Endodontic Procedural Errors by Students in Two Saudi Dental Schools

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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

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

| TABLE 1. Distribution of endodontic errors and types of endodontic errors for the whole sample and by gender |
|-----------------|-----------------|----------------|----------------|----------------|
| Factor          | Gender          | P value | All % |
| Study level     | Gender          | P value | All % |
| 5th year        | Males (43.3)    | 0.001   | 164 (35%) |
|                 | Females (25.7)  |         | 305 (65%) |
| 6th year        | Males (56.7)    |         | 262 (56%) |
|                 | Females (74.3)  |         | 207 (44%) |
| Endodontic error| Yes (121 (49))  | 0.002   | 135 (51.5%) |
|                 | No (126 (51))   |         | 78 (29.7%) |
| Arch            | Maxillary (65 (53.7)) | 0.794 | 135 (51.5%) |
|                 | Mandibular (55 (45.5)) |         | 125 (47.7%) |
|                 | Both (1 (0.8))  |         | 2 (0.8) |
| Area            | Anterior (19 (15.8)) | 0.704 | 40 (15.2%) |
|                 | Premolar (34 (28.3)) |         | 78 (29.7%) |
|                 | Posterior (66 (55)) |         | 142 (54.1%) |
|                 | More than one area (1 (0.8)) |         | 1 (1%) |
| Tooth anatomy   | Curved root/s (76 (62.8)) | 0.005 | 170 (65%) |
|                 | Short root/s (20 (16.5)) |         | 47 (18%) |
|                 | Abnormal root anatomy (22 (18.2)) |         | 42 (16%) |
|                 | More than one anatomy (3 (2.5)) |         | 3 (1%) |
| Access cavity errors | Yes (36 (29.8)) | 1 | 78 (30%) |
|                 | No (85 (80.2))  |         | 184 (70%) |
| Types of access cavity errors | Furcation perforation (16 (44.4)) | 0.030 | 25 (32.1%) |
|                 | Gouging (20 (55.6)) |         | 53 (67.9%) |
| Instrumentation errors | Yes (74 (61.2)) | 0.542 | 155 (59%) |
|                 | No (47 (38.8))  |         | 107 (41%) |
| Types of instrumentation errors | Ledge (34 (45.9)) | 0.020 | 73 (47.1%) |
|                 | Apical perforation (17 (23)) |         | 49 (31.6%) |
|                 | Broken instrument (20 (27)) |         | 29 (18.7%) |
|                 | More than one error (3 (4.1)) |         | 4 (2.6%) |
| Obturation errors | Yes (98 (81.7)) | 0.163 | 203 (77.5%) |
|                 | No (22 (18.3))  |         | 58 (22.5%) |
| Types of obturation errors | Overfilled (24 (24.5)) | 0.094 | 53 (26.1%) |
|                 | Underfilled (25 (25.5)) |         | 42 (20.7%) |
|                 | Voids (34 (34.7)) |         | 84 (41.4%) |
|                 | More than one error (15 (15.3)) |         | 23 (11.3%) |
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” (=68%), related to instrumentation was “ledge” (=47%), and during obturation was “voids” (=41%). Endodontic errors were reported more frequently by female students (=65%) than by male students (49%, P=0.002), and by 6th level students (=65%) than by 5th level students (=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 (=67%) than among male students (=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 (=66%) than among their peers (=43%) in contrast to that for errors in the anterior areas (=9% vs. =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 (=63%) than by 5th level students (=48%, P=0.032). Up to 70% of 5th level students reported having “ledge” errors while doing endodontic treatment in comparison to ≈42% of the 6th level students (P=0.007, Table 3).

### Table 2. Distribution of endodontic errors and types of endodontic errors by university

| Factor                        | University | P value |
|-------------------------------|------------|---------|
| Study level                   |            |         |
| 5th year                      | KH 120 (51.3) | 44 (18.7) | <0.001 |
|                              | F 114 (48.7) | 191 (81.3) |         |
| 6th year                      | KH 127 (54.3) | 120 (51.1) | 0.486 |
|                              | F 107 (45.3) | 115 (48.9) |         |
| Gender                        |            |         |
| Males                         | KH 127 (54.3) | 120 (51.1) | 0.486 |
|                              | F 107 (45.3) | 115 (48.9) |         |
| Females                       | KH 128 (54.7) | 134 (57) | 0.613 |
|                              | F 106 (45.3) | 101 (43) |         |
| Endodontic error              |            |         |
| Yes                           | KH 128 (54.7) | 134 (57) | 0.613 |
|                              | F 106 (45.3) | 101 (43) |         |
| No                            | KH 105 (44.3) | 84 (35.4) | 0.284 |
|                              | F 102 (43.8) | 87 (36.2) |         |
| Arch                          |            |         |
| Maxillary                     | KH 59 (46.1) | 76 (56.7) | 0.069 |
|                              | F 69 (53.9) | 56 (41.8) |         |
| Mandibular                    | KH 69 (53.9) | 56 (41.8) |         |
|                              | F 69 (53.9) | 56 (41.8) |         |
| Both                          | KH 0 (0) | 2 (1.5) | 0.002 |
|                              | F 0 (0) | 1 (0.7) |         |
| Area                          |            |         |
| Anterior                      | KH 12 (9.4) | 28 (20.91) | 0.002 |
|                              | F 31 (24.4) | 47 (35.1) |         |
| Premolar                      | KH 84 (66.1) | 58 (43.3) | 0.284 |
|                              | F 56 (43.8) | 87 (56.7) |         |
| Posterior                     | KH 84 (66.1) | 58 (43.3) | 0.284 |
|                              | F 56 (43.8) | 87 (56.7) |         |
| More than one area            | KH 0 (0) | 1 (0.7) | 0.002 |
|                              | F 0 (0) | 1 (0.7) |         |
| Tooth anatomy                 |            |         |
| Curved root/s                 | KH 84 (65.6) | 86 (64.2) | 0.284 |
|                              | F 21 (16.4) | 26 (19.4) |         |
| Short root/s                  | KH 23 (19) | 19 (14.2) | 0.062 |
|                              | F 0 (0) | 3 (2.2) |         |
| Abnormal root anatomy         | KH 23 (19) | 19 (14.2) | 0.062 |
|                              | F 0 (0) | 3 (2.2) |         |
| More than one anatomy         | KH 0 (0) | 1 (0.7) | 0.002 |
|                              | F 0 (0) | 1 (0.7) |         |
| Access cavity errors          |            |         |
| Yes                           | KH 45 (35.2) | 33 (24.6) | 0.062 |
|                              | F 83 (64.8) | 101 (75.4) |         |
| No                            | KH 10 (22.2) | 15 (45.5) | 0.030 |
| Types of access cavity errors |            |         |
| Furcation perforation         | KH 35 (77.8) | 18 (34.5) | 0.349 |
|                              | F 25 (34.7) | 24 (28.9) |         |
| Gouging                       | KH 72 (56.3) | 83 (61.9) | 0.349 |
|                              | F 56 (43.8) | 51 (38.1) |         |
| Instrumentation errors        |            |         |
| Yes                           | KH 56 (43.8) | 51 (38.1) | 0.349 |
|                              | F 56 (43.8) | 51 (38.1) |         |
| No                            | KH 41 (56.9) | 32 (38.6) | 0.002 |
| Types of instrumentation errors |        |         |
| Ledge                         | KH 41 (56.9) | 32 (38.6) | 0.002 |
|                              | F 25 (34.7) | 24 (28.9) |         |
| Apical perforation            | KH 25 (34.7) | 24 (28.9) | 0.002 |
|                              | F 25 (34.7) | 24 (28.9) |         |
| Broken instrument             | KH 6 (8.3) | 23 (27.7) | 0.002 |
|                              | F 6 (8.3) | 23 (27.7) |         |
| More than one error           | KH 0 (0) | 1 (0.7) | 0.002 |
|                              | F 0 (0) | 1 (0.7) |         |
| Obturation errors             |            |         |
| Yes                           | KH 92 (72.4) | 111 (82.8) | 0.043 |
|                              | F 37 (28.9) | 23 (17.2) |         |
| No                            | KH 35 (38) | 18 (16.2) | 0.000 |
| Types of obturation errors    |            |         |
| Overfilled                    | KH 15 (16.3) | 27 (24.3) | 0.000 |
|                              | F 41 (44.6) | 43 (38.7) |         |
| Underfilled                   | KH 15 (16.3) | 27 (24.3) | 0.000 |
|                              | F 41 (44.6) | 43 (38.7) |         |
| Voids                         | KH 35 (38) | 18 (16.2) | 0.000 |
|                              | F 41 (44.6) | 43 (38.7) |         |
| More than one error           | KH 0 (0) | 2 (1.5) | 0.002 |
|                              | F 0 (0) | 1 (0.7) |         |

KH: King Khalid University, F: Alfarabi Dental College
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 (≈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 de-
The study was approved by the research and ethics committees of both universities No: SRC/ETH/2015-16/015. Ethics Committee Approval: Internally peer-reviewed.

Disclosures
Conflict of interest: None declared.

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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.
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