

## Radiographic Evaluation of Iatrogenic Errors of Root Canal Treatments Performed in an Undergraduate Dental Clinic

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### Abstract

**Introduction:** Iatrogenic errors may occur during root canal treatments (RCTs) performed by undergraduate students. The current study explores the iatrogenic errors of RCTs made by undergraduate students at Gorgan School of Dentistry, Golestan, Iran. **Methods:** This cross-sectional study was conducted using 236 randomly selected treatment records of RCTs performed on first molars by undergraduate dental students. Periapical radiographs were independently explored for the following errors: overfilling, underfilling, ledge formation, and apical transportation. Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 17.0, and a Chi-square test at the 0.05 level of significance. **Results:** Periapical radiographs of 236 endodontically treated first molars were assessed. The results showed that 87.1% of root canals were adequately filled to the working length. Among the teeth treated by fifth- and sixth-year students, 62.5% and 66.4% of teeth were adequately filled to the working length, respectively, resulting in no statistically significant difference ( $P > 0.05$ ). In respect to the prevalence of ledge formation and apical transportation errors, there was no statistical difference either between the treatments performed by fifth- and sixth-year students ( $P > 0.05$ ) or the location of the treated tooth (mandible or maxilla) ( $P > 0.05$ ). **Conclusion:** Within the limitations of the present study, the results showed a rather low, but non-negligible prevalence of procedural errors in RCTs performed by fifth- and sixth-year undergraduate students at Gorgan School of Dentistry.

Prevalence of errors made by fifth- and six-year students was similar.

**Keywords:** Endodontics, Dental Student, Iatrogenic, Procedural Errors, radiography.

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### Introduction

Endodontic treatment procedures vary from treatments designed to maintain vitality of all or part of the dental pulp to complete excision of the pulp tissue, known as root canal treatment (RCT) which is usually indicated in cases of irreversible inflammation of the pulp or presence of an infected necrotic pulp (1).

Root canal treatment (RCT) has long been a part of curriculum in undergraduate dental education(2). Although endodontics has been recognized as a specialty for decades, reports indicate that a great proportion of RCTs are performed by general dental practitioners around the world (3,4).

Typically, students gain clinical experience by performing RCTs, supervised by a faculty member or a skilled clinician (3). Key operative steps of RCT include the following: taking a preoperative radiograph, administration of local anesthesia, isolation, access

cavity preparation, determination of working length (WL), instrumentation of the root canal system, irrigation, and filling of the root canal system (5).

When performing RCTs, iatrogenic errors may occur in any of the mentioned steps either by an experienced clinician or a dental student, which might lead to the failure of treatment or even tooth loss. Fortunately, these errors are often preventable (6).

When graduated, dentist might repeat systematic iatrogenic errors of RCT procedure, turning them into habits. Even if noticed, such errors are less prone to correction through continuing education programs (7). Therefore, it is essential to point out the most frequent errors made by dental students in order to put more emphasis on teaching the knowledge and skills needed to prevent such errors, before they turn into unfavorable habits. Therefore, the current study is performed to explore the iatrogenic errors of root canal treatment procedure made by undergraduate students at Gorgan School of Dentistry, Golestan, Iran.

## Materials and Methods

This cross sectional study was conducted using 236 randomly selected treatment records of RCTs performed by fifth- and sixth-year undergraduate dental students at Gorgan School of Dentistry during 2017-2018 academic year. The study protocol was approved by the ethics committee and vice chancellery for research and technology of Golestan university of medical sciences (approval code: 110291). Informed consent to use clinical data for scientific purposes is routinely obtained from the patients treated in the dental school. Sample size was calculated based on the data from a previous similar study performed by Haji-Hassani et al. (14) using Cochran's formula with 95% confidence level,  $\alpha = 0.05$ , 66% prevalence of students' errors, and error margin = 0.06.

Inclusion criteria were permanent maxillary and mandibular first molars, having the standard four Parallel profile radiographs (initial, working length, master cone and post-treatment), radiographs with diagnostic value, and complete root formation at the time of treatment. Exclusion criteria were missing any of the standard four radiographs, having radiographs of poor diagnostic value, root canal calcification, incomplete root formation, internal or external root resorption, and endodontic-periodontal lesions.

All teeth were prepared using conventional stainless-steel hand K-files and root canals were irrigated with 2.5% sodium hypochlorite. Standard lateral

condensation technique was used to fill the root canal with gutta-percha (Meta Biomed Co. Ltd, Korea) and AH26 sealer (Dentsply, DeTrey, Germany).

Periapical radiographs were independently explored by a final year dental student and an endodontist, for the following errors: overfilling, underfilling, ledge formation, and apical transportation. Findings were compared and a consensus was reached. In case of any disagreement, a third clinician was consulted.

Length of root canal filling was categorized as follows:

- Adequate filling: Root canal filling material ending at the radiographic apex or presence of a gap distance less than 2 mm between the end of the filling material and the radiographic apex
- Overfilling: Root canal filling material ending beyond the radiographic apex
- Underfilling: Presence of a gap distance of 2 mm or more between the end of the filling material and the radiographic apex

Length of filling was recorded for each root canal separately, and also a filling length status was reported for each tooth as a unit. If a tooth had roots categorized differently, a consensus was made to record the most significant error.

The ledge formation error was defined as deviation of the filling material from the path which was determined by WL radiograph, while the filling is at least 1 mm shorter than the WL, and apical transportation was defined as placement of the filling material, outside the curve of the root canal at the apical third (8).

Presence or absence of ledge formation and apical transportation was recorded for each tooth.

Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 17.0 (SPSS Inc., Chicago, IL, USA), and a Chi-square test at the 0.05 level of significance was utilized.

## Results

Records of 236 endodontically treated first molars, including 96 (40.7%) maxillary molars and 140 (59.3%) mandibular molars were reviewed. Eight teeth (3.4%) had four root canals and 228 (96.6%) had three root canals, so a total of 716 root canals was included. Ninety-six (40.7%) teeth were treated by fifth-year undergraduate students and 140 (59.3%) were treated by sixth-year students.

The results showed that 87.1% of root canals (64.8% of teeth) were adequately filled to the working length, while underfilling and overfilling errors were seen in 9.21% (24.6% of teeth) and 3.77% of root canals (10.6% of teeth), respectively. Prevalence of adequate filling

showed statistically significant difference in mandibular and maxillary molars, with a lower frequency in the latter ( $P = 0.012$ ), while overfilling ( $P = 0.115$ ) and underfilling ( $P = 0.058$ ) errors were not significantly different between arches (Tables I and II).

Table I: Distribution of treated root canals according to filling length

Radiographic finding	N (% of treated root canals)
Overfilling	27(3.77%)
Underfilling	66(9.21%)
Adequate	624(87.1%)
Total	716(100%)

Table II: Distribution of treated teeth with filling length errors, according to student's academic year (5<sup>th</sup>, 6<sup>th</sup>) and tooth location (mandible, maxilla)

Radiographic finding	Student's Academic level			Tooth location			Total Teeth
	5 <sup>th</sup> year	6 <sup>th</sup> year	P-value	maxilla	mandible	P-value	
adequate	60 (25.4%)	93 (39.4%)	153 (64.8%)	63 (26.6%)	90 (38.1%)	0.012	153 (64.8%)
Overfilling	9(3.8%)	16(6.7%)	$P > 0.05$	9 (3.8 %)	16 (6.7%)	0.115	25(10.6%)
Underfilling	27(11.4%)	31(13.1%)	$P > 0.05$	24(10.1%)	34(14.4%)	0.058	58(24.6%)

Among the teeth treated by fifth- and sixth-year students, 60 (62.5%) and 93 (66.4%) teeth were adequately filled to the working length, respectively, showing no statistically significant difference ( $P > 0.05$ ). While underfilling was seen in 27(28.1%) of the teeth treated by fifth-year students and 31 (22.14%) of the teeth treated by sixth-year students, and overfilling was reported in 9(9.3%) and 16(11.4%) of the teeth treated by fifth- and six-year students, respectively. Distribution of

filling length was not statistically different in fifth- and sixth-year students ( $P > 0.05$ ) (Tables II and III). Considering the prevalence of ledge formation and apical transportation errors, there was no statistical difference either between the treatments performed by fifth- and sixth-year students ( $P > 0.05$ ) or the location of teeth (mandible or maxilla) ( $P > 0.05$ ) (Table IV).

Table III: Distribution of treated teeth with ledge formation or apical transportation errors, according to student's academic year (5<sup>th</sup>, 6<sup>th</sup>) and tooth location (mandible, maxilla)

Radiographic findings	Student's Academic level			Tooth location		
	5 <sup>th</sup> year	6 <sup>th</sup> year	P-value	maxilla	mandible	P-value
Ledge formation	3(1.2%)	5(2.1%)	1.000	5(2.1%)	3(1.2%)	0.276
Apical transportation	17(7.2%)	18(7.6%)	0.353	15(6.3%)	20(8.4%)	0.853

Table IV: Distribution of filling length errors, ledge formation, and apical transportation, according to student's academic year (5<sup>th</sup>, 6<sup>th</sup>)

Radiographic findings	Student's Academic level		
	5 <sup>th</sup> year	6 <sup>th</sup> year	P-value
Ledge formation	3(3.1%)	5(3.57%)	1.000
Apical transportation	17(17.7%)	18(12.8%)	0.353
Overfilling	9(9.3%)	16(11.4%)	P>0.05
Underfilling	27(28.1%)	31(22.1%)	P>0.05
Total	96 (100%)	140 (100%)	-

## Discussion

Supervised clinical practice including root canal therapy which is performed by undergraduate dental students is essential in acquisition of necessary clinical skills (2,9).

The current study is performed to assess the iatrogenic errors of root canal treatment procedure made by undergraduate students at Gorgan School of Dentistry, Golestan, Iran.

In the present study, 87.1% of root canals were adequately filled to the working length, which is similar to the results reported by Saatchi et al (10). and Motamedi et al. (11), and higher than the results reported in some other studies (12-18). The difference might be explained by the following reasons: difference in assessment methods (eg, using magnifying lens to detect errors) (13), incorporating the bisecting angle rather than parallel profile radiographs (10), using digital imaging rather than conventional radiographic images (11), different inclusion criteria (e.g. including all types of teeth rather than only first molars) (11,13-15), incorporating different definitions for the errors (e.g. categorizing tip-to –tip fillings different from overfilling,

or setting a 1.5 mm distance as a cut-off point for filling length rather than 2 mm), and different root filling techniques (e.g. step-back rather than lateral condensation) (16).

In the current study, prevalence of adequate filling showed statistically significant difference in mandibular and maxillary molars, with a lower frequency in the latter, which is in consistency with the results from the study performed by Haji-Hassani et al., Moradi et al., Saatchi et al., and Motamedi et al. (10,11,13,14). These results suggest that students have more difficulty in achieving the adequate filling length for maxillary rather mandibular molars. Possible explanations include: more difficult access to the upper teeth, a higher dependence on indirect vision (i.e. using a dental mirror), and superimposition of the anatomic structures which makes the upper periapical radiographs less useful in deciding the accurate WL.

About 62% of the teeth treated by fifth-year students and 66% of teeth by sixth-year students were adequately filled to the working length which is comparable to the results reported by Saatchi et al. In both studies, RCTs performed by fifth-year students

included more filling length errors than treatments performed by sixth-year students, although the difference was statistically significant in Saatchi et al.'s study and not significant in the present study (10). Similarity of prevalence of errors in fifth- and six-year students suggests that more effort should be concentrated on elimination of errors with moving to senior academic year.

The prevalence of ledge formation error reported in the current study was 1.2% and 2.1% in RCTs performed by fifth- and sixth-year students, respectively, with no statistical difference according to students' academic year, which is in consistency with the results reported by Saatchi et al., (10) while Balto et al. reported a higher prevalence of ledge formation in treatments performed by fifth year students (12).

The total number of ledge formations reported in the current study was lower than the other studies (10,12,14). The difference can be explained by the fact that in case of ledge formation, students were instructed to bypass the ledge and reach the adequate WL, making the case no longer compatible with the established definition of ledge formation (deviation of the filling material from the path which was determined by WL radiograph, while the filling is at least 1 mm shorter than the WL).

Ledge formation was seen in both maxillary and mandibular molars with no statistical difference in the prevalence ( $P>0.05$ ), which is similar to the findings of Haji-Hassani et al. (14). There was also no statistical difference between the treatments performed by fifth- and sixth-year students, regarding ledge formation ( $P>0.05$ ), which is in consistency with the results reported by Balto et al. (12).

Prevalence of apical transportation was higher in mandibular teeth, although the difference was not statistically significant ( $P>0.05$ ). Hendi et al. and Vukadinov et al. also reported a higher prevalence in mandibular rather than maxillary teeth (19,20).

Limitations of the present study were as follow: all procedural errors cannot be detected using 2-dimensional radiographs (21) and the study does not include all the errors which could be radiographically detected, probable personal variance in taking the radiographs, operator-dependent interpretation of the radiographs, a relatively small sample size, and the inherent limitations of the retrospective study design.

## Conclusion

Within the limitations of the present study, the results show a rather low, but non-negligible prevalence of

procedural errors in RCTs performed by fifth- and six-year undergraduate students at Gorgan School of Dentistry. The prevalence of errors made by fifth- and six-year students was similar.

## Conflict of interest

The authors state no conflict of interest

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