

Radiographic Quality of Root Canal Therapy Accomplished Clinically by Undergraduate Dental Students

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Abstract

Objective: To analyze the technical quality of root canal therapy done by dental students while in clinical training. **Material and Methods:** The frequency of common technical errors was assessed using dental periapical radiographs. 870 charts (n= 870) were evaluated which involved 870. In each chart, 3 periapical radiographs were used for evaluation of the incidence rate and types of errors happening within the root canal procedure. The 3 periapical radiographs were diagnostic (pre-treatment) radiograph, working length determination radiograph, and gutta-percha and sealer (obturation) radiograph. **Results:** It was found that phase 3 (obturation phase) shows the highest frequency of errors 54.37%, followed by phase 1 (access opening) 11.84%, and finally phase 2 (root canal preparation) shows the least frequency 4.01%. **Conclusion:** This study identified that the least rate of errors in endodontic therapy happened during access opening and instrumentation when compared to obturation.

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Introduction

In the school of dentistry, one of the important requirements that should be done by the undergraduate students is the root canal therapy (RCT) [1]. This treatments involves cleaning, shaping and appropriate filling of the radicular space [2]. The main aim of the RCT is to allow healing of the periapical tissues surrounding the root of the tooth and prevent the re-infection of the radicular space [3]. The outcome of the endodontic treatment mainly rests on the quality of the procedural technique of the root canal filling (RCF) [4,5]. The common method that has been implemented to judge the quality of the root canal fillings is periapical radiographs during the different phases of the root canal therapy [6-8].

The successful root canal therapy (RCT) prevents tooth pain. It should also reduce the

risk of tooth loss and/or developing apical periodontitis [9]. Dentists should remember that in each phase of the treatment, any operative mistake may have negative effect on prognosis, as these mistakes increase the risk to failure of the entire treatment [9].

According to previous research, errors during RCT can be divided into three groups according to the treatment phase as follows [10-14]:

Phase 1 (Access opening errors):

- Gouging
- Coronal perforation
- Over preparation

Phase 2 (Cleaning and preparation errors):

- Ledge
- Transportation "zipping"
- Strip perforation
- Broken instruments
- Apical perforation

Phase 3 (Root canal obturation errors):

- Void
- Over-filling
- Under-filling

Usually, the evaluation of the RCT technical quality is based on careful radiographic examination [6,15-17].

Therefore, the current study assessed radiographically the quality of endodontic therapy done by undergraduate students through these 3 phases of treatment, while in their clinical training. The frequency of common technical errors was evaluated by multiple dental periapical radiographs.

Material and Methods

This study was done at the dental school, University of Babylon, Iraq. It was done in

agreement with the 1964 Declaration of Helsinki and its succeeding revisions. The root canal therapy was performed by under-graduate students in their fifth year of study in the clinics of the dental school under the supervision of qualified supervisors (endodontists). The RCT was performed on single-root canal treated teeth on upper and lower incisors, canines, and premolars, during 6-year period from October 2014 to October 2020.

The single-root canal teeth were endodontically treated, firstly access opening was done into the pulp space of the tooth and the dental pulp was extirpated, and then the root canal system was instrumented by K-files (Dentsply, Maillefer, Switzerland) with a 0.02 taper. The conventional step-back technique was applied. Canals irrigation was performed using normal saline and an endodontic gauge 27 syringe. Obturation of the canals was then performed by cold lateral compaction technique using standardized gutta-percha cones (Dentsply Maillefer, Switzerland) and a ZOE-based endodontic sealer (Endofill, Dentsply, Brazil).

In this study, 870 charts ($n = 870$) were evaluated which involved 870. In each chart, 3 periapical radiographs were used for the evaluation of the executed endodontic procedures in terms of types and incidence of errors. The 3 periapical radiographs were diagnostic (pre-treatment) radiograph, working length determination radiograph, and gutta-percha and sealer (obturation) radiograph. Two qualified dentists (two endodontists) assessed these radiographs on a light box x-ray viewer in dark environment [11].

A comparative evaluation between these radiographs was used to verify any errors that could have occurred during the phases of the root canal therapy. The applied parameters in this study were: no-fault cases; where there was no detected procedural mistakes and gutta percha is shorter than the radiographic apex by less than 2 mm, coronal-perforation, over preparation, gouging, strip perforation, apical perforation, broken instruments, ledging, transportation, void in the filling material, overfilling, and under filling of guttapercha [10,11].

Before conducting this study, Intra- and inter-examiner agreements were verified by values calculation of Cohen's Kappa (k) using 35 randomly chosen periapical radiographs that had been used in this study [18]. The results were 0.88 and 0.81, respectively, so both values indicated excellent intra- and inter-examiner agreements. Finally, SPSS software (version 20.0, SPSS Inc., Chicago, IL, USA) was implemented for the processing of data. Pearson's chi-square test was applied to analyze the data at $P < 0.05$.

Results

Table 1 shows that 70.33% of cases have various types of errors, but 29.77% of them have no error (normal). The various types of errors in phase 1 are 4.48% gouging and 7.36% over preparation, in phase 2 are 1.26% ledge, 0.8% strip perforation, 0.69% broken instruments and 1.26% apical perforation, and in phase 3 are 12.99% void, 4.83% overfilling and 36.55% underfilling.

It seems that the dominant type of error is the underfilling which shows the highest frequency, followed by void, over preparation, overfilling then gouging. While, ledge, apical perforation, strip perforation and broken instruments show tiny frequencies. However, the difference between all types of were significantly different, $P < 0.05$, table 2. It also seems that phase 3 (obturation phase) shows the highest frequency of errors 54.37%, followed by phase 1 (access opening) 11.84%, and finally phase 2 (root canal preparation) shows the least frequency 4.01% (Table 1).

Discussion

The accurate chemo-mechanical cleaning and shaping of the dental root canal could result in successful RCF. Any error happens during the 3 phases of the root canal therapy could affect the prognosis. In dental schools, the undergraduate students should be taught about these errors to avoid any technical error that could happen during the RCT and to improve the prognosis of the RCT.

This study paid close attention to the assessment of the quality of the RCT whether the treatment was without error (normal) or with error during all phases of the RCT. The periapical radiographs were utilized to evaluate the success of root canal therapy in patients operated by the 5th year under-graduate students at the dental school clinics of University of Babylon.

Several studies have evaluated the errors, such as gouging, ledges, apical perforation, broken instruments, underfilling, overfilling and voids which could happen during RCT treatment [10,11,16,19]. In this study, errors occurred during all the phases of the RCT, but the most frequent errors were during the third phase (obturation phase). This was followed by phase 1 (access opening), whereas phase 2 (root canal preparation) recorded the least frequency of errors.

In phase 3, the underfilling error showed the highest incidence. This could be attributed to the debris accumulating at the apical third of the root canal due to instrumentation without enough irrigation of the canal which could result in shortening of the working length and finally results in underfilling. The

other possible reason for the underfilling, is the non-complete instrumentation of the root canal which could happen from the wrong measurement of the root canal length [20].

Again, in phase 3, voids error was the next higher incidence, in which spaces could form between the gutta-percha cones. These voids might harbor pathological microorganisms. These voids could be due to not-enough condensation of the gutta-percha cones into the radicular canals [21]. In addition, the non-homogeneous mixing of the endodontic sealer could also result in these voids [22].

Finally in phase 3, the overfilling was with the least frequent error. it could have been the result of over-estimation of working length of root canal, which could end in loss of the apical stop. Generally, it has been agreed that root canal filling is preferred to be within 2 mm distance away from the radiographic apex [6,23]. Higher success rates of RCF were associated in teeth filled with root canal filling ≤ 2 mm short from the radiographic apex with decreased occurrence of apical periodontitis in comparison with teeth filled > 2 mm away from the radiographic apex [24]. According to this study, the quality of the endodontic therapy that is offered for the patient by undergraduate students is not good enough. This result is supported by the results of three previous studies [10,16,25].

Improving knowledge, training and skills of the undergraduate students is very important. This can be done by improvement of several factors such as increasing the ratio of supervisors to students and improvement of the training aids of the undergraduate students, in addition to introduction of different methods for evaluation the work of the students.

Conclusions

This study identified that the access opening phase and instrumentation phase in root canal therapy have less incidence of errors when compared with the obturation phase. Whereas, in obturation phase, the errors which recorded the highest incidence rate were underfilling, voids and then overfilling. Consequently, it is advised to enhance the practical training sessions of the RCT, especially in the last phase (obturation phase).

Ethical Approval

This study was reviewed and approved by the Research Ethical Approval Committee of the Dental School of the University of Babylon (Babylon, Iraq), with reference number (27) on (29/5/2024).

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Table1. Incidence of errors throughout root canal therapy.

	Type of error	Number (%)		
	No Error (Normal)	259 (29.77%)		
Phase 1 (Access opening)	Gouging	39 (4.48%)	11.84%	70.33%
	Over preparation	64 (7.36%)		
Phase 2 (Preparation)	Ledge	11 (1.26%)	4.01%	
	Strip perforation	7 (0.80%)		
	Broken instruments	6 (0.69%)		
	Apical perforation	11 (1.26%)		
Phase 3 (Obturation)	Void	113 (12.99%)	54.37	
	Over filling	42 (4.83%)		
	Under filling	318 (36.55%)		
	Total	870 (100%)		