical perforation were subtle for treatment failures.

A study by Asnaashari M, [35] on the procedural errors by dental students showed ledge formation as the most prevalent error, and the ledge formation in this study has second highest

**Table 2. The frequency and percentages of procedural errors in maxillary and mandibular**

Arches	Cases with error	Cases without error	Total	Error (%)
Maxillary	33	48	81	40.7 %
Mandibular	45	76	119	37.8%

**Table 3. The frequency and percentages of procedural errors in male and female patients**

Gender	Number of cases with error	Number of cases without error	Total	Percentage error
Male	24	42	66	36.3%
Female	54	80	134	40.2%

incidence. Kapalas and Lambriandis [36] showed 51.5% ledge formation by dental students using step-back technique. Mckendry et al. [37] showed 37% ledge formation with K-Flex files. Zmener and Marrero [38] reported 30% ledge formation using K-Files. Another study by H. Balto and Sh. Al Khalifah [39] showed 14% ledges, 7% apical transportation, and 7% apical perforation which differs from the results in the present study.

The high incidence of apical transportation in our study reflects the skills and technique followed by our interns, the other factors contributing to this high frequency of errors could be aggressive filing, failure to pre-curve the file in case of curved root canals using fatigued files and setting larger MAFs larger than 40. since the files become stiffer as the diameter of the files increases, use of stainless steel files, and also the use of step-back techniques. The percentage of errors could be minimized by either using the crown down technique, flaring of the coronal third of the root canal before determining the working length. Morgan and Montgomery [40] and Stabholtz et al. [41] and Miserendino et al. [42, 43] proposed that the blunt tip design of the modern hand and rotary instruments make coronal flaring easier and safer. Use of rotary NiTi instruments, minimizes the risk of procedural accidents during root canal treatment. Xu et al. [44] reported 0% ledge formation using ProTaper rotary system and 5.8% using hand files step back technique, but the initial startup cost for rotary instrumentation can be expensive, and the overhead cost is also high in maintaining a supply of files.

French dental schools have advocated the use of rotary NiTi Instruments and have incorporated lectures and laboratory courses related to these systems, to their undergraduate dental

curriculum [45]. The data presented in the present study is not representative of the whole dental fraternity, and the radiographs are a less precise method of evaluating procedural accidents [23].

Additionally, the complexity of root canal system of teeth and the position of individual teeth should also be taken account when treating teeth endodontically.

#### 4. CONCLUSION AND RECOMMENDATIONS

The present study suggests a high frequency of procedural errors 39% in all cases performed by interns. This reflects the amount of clinical knowledge and skill possessed and applied by operator during the course of the treatment. In the light of this study it is recommended that endodontic training of undergraduates should be started earlier in the undergraduate curriculum and the students should be thoroughly familiarized with endodontic instruments and techniques prior to dealing with patients. Undergraduates should be given extensive clinical exposure during their final year under the strict supervision of specialist endodontists. Further studies are essential to evaluate the performance of interns employing different types of instruments and different instrumentation techniques. Finally, it is recommended the dental graduates be aware of the complex root morphology and be supervised until they have adequate training before practicing endodontics independently.

#### CONSENT

All authors declare that written informed consent was obtained from all participants.

## ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee at Fatima Jinnah Dental College and Hospital and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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