

Endodontic procedural errors by students in two Saudi dental schools

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ABSTRACT

Objective: To explore endodontic procedural errors committed by undergraduate dental students in King Khalid University (KKU), Abha and AlFarabi dental college, Riyadh.

Methods: In this cross sectional study, a questionnaire was distributed to 500 dental students from both schools and of both genders in the 5th and 6th levels in the academic year 2016–2017. Participants were asked to record their endodontic procedural error(s) that had occurred during training.

Results: Returned and eligible questionnaires were 469 (93.8% response rate) and were almost equally distributed by university (KKU and Alfarabi). The participants' age ranged from 22 to 24 years, and approximately 47% of them were female students and 65% were 6th level students. Almost 56% of the sample reported at least one endodontic procedural error during their training. Female students reported errors (65%) more frequently than the male students (49%; $P=0.002$). Up to 54% of these errors were in the posterior teeth and 65% were in teeth with curved roots. Most common error during access cavity preparation was gouging (68%) and due to instrumentation was ledge formation (47%), during obturation was voids (41%). There were no differences in the reported endodontic errors between the two universities.

Conclusion: The frequency of reported endodontic procedural errors by senior dental students in both schools, more specifically those in the 6th year, is high. Ledge formation and voids in the root canal filling are the most frequently reported endodontic errors.

Keywords: Dental students, endodontics, procedural errors, teaching

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HIGHLIGHTS

- The frequency of endodontic errors among undergraduate dental students appears to be high with conventional endodontic education.
- Endodontic errors are most common in posterior teeth because of the presence of curved roots, narrow canals, and very complex anatomy and variable morphology.
- The most common endodontic procedural errors were ledge formation and voids in the root canal filling.
- Endodontic errors were reported more frequently by female students possibly because of their lower levels of confidence than male students.

INTRODUCTION

Similar to other disciplines in dentistry, endodontics could be associated with some unforeseen or unwanted challenges that can affect prognosis of treatment. The root canal system has a very complex and variable morphology. This causes challenges to a dental student by whom errors may commonly occur. Endodontic procedural errors, such as missed canals, ledge formation, zipping, broken files, perforations and voids formation in the root canal filling, are considered as some of the causes

for endodontic failure. (1) Such errors during any stage of root canal treatment (access cavity preparation, instrumentation, and obturation) will complicate the treatment and ultimately may lead to failure of treatment. (1-3)

Among the causes of poor quality endodontic treatment in general practice are lack of expertise and poor understanding of the principles by graduated dentists. (4) In 2013, a survey study was conducted to evaluate endodontic errors among undergraduate dental students in two dental schools in Riyadh, Saudi Arabia; the reported percentage of endodontic errors was 68%. (5) According to the findings of a study by Nejad et al, (6) students had a high level of knowledge about treatment and prognosis of procedural errors; however, they reported lower knowledge about

causes and prevention. On the other hand, Donnelly et al (7) reported that auditing the work of undergraduate students on a regular bases ensures that an adequate standard of treatment is being conveyed. It has been stated that no minimum level of knowledge or skill-based input for dental student can be deemed acceptable. (8)

Exploration of procedural errors committed by students in endodontics has not yet been fully evaluated. It is important that students provide feedback that could be informative for evaluating and improving students' work and correct their mistakes. Improvement in educational programs, achieved by studying the quality of root canal treatment and prevalence of endodontic procedural errors, would lead to improvement in oral health-related quality and success. (9) Therefore, in this study, we aimed to explore endodontic procedural errors occurring during conventional root canal treatment performed by undergraduate students attending King Khalid University (KKU), Abha and Alfarabi dental college, Riyadh.

MATERIALS AND METHODS

This is a cross sectional survey study involving senior undergraduate dental students attending two dental schools in Saudi Arabia during the academic year 2016–2017: one govern-

mental, King Khalid University (KKU), Abha, and one private, Alfarabi, dental college, Riyadh. The study was approved by the research and ethics committees of both universities No: SRC/ETH/2015-16/015.

A well-structured, pre-validated questionnaire (5) with slight modifications was distributed to 500 male and female dental students in the 5th and 6th levels in 2016-2017 academic year in both colleges. Participation was voluntary, and confidentiality of participants' data was guaranteed.

The questionnaire was composed of twenty closed-ended questions in two parts. In the first part, students were asked about the schools they attend, their academic level, gender, age, and whether they had committed any endodontic errors. The students whose answer for the last question was "no" did not complete the questionnaire (second part). The second part included questions related to types of endodontic errors, academic level at which these errors occurred, jaw position and anatomy of the tooth/teeth, and the step(s) during which these errors happened.

Statistical analysis:

Completed questionnaires were input in to excel file. Data were coded and analyzed by IBM SPSS program for Windows,

TABLE 1. Distribution of endodontic errors and types of endodontic errors for the whole sample and by gender

Factor		Gender		P value	All %
		Males	Females		
Study level	5th year	107 (43.3)	57 (25.7)	< 0.001	164 (35%)
	6th year	140 (56.7)	165 (74.3)		
Endodontic Error	Yes	121 (49)	141 (63.5)	0.002	262 (56%)
	No	126 (51)	81 (36.5)		
Arch	Maxillary	65 (53.7)	70 (49.6)	0.794	135 (51.5%)
	Mandibular	55 (45.5)	70 (49.6)		
	Both	1 (0.8)	1 (0.7)		
Area	Anterior	19 (15.8)	21 (14.9)	0.704	40 (15.2%)
	Premolar	34 (28.3)	44 (31.2)		
	Posterior	66 (55)	76 (53.9)		
	More than one area	1 (0.8)	0 (0)		
Tooth anatomy	Curved root/s	76 (62.8)	94 (66.7)	0.005	170 (65%)
	Short root/s	20 (16.5)	27 (19.1)		
	Abnormal root anatomy	22 (18.2)	20 (14.2)		
	More than one anatomy	3 (2.5)	0 (0)		
Access cavity errors	Yes	36 (29.8)	42 (29.8)	1	78 (30%)
	No	85 (80.2)	99 (88.2)		
Types of access cavity errors	Furcation perforation	16 (44.4)	9 (21.4)	0.030	25 (32.1%)
	Gouging	20 (55.6)	33 (78.6)		
Instrumentation errors	Yes	74 (61.2)	81 (57.4)	0.542	155 (59%)
	No	47 (38.8)	60 (42.6)		
Types of instrumentation errors	Ledge	34 (45.9)	39 (48.1)	0.020	73 (47.1%)
	Apical perforation	17 (23)	32 (39.5)		
	Broken instrument	20 (27)	9 (11.1)		
	More than one error	3 (4.1)	1 (1.2)		
Obturation errors	Yes	98 (81.7)	105 (74.5)	0.163	203 (77.5%)
	No	22 (18.3)	36 (25.5)		
Types of obturation errors	Overfilled	24 (24.5)	29 (27.6)	0.094	53 (26.1%)
	Underfilled	25 (25.5)	17 (16.2)		
	Voids	34 (34.7)	50 (47.6)		
	More than one error	15 (15.3)	8 (7.6)		

Version 21.0. (Armonk, NY: IBM Corp). Chi-square test (X^2) was used for comparing the occurrence of endodontic errors by different variables. The significance level was set at $P < 0.05$.

RESULTS

The sample comprised 469 Saudi dental students, which represented a 93.8% response rate. The participants were almost equally distributed by university (KKU and Alfarabi), and their age ranged from 22 to 24 years. Forty-seven percent of the whole sample comprised female students, and 65% were 6th level students.

Results are presented in Tables 1, 2, and 3. Fifty-six percent of the sample reported at least one endodontic error. These errors were almost equally distributed by arch. Up to 54% of these errors were in the posterior teeth and 65% were in teeth with curved canal(s). Among the reported endodontic errors, access cavity, instrumentation, and obturation errors were reported by 30%, 59%, and 77.5% participants, respectively. Most common error during access cavity preparation was "gouging" ($\approx 68\%$), related to instrumentation was "ledge"

($\approx 47\%$), and during obturation was "voids" ($\approx 41\%$). Endodontic errors were reported more frequently by female students ($\approx 65\%$) than by male students (49%, $P = 0.002$), and by 6th level students ($\approx 65\%$) than by 5th level students ($\approx 38\%$, $P < 0.001$). However, there was no significant difference in the reported endodontic errors by university.

Errors due to curved canals were significantly higher among female students ($\approx 67\%$) than among male students ($\approx 63\%$) in contrast to that for errors due to "abnormal root anatomy" (14% vs. 18%, respectively; $P = 0.005$). Similarly, the distribution of types of access cavity errors and types of instrumentation errors were significantly different by gender (Table 1).

Errors in the posterior area were higher among King Khalid University students ($\approx 66\%$) than among their peers ($\approx 43\%$) in contrast to that for errors in the anterior areas ($\approx 9\%$ vs. $\approx 21\%$; respectively; $P = 0.002$). Distributions of types of access cavity, instrumentation, and obturation errors were significantly different by university (Table 2).

Instrumentation errors were reported more frequently by 6th level students ($\approx 63\%$) than by 5th level students ($\approx 48\%$,

TABLE 2. Distribution of endodontic errors and types of endodontic errors by university

Factor		University		P value
		KH	F	
Study level	5th year	120 (51.3)	44 (18.7)	< 0.001
	6th year	114 (48.7)	191 (81.3)	
Gender	Males	127 (54.3)	120 (51.1)	0.486
	Females	107 (45.3)	115 (48.9)	
Endodontic Error	Yes	128 (54.7)	134 (57)	0.613
	No	106 (45.3)	101 (43)	
Arch	Maxillary	59 (46.1)	76 (56.7)	0.069
	Mandibular	69 (53.9)	56 (41.8)	
	Both	0 (0)	2 (1.5)	
Area	Anterior	12 (9.4)	28 (20.91)	0.002
	Premolar	31 (24.4)	47 (35.1)	
	Posterior	84 (66.1)	58 (43.3)	
	More than one area	0 (0)	1 (0.7)	
Tooth anatomy	Curved root/s	84 (65.6)	86 (64.2)	0.284
	Short root/s	21 (16.4)	26 (19.4)	
	Abnormal root anatomy	23 (19)	19 (14.2)	
	More than one anatomy	0 (0)	3 (2.2)	
Access cavity errors	Yes	45 (35.2)	33 (24.6)	0.062
	No	83 (64.8)	101 (75.4)	
Types of access cavity errors	Furcation perforation	10 (22.2)	15 (45.5)	0.030
	Gouging	35 (77.8)	18 (54.5)	
Instrumentation errors	Yes	72 (56.3)	83 (61.9)	0.349
	No	56 (43.8)	51 (38.1)	
Types of instrumentation errors	Ledge	41 (56.9)	32 (38.6)	0.002
	Apical perforation	25 (34.7)	24 (28.9)	
	Broken instrument	6 (8.3)	23 (27.7)	
	More than one error	0 (0)	4 (4.8)	
Obturation errors	Yes	92 (72.4)	111 (82.8)	0.043
	No	37 (28.9)	23 (17.2)	
Types of obturation errors	Overfilled	35 (38)	18 (16.2)	0.000
	Underfilled	15 (16.3)	27 (24.3)	
	Voids	41 (44.6)	43 (38.7)	
	More than one error	0 (0)	23 (20.7)	

TABLE 3. Distribution of endodontic errors and types of endodontic errors by academic level

Factor		Study level		P value
		5th level	6th level	
Endodontic Error	Yes	63 (38.4)	199 (65.2)	< 0.001
	No	101 (61.6)	106 (34.8)	
Arch	Maxillary	35 (55.6)	100 (50.3)	0.583
	Mandibular	28 (44.4)	97 (48.7)	
	Both	0 (0)	2 (1)	
Area	Anterior	13 (21)	27 (13.6)	0.069
	Premolar	24 (38.7)	54 (27.1)	
	Posterior	25 (40.3)	117 (58.8)	
	More than one area	0 (0)	1 (0.5)	
Tooth anatomy	Curved root/s	37 (58.7)	133 (66.8)	0.664
	Short root/s	14 (22.2)	33 (16.6)	
	Abnormal root anatomy	11 (17.5)	31 (15.6)	
	More than one anatomy	1 (1.6)	2 (1)	
Access cavity errors	Yes	16 (25.4)	62 (31.2)	0.384
	No	47 (74.6)	137 (68.8)	
Types of access cavity errors	Furcation perforation	3 (18.3)	22 (35.5)	0.201
	Gouging	13 (81.3)	40 (64.5)	
Instrumentation errors	Yes	30 (47.6)	125 (62.8)	0.032
	No	33 (52.4)	74 (37.2)	
Types of instrumentation errors	Ledge	21 (70)	52 (41.6)	0.007
	Apical perforation	9 (30)	40 (32)	
	Broken instrument	0 (0)	29 (23.2)	
	More than one error	0 (0)	4 (3.2)	
Obturation errors	Yes	46 (74.2)	157 (78.9)	0.437
	No	16 (25.8)	42 (21.1)	
Types of obturation errors	Overfilled	17 (37)	36 (22.9)	0.075
	Underfilled	7 (15.2)	35 (22.3)	
	Voids	21 (45.7)	63 (40.1)	
	More than one error	1 (2.2)	22 (14)	

$P=0.032$). Up to 70% of 5th level students reported having "ledge" errors while doing endodontic treatment in comparison to $\approx 42\%$ of the 6th level students ($P=0.007$, Table 3).

DISCUSSION

Dental practitioners, in general, and dental students, more specifically, consider root canal treatment as a complex, difficult, and stressful procedure. It requires understanding the root canal morphology and its variations to avoid any procedural errors. In this study, we found that 54% of procedural errors occurred in teeth in the posterior area and 65% errors occurred in teeth with curved roots. These results are similar to those obtained by Alhekeir et al (5). Balto et al (10) reported similar results based on radiographic evaluation of teeth treated endodontically by dental students. This can be simply attributed to the higher frequency of narrow and curved canals in posterior teeth causing challenges for students. This was supported by a recent meta-analysis (11) which included 12 studies (12-23) and confirmed that the frequency of unacceptable root fillings significantly increased with the posterior position of the tooth.

The manual step-back technique of root canal instrumentation using stainless steel K-files is used for teaching endodontics to undergraduate dental students at both schools. It involves preparation of the apical third of the root canal. Typically, stainless steel files in sizes above # 15 or 20 become inflexible and hence, they have a tendency to straighten causing devi-

ation from the original canal shape. This ultimately results in over-cutting on the outer wall in the apical region causing zip-ping, ledging, perforation, or canal transportation. It also results in blockage of canals by dentine debris. (24)

In this survey, we found that up to 64% of female students performed endodontic procedural errors. This result differs from the results reported by Alhekeir et al (5). Other studies evaluated the technical quality of root filling performed by undergraduate students and found no gender-related differences in endodontic treatment outcomes. (10, 25, 26) In our study, the difference in errors by gender, with male students reporting lower errors compared to females, may be explained by their higher confidence than female students. However, overall results from different studies were not consistent regarding difference in errors reported based on the gender.

In the present study, "ledge" was the most common instrumentation error ($\approx 47\%$) reported by students of both genders. This is similar to what was reported elsewhere, (10, 13, 15, 17, 18, 27-29) although these studies were based on evaluation of radiographic films. On the other hand, this type of instrumentation error was reported less frequently by Alhekeir et al (5) probably because they assessed radiographic films of teeth treated endodontically by students. These radiographs provide only a two-dimensional view. In this study, however, students were asked if they had ledged the canals during their practical sessions.

For easy work and to decrease the incidence of iatrogenic errors, the crown-down technique with apical patency has been suggested for undergraduate students. This technique depends on the use of larger instruments at the canal orifice during preparation. Working down the root canal is accomplished with progressively smaller files. The apical portion of the canal is maintained free of debris by recapitulation with a small file through the apical foramen. (30-32) This offers numerous advantages including straighter line access to the apical part of root canals, better tactile sensation, and facilitation of irrigation in the apical thirds of the canal. Using this technique, most of the errors that occur during root canal instrumentation can be avoided. (32-34)

In the current study, there was no significant difference in the reported endodontic errors among the two university, and this result is in agreement with that obtained by Alhekeir et al (5). In our study, endodontic errors were more frequently reported by 6th level students than by 5th level students. This result is contradictory to that obtained by Alhekeir et al (5). This is can be attributed to the fact that students in 6th level started treatment of posterior teeth which have a more complex anatomy (variations) due to narrow and curved canals. These anatomical variations make root canal treatment more challenging for these students. In addition, students in the 6th level had already treated more root canal cases than 5th level students.

The most common obturation error in this study was voids (41.4%), similar to that reported by Alhekeir et al (5). Moreover, this finding was in agreement with that by others (10, 22, 35-37) whose assessment was based on radiographs. Generally, "voids" is the most common procedural errors reported in majority researches. This might be due to misuse of spreader during condensation of gutta-percha, displaced accessory gutta-percha in the root canal, and inappropriate sizes of the spreader and accessory cone.

Dental students at both schools start learning the preclinical endodontics course during the 4th year (two academic semesters). The course consists of a 2-credit hours/week in which they perform technical aspects of the root canal treatment on plastic and extracted teeth. The clinical endodontic course is taken in the 5th year (two academic semesters) and it also consists of 2-credit h/week. In the 6th year, endodontic treatments are performed as part of a comprehensive clinical dentistry course as per cases and under the supervision of specialists. Both schools teach the manual step-back technique to their undergraduate students, using stainless steel files for instrumentation and cold lateral compaction technique for root filling. These techniques are most widely taught and used in dental schools. (32) Main factors that affect teaching endodontics are patients' absenteeism and/or delays, selection of patients, preclinical and clinical training, type of technique employed, and teachers' attitudes during endodontic treatment. (38)

In a recent systematic review on radiographic evaluation of teeth endodontically treated by dental students, Ribeiro et al (11) concluded that the frequency with which undergraduate students were able to perform root fillings of an acceptable technical quality was quite low (48.75%). This further appears

to significantly decrease with the posterior position of the tooth. Ledges, furcation perforations, apical transportations, and apical perforations were the most common errors found in the root fillings performed by dental students. The assessment indicates that the undergraduate students are acquiring limited confidence and competence to perform satisfactory root fillings, thereby revealing that endodontic education is only partially achieving its goals. Staff responsible for endodontic education and training needs to discuss the steps to be taken to improve the quality of root canal treatment.

A recent study has emphasized the importance of teaching new technologies (7) in endodontics; it argued that this will lead to a substantial improvement in technical quality and standards of root canal treatment performed by undergraduate students. Hence, it is time that dental schools that are still teaching conventional endodontic methods to turn into incorporating and teaching new technologies (rotary nickel-titanium files, apex locators, and greater-taper gutta-percha points) in their curricula (7). Teaching endodontics is a substantially more challenging academic task than teaching in other dental fields. A comprehensive review must be initiated to stand on the shortage of endodontic teaching along with radical modifications and new strategies that must be employed in this context.

Through intensive awareness of complications and variations in root canal anatomy, excellent training, and sufficient clinical instructors, endodontic procedural error can be prevented. Furthermore, it is believed that the use of the crown-down technique with flexible nickel-titanium files could result in less procedural accidents.

CONCLUSION

Within the limitations of this study, the frequency of endodontic procedural errors committed by undergraduate dental students is high in both King Khaled and Al Farabi universities.

Disclosures

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