

Prevalence of the root canal treatment errors and its related factors in patients treated by undergraduate dental students

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ABSTRACT

Since errors of root canal treatment can result in tooth loss, it is important to study effective factors on incident of these errors. In recent years, aiming at reducing errors of root canal treatments and improving performance of dental department in Islamic Azad University, Tehran, facilities were provided which included apex locator, teaching Passive-step back in pre-clinic period and presence of professional assistants and professors who helped students. Studying and investigating errors during treatment by students and providing proper preventative solutions increases the chance of successful treatment of patients. According to the changes in methods of teaching root canal preparation and considering benefit that annual and biennale assessment of prevalence of errors during the treatment has for studying educational performance and future planning, in this study we studied prevalence of errors during root treatment by dental students in general dentistry major and its effective factors, in order to study whether these applied changes reduced errors or not? Firstly, it is hypothesized that effective factors on this errors include quality of radiography, numbers of radiographies, patients' age, type of tooth, type of jaw, canal curvature, periapical lesion, student's semester of the study, student's gender, and numbers of treatment sessions, first treatment of root and second treatment of root. In this research 840 record of patients who had received root canal treatment in public Endodontics sector were evaluated from 2010/9/23 to 2012/09/23. Firstly, two endodontists were calibrated in order to make sure that kappa coefficient is positive and they both agreed on that, and then endodontists, separately, completed data forms pertinent to errors during root treatment and related factors. Prevalence of errors was identified in the samples and then role of associated factors was evaluated by logistic regression as statistical test. And after first evaluation of records, sample of study consists of 613 teeth (1131 canals) which out of them 567 teeth received RTC and 46 teeth received re treatment (Redo). Results indicated that there is statistical difference in frequency of errors

ARTICLE INFORMATION:

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Received 27th June, 2017

Accepted after revision 27th Sep, 2017

BBRC Print ISSN: 0974-6455

Online ISSN: 2321-4007 CODEN: USA BBRCBA



Thomson Reuters ISI ESC and Crossref Indexed Journal

NAAS Journal Score 2017: 4.31 Cosmos IF: 4.006

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Online Contents Available at: <http://www.bbrc.in/>

DOI: 10.21786/bbrc/10.4/12

during first root treatment and re treatment. In addition, factors including jaw type, tooth type, canal curvature, periapical lesion, and student's semester of study have significant effect on Non homogeneous-Exact filling length 'Transportation' 'Ledge' Over filling's error. However, numbers of treatment sessions was effective with low correlation. Comparing frequencies of errors during root treatment in this study and paper, it was clarified that adding tools such as apex locator, teaching Passive-step back in pre-clinic period and presence of professional assistants and professors who helped students reduces errors during root treatment.

KEY WORDS: DENTAL STUDENTS, RADIOGRAPHIC ENDODONTIC ERRORS, QUALITY OF ROOT CANAL TREATMENT

INTRODUCTION

Root treatment, aiming at preventing periapical periodontitis and improving periapical lesion, has been recognized as a complicated treatment in dentistry treatments. This treatment is conducted by removing necrosis pulp, infectious pulp and bacteria and via irrigation and preparing canal, mechanical cleaning and also high quality obturation. Epidemiologic studies introduced errors in mentioned procedure as the main reason of treatment failures and imposing higher costs (Lynch 2006; Mozayeni 2006; Yousuf, 2015). It has been indicated that acceptable RCT refers to treatments in which root fillings terminate within 2mm of the radiographic apex and that are of adequate homogeneous density and without void from crown to apical area (Bramanten 1987; Kulic 2011). Applied method for studying quality of root treatment is assessing PA Radiographs that are provided before and after root treatments, radiographically (Kelbauskas 2009; Mosby Co. 2009). Literature review indicated that errors rate varies from 10 to 58% in different centers while prevalence of these errors rate in academic centers (25-45%) is significantly higher than professional centers (10-16%) (Cohen 1998; Er 2006; Estrela, 2017).

Estrela1 *et al* (2017) performed a research titled as "Common Operative Procedural Errors and Clinical Factors Associated with Root Canal Treatment". They concluded that in each phase of RCT, an operative error can have adverse implication on prognosis, and these errors show that risk factors lead to failure. Akbar (2015) performed radiographic study of the endodontic treatment's problems and failures. His results illustrated that compare to anterior and premolar teeth, endodontic problems and failures were most common in molars. The most frequently canals with endodontic problems and failures included Mesio Buccal, mesiolingual and distobuccal root canals. Finally, based on results he concluded that the most common cause of endodontic treatment failure was under filling followed by poor filling and over filling and first molar was the most frequently involved tooth with endodontic problems and failures. Yousuf, *et al.*, (2015) studied endodontic procedural errors and showed that the most frequently treated tooth was right permanent mandibular first molar. The least commonly treated teeth were the permanent mandibu-

lar third molars. Bakhshi and Shahabi (2015) identified the least mistakes compared to obturation phase, with the most frequent errors including void, overfilling and imperfect cleaning.

A research was carried out by Kulic *et al* in 2011 in Serbia which indicated that 51.6% treatments were acceptable with accurate working length and homogeneity density. In Fonseka *et al* (2015) study, it was reported that 74.3% treatments were acceptable. In addition, in a research in 2008 in Islamic Azad University, endodontics department, Tehran, it was reported that 51.5% errors happened during root canal treatment while 49.5% were error-free. Most of the studies illustrated that highest error incident was occurred in posterior teeth (Bramanten CM. 1987; Eleftheriadis GI. 2005; Khabbaz M.G. 2010) and factors including increasing instruction hours reduces errors (Yousuf, W. 2015). Study and consideration of students' errors during treatment and providing appropriate preventive ways increase treatment success in patients (Bramanten CM. 1987) Recent years, facilities including apex-locator, teaching Passive-step back method in pre-clinic, presence of professional assistants and professors who helped students were added into endodontics department of Islamic Azad University in order to reduce errors during treatment.

Based on literature review (Estrela, 2017; Lynch 2006; Yousuf, 2015), popular errors during endodontic treatments are as follow:

Last years equipment including teaching Passive-step back method in pre clinic and presence of professional assistants helping students were applied in order to reduce errors during treatment in endodontic sector. According to the changes made in methods of teaching root canal preparation and considering the benefits that annual and biennale assessment of prevalence of errors during the treatment has for studying educational performance and future planning, thus due to lack of information about the subject in endodontics sector of Islamic Azad University, Tehran, and also because of differences and lacks of previous researches (Er O. 2006 and Yousuf 2015), studying students' error during treatment and providing proper methods increase chance of successful treatment of patients. This study, therefore, investigates prevalence of errors during root trees and related factors in patient referring to endodontics sector of Islamic Azad

Table 1. popular errors during endodontic treatments are as follow

	Error type	Description
1	Under filling	Space between canal obturation and radiographic apex is more than 2 mm
2	Over filling	Radiographic beyond apex filling
3	Non-homogen	Lack of homogene density of filling material from coronal area to apical area
4	Ledge	Deviation from main path of canal and creating one step in some cases is cause of underfilling
5	Transportation	Deviation from main path of canal and finding new path in root
6	Zippering	Perforation of apical area which results in reverse cone and it disrupts apical seal
7	Strip perforation	Association of pulp space with periodontal space in root branching region
8	Cervical perforation	Association of pulp space with periodontal space in cervical region of tooth
9	Forcation perforation	Association of pulp space with periodontal space in forcal region of tooth
10	Broken Instrument	Broken instrument that is not extracted from canal
11	Gouging	Over Opening cavity more than required space due to not locating grinder in longitudinal axis of tooth or futile attempt for accessing to the pulp

University, Tehran, during 2010-2012 in order to find out whether these applied changes reduced error or not?

MATERIALS AND METHODS

All people who received root treatment from 2010/9/23 to 2012/09/23 in public Endodontics sector in Islamic Azad University; Tehran belonged to the population of the current study. Then, out of endodontics sector records' list that belonged to two years and was gathered statistically, accurate records were selected and studied. In this study, research method was performed by existing data which collected by observation and filing information forms. In addition, samples were selected statistically from all treated patients by dentistry students in general coarse. Out of 840 selected records, 227 records (27%) were eliminated due to poor radiography quality (182 records, 21.6%) and lack of sufficient radiography (45 records, 5.3%).

Records that lacked final radiography, or did not contain at least both *diagnostic* and final radiography and also records that, in spite of second recording, their radiographic quality was poor were eliminated from the study. Lack of radiography quality happens due to manual radiography developing and fixing by student in public sector of endo which results in over developing the films, insufficient fixing, and lack of PA Radiographs quality. Assessing quality of student's performance in root treatment procedure was conducted in two steps including preparation and root canal obturation based on recorded radiographic images in patients' records. Nevertheless, there are 2 dimension images instead of 3 dimension structures, this system has been applied in different studies (Cohen 1998; Guttman 1997).

Assessing images of all records was conducted by two experts from university endodontic sector, separately, by microscope with at times enlargements and desktop negatoscope. Before study, observers agreed on similar interpretation for radiographic PA Radiograph after performing an experiment. Evaluators were calibrated and Kappa coefficient was reported as 0.88 which proved there is perfect coefficient of agreement among evaluators. Due to perfect coefficient of agreement among evaluators, mentioned samples were assessed again in cases with no agreement among observers. This method was utilized by Khabbaz et al. (2010).

For PA Radiograph homogenization by observers, ray radiation direction considered mesial in all radiographies. Poor radiographies were fixed again and reevaluated. Records which lacked 2 diagnostic and final radiographies were eliminated. Two endodontists conducted diagnostic and final radiographies and used microscope at five times enlargement and one negatoscope. In addition, some rare errors mentioned in the record and they were not observable in radiography but they were mentioned in the record were studied. Firstly, errors' evaluators explained errors, then coefficient of concordance (Kappa) were identified and then records' assessment was started. Evaluators were calibrated in order to make sure that Kappa coefficient is positive and they are compatible. For preventing errors of answers, each endodontist filled data forms separately and then errors that endodontist were agreed upon considered as real error. In cases that observers did not agree on, due to perfect coefficient of agreement between evaluators, mentioned samples were reassessed and evaluators agreed on that.

In epidemiologic studies, there are different standards for categorizing root treatment quality. The most prevalent parameters of acceptable treatment categorization

are length of root canal filling, filling homogenization without void, and absence of iatrogenic errors (Cohen 2006; Haji-Hassani, 2015; Mozayeni 2006). In this study, standards of determining radiographic categorization of root treatment were based on length and density of filling in the absence of iatrogenic errors and they were categorized into two acceptable and unacceptable treatments.

The filling material ends 0-2 mm shorter than radiographic apex with no visible voids within the material or between the material and root canal walls. 2) Unacceptable treatments: A) the filling material ends more than 2mm from radiographic apex or beyond the radiographic apex. B) Visible voids within or between filling material and root canal walls

1. Acceptable treatment: under filling is 0-2 mm and density of filling material is homogene with no visible void within the material or between crown and apical area. Besides no observable iatrogenic error is in patient's record and in canals.
2. Unacceptable treatment
 - a. The filling material ends more than 2mm from radiographic apex or beyond the radiographic apex
 - b. Density of filling material in not homogene and there is void between crown to apical area.
 - c. Iatrogenic error is observed in canals and it is also reported in pateint's record.

In addition, in this study we assessed demographic information of students (gender, and the semester) and factors pertinent to patient and tooth including patient

gender, age, tooth location, tooth root numbers, canal numbers, periapical radiolucencies, canal curvature and treatment sessions numbers.

RESULTS AND DISCUSSION

Results indicated that 61% first treatments (RCT) were acceptable and 39% had errors during root treatment. Acceptable treatment which consists of exact length of filling and proper density of filling and no incidence of iatrogenic errors, in anterior teeth was 75.6%, in premolar was 72% and in molars was 38.4%. Redo were acceptable for 100% cases and the most prevalent redo tooth was Mandibular second premolar. Previous short filling was identified as the most common cause of redo.

In table 2, there is information about frequency of errors during root treatment in patients who received treatment by dental students in general coarse in endodontics sector of Islamic Azad University, dentistry department, during 2010-2012. In addition, table 2 indicates frequency of errors during root treatment associated to relevant factors.

Based on table 2 and table 3 and results of logistic regression, it is concluded that:

1. 55% studied canals had curvature which it was more in molar teeth. 24.2% canals with curvature had errors during root treatment. 14.5% tooth that received RCT had periapical lesion which was more in mandibular first molar. 47% canals had periapical error during treatment.

total		Molar		premolar		anterior		Error type Tooth type
Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	
100	7	42.8	3	28.6	2	28.6	2	Broken instrument
100	40	67.5	27	20	8	12.5	5	Homogen
100	22	59	13	32	7	9	2	Nonhomogen
100	35	45.7	16	25.7	9	28.6	10	Homogen
100	28	67.8	19	21.4	6	10.8	3	Nonhomogen
100	102	60.8	62	23.5	24	15.7	16	Nonhomogen- Exact filling length Root canal
0	0	0	0	0	0	0	0	Forcal Perforation
0	0	0	0	0	0	0	0	Cervical Perforation
100	5	100	5	0	0	0	0	Strip Perforation
100	9	100	9	0	0	0	0	Strip preparation
100	25	52	13	16	4	24	6	Ledge
100	54	72.2	39	18.5	10	9.3	5	Transportation
100	4	75	3	25	1	0	0	Zippping
100	6	0	0	33.3	2	66.7	4	Gouging
100	567	35.8	203	35.9	204	28.2	160	

Table 3. related factors to errors during treatment

Related factors Error	gender		manual endo coarse			Numbers of treatment sessions				
	male	Female	two	three	four	one	two	three	Four	Five
No error	148 61.7	197 60.3	192 71.9	96 60	59 41.1	112 70.4	185 63.8	45 44.1	4 28.6	1 50
With error	92 38.3	130 39.7	75 28.1	64 40	81 57.9	47 31.6	105 36.2	57 55.9	10 71.4	1 50
Total	240	327	267	160	140	159	290	102	14	2

(A)

Related factors Error	Canal numbers				Tooth type			Jaw type	
	one	two	three	four	anterior	Premolar	molar	lower	upper
No error	205 75.3	69 67.6	64 40	9 28.1	121 75.6	147 72	78 38.4	125 53.9	221 66
With error	68 24.7	23 32.4	96 60	23 71.9	39 24.4	57 28	125 61.6	107 46.1	114 34
Total	273	92	160	32	160	204	203	232	335

(B)

Related factors error	Canal curvature		lesion PA		Patient age		
	Direct canal	Curved canal	With error	No error	Under 30	Between 30-45	Older than 45
No error	412 84.1	451 75.8	44 53	819 81.7	143 60.3	123 57.5	80 69
With error	78 15.9	144 34	39 47	183 19.3	94 39.7	91 42.5	36 31
Total	490	335	83	1002	237	214	116

(C)

- 39.7% treatments conducted by female students and 38.3% performed by male students had errors during the treatment. But there was no significant difference between students' gender and errors during treatment ($p > 0.05$).
- 71.4% four sessions treatment and 29.1% one session treatment had errors during the treatment. It means that there was significant difference between errors rate during treatment and treatment sessions number ($p < 0.001$). However, considering correlation coefficient ($\phi = 0.21$), this relationship was poor.
- Considering root treatment error, there was significant difference between two jaws ($p = 0.004$). Regarding that its incidence in mandibular teeth was significantly more than maxillary teeth (34%). Considering correlation coefficient, $\phi = -0.12$, this error was more prevalent in mandibular than upper jaw.
- Error incidence rate by students in manual endo coarse 2 was identified 28.1%, by manual endo coarse 3 was 40%, and by manual endo coarse 4 was 57.1%, which indicated that there is significant relationship between errors during treat-

ment and students study in manual endo coarse ($p < 0.001$) and considering correlation coefficient, $\phi = 0.52$, this relationship was average.

In addition, results obtained from prevalence of errors during treatment indicated that:

- Non homogen-Exact filling length was identified in 13.4% canals (145 canal) as the most prevalent error in root filling procedure (filling with in adequate quality in exact length of function). This error was significantly more prevalent in molar teeth canal (60.8%) than premolar and anterior teeth ($p < 0.001$) but considering correlation coefficient, $\phi = 0.25$, this relationship was poor. This error was 35.3% in mandibular molars and 25.5% in maxillary molars. Highest prevalence was identified in mandibular molars and mesiobacal canal (18%) and then it was observed in mesiolingual (17.2%).
- In field of errors during root canal preparation, the most common error was transportation which was observed in 9.5% teeth (54 teeth) highest rate of this error happened among molars which prevalence rate was 72.3% and highest prevalence happened in mesiobacal canal of mandib-

- ular first molar. There was significant relation between transport and canal curvature ($p < 0.05$). However, considering correlation coefficient, $\phi = 0.1$, this relation was weak. There was significant difference in transport incidence among molar teeth (72.2%) and premolars (18.5%) and anteriors (9.3%) ($p < 0.05$).
- c. Second prevalent error during canal preparation was ledge which was observed 4.4% of total teeth. There was significant relation between canal ledge and curvature ($p < 0.05$) however considering correlation coefficient, $\phi = 0.06$, this relation was poor. In molar teeth, error prevalence was 52% which was more than pre molar and anterior teeth. In addition, ledge prevalence was significantly higher in mandibular (40%) than maxillary (12%) ($P < 0.005$). Highest rate of error happened in first mandibular (32%) and mesial root and it is observed equally in mesiobasal canals (25.6%) and mesiolingual (25.6%).
 - d. Over filling has been studied in 6.8% canals and it was identified that 4.2% were over homogeneous and 2.6% were over non-homogeneous. The highest prevalence rate happened in mesiolingual canals of mandibular molars. Significant difference was observed in overfilling and teeth with periapical lesion ($p < 0.05$) however considering correlation coefficient, $\phi = 0.08$, this relation was very poor.
 - e. Foracal Perforation and Cervical Perforation were not observed. 6 Strip Perforation cases, 7 Broken Instrument cases, 4 zipping cases, 6 Gouging cases and 9 Strip Preparation cases were identified and there was not significant relationship with related factors.

In this study, maximum error happened in root filling step, Non homogen-Exact filling length (filling with inadequate quality in exact length of function) and the most prevalent error in field of errors during root canal preparation was transportation error. Second prevalent error during canal preparation was ledge. In this study, 613 teeth including 1131 canal were evaluated which consists of 567 teeth which received RCT and 46 teeth received retreatment. Acceptable treatment in anterior teeth was 75.6%, 72% in premolars and 38.2% in molars. 100% redo were identified as acceptable treatment and the most prevalent retreated tooth was mandibular second premolar and under-filling was identified as the most prevalent cause of retreat.

In this study, similar to Kulic *et al* (2011), multi root teeth which had error during treatment, even in one canals, was considered as unacceptable treatment. Unal *et al* (2011) reported highest prevalence of acceptable

treatment in anterior teeth was 90.1% and the least prevalence was reported in 46.6% molars. In 71% anterior teeth, 61% premolars and 30% molars were reported as acceptable treatment prevalence by Khabbaz *et al* (2010). In current study, 61% treatments were acceptable and 39% treatment were unacceptable. Acceptable treatment in anterior teeth was 75.6%, in premolars was 72% and in molars was 38.2%.

Mozayeni *et al* (2006) reported that the most prevalent error during root canal preparation was transportation. In addition, Dadresanfar *et al* (2008) reported that transport prevalence was 27.5%. Statistical difference of these findings can be due to applying Passive-step back preparation method in pre clinic course, applying Gates-Gliden drills for coronal preparation of root which reduces coronal interferences from deviation of first path canal and also due to professional assistance and their help to students. High prevalence of transportation in molar teeth its significant difference with anterior and pre molar teeth can be due to complicated anatomy of these teeth, high numbers of canals and curvature of canals in these teeth. There was significant statistic relationship between root canal curvature and transportation which shows there is potential effect of root canal curvature on canal displacement. Lack of attention to canal curvature, not providing Pre curve to files during preparation of curved canals and lack of removing interferences of root canal Orifices can be reasons of high transportation rate in canals.

Second prevalent error during anal preparation was ledge. Al-Kahtani *et al* reported that ledge prevalence was 7.5% which is compatible with current study. Eleftheriadis *et al* reported that ledge prevalence in molars were 34.9% which is caused by step-back technic and curvature of molar canals. Less prevalent of ledge in this study can be due to using other canal preparation technics including Passive-step back and applying files with higher flexibility such as Flexo File by dentistry students. The most prevalent error during root filling was Non homogen-Exact filling length. More errors in molars can be because of lack of adequate access of students to these teeth and in adequate canal flaring which is caused by their stress for bad incidents. Because inadequate canal flaring prevents suitable penetration of spreader, especially stainless spreaders, which will cause bad filling density.

Er *et al* (2006) reported that 48.8% filling had inadequate density. In addition, Khabbaz *et al* (2010) stated that 33.5% filling had inadequate density and Kulic L *et al* (2011) in 25% and Dadresanfar *et al* reported that 29.2% filling had inadequate density. Statistical difference of these results with mentioned studies can be stemmed from increase of assistants and professors'

numbers and continuous study of patients during treatment by professors via providing constancy control radiographies during obscuration which reduces prevalence of errors during canal filling.

Maximum error prevalence of over filling was found in mesiolingual canal of mandibular molars and there was significant statistical difference between overfilling and teeth with periapical lesion, because periapical lesion root top resorption so students cannot deal with length control easily then it ends to overfilling. Kelbaskas *et al* (2009) reported that 5.42% had overfilling which was compatible with this study. Kulic *et al* (2011) reported 3.3% overfilling which this low prevalence can be due to less numbers of their samples (306 canal). Er *et al* (2006) reported 13% overfilling cases and Khabbaz *et al* reported 22.6% overfilling. Statistical difference of current studies with those can be due to studying more canals in samples (1109 canals).

Highest rate of underfilling error happened in Mesio-basal canal of mandibular molars. It can be due to higher rate of transportation and ledge in molars which results in diversion from main canal path and interference in filling steps. In addition in Step-back technic there is possibility of debris and dentin debris packaging in apex top so there is no way for filling with exact length. Kelbaskas *et al* (2009) reported that in 10.5% cases, underfilling happened. They also reported that the main reason is ledge and debris packaging.

CONCLUSION

It seems that using tools such as apex locator, presence of professional assistants and attention of professors of the related sector and also applying Passive-Step back in curved canals by some students reduces preparation error rate and errors of root canal filing. However utilizing more flexible files, emphasizing on before-during and after treatment radiographies, meticulous supervision of professors during treatment and presence of lower semester students with higher semester students and professional assistants in third and second year of experience could be considered as a guide for increasing quality of root treatments and reducing errors.

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