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Significance of Endodontic Case Difficulty Assessment: A Retrospective Study

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ABSTRACT

Objectives: The present study aimed to evaluate the significance of the American Association of Endodontics (AAE) Case Difficulty Assessment on the occurrence of endodontic mishaps in an undergraduate student clinic at the Dental College at King Saud University.

Methods: All teeth endodontically treated by undergraduate dental students in their fourth year at the College of Dentistry, Girls University Campus at King Saud University over 2 years (2018-2019) were selected. Four investigators (3 dental interns and 1 endodontist) recorded the AAE case difficulty level, mishap occurrence, number of treatment visits, type of teeth, and type of instrumentation technique. The associations amongst these variables were analysed.

Statistical analysis: A point-biserial correlation was used to determine the relationship between the number of visits and the AAE case difficulty and the instrumentation technique. Spearman's rank-order correlation was used to assess the relationship between the number of visits and mishaps. A Mann-Whitney U test was applied to determine any differences in mishaps amongst cases with different difficulty levels.

Results: A total of 586 teeth were included (54.1% moderate- to high-difficulty cases), and 34.98% of cases experienced mishaps. Molars were significantly more often found in the moderate- to high-difficulty category. The moderate- to high-difficulty cases experienced more mishaps (64.8%; $P = .000$) and a greater number of treatment visits (3.49 ± 1.27 ; $P = .000$) compared to minimal-difficulty cases (35.12%, 2.38 ± 1.24 , respectively). The type of instrumentation technique was not associated with mishap occurrence.

Conclusions: Undergraduate students should use the AAE case classification assessment tool to reduce the number of endodontic treatment mishaps and the number of visits.

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Introduction

The main goal of root canal treatment is to remove irritants from the root canal, appropriately fill the cleaned and shaped system, and avoid any further recontamination by sealing the root canal system.¹ Performing an acceptable root canal treatment whilst simultaneously avoiding procedural errors is a challenging assignment for dental students due to lack of experience, incorrect selection of cases, and limitations in

the availability of the proper instruments.² These procedural errors may jeopardise the outcome of endodontic treatment.³ Several studies have evaluated the quality of root canal filling performed by undergraduate dental students.⁴⁻⁷ Their inconsistent results reveal a need for a more standardised case selection method and a better understanding of the students' knowledge and skills.

Several guidelines are available to measure the complexity of cases using a cumulative numerical value score system. The American Association of Endodontists (AAE) published a form to assess the difficulty of an endodontic case by evaluating 17 areas; this form has been used as an educational tool for students.^{8,9} The Dutch Endodontic Treatment Index

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(DETI) consists of 15 criteria to differentiate a simple case (DETI-A) from a complex case (DETI-B). Then, cases that are considered complex (DETI-B) are assessed for the risks and difficulty of root canal treatment using the endodontic treatment classification, which is a criteria-based list, and a decision is accordingly made to treat the patient or refer them to an endodontist.¹⁰ The Canadian Academy of Endodontics introduced a complexity index based on the degree of complexity and risk, but its validity could not be confirmed due to inconclusive results.¹¹ An index for restorative dental treatment was developed. One of its main components was an evaluation of the complexity of treatment, where clinicians determine levels of difficulty of treatment for endodontics, periodontics, and fixed and removable prosthodontics through a scoring system, and this index was found to be a practical tool.¹²

Haug et al reported that AAE case difficulty assessment is a significant predictor of endodontic mishaps in undergraduate clinics.¹³ The objective of the present retrospective study was to determine the association between AAE case difficulty and endodontic mishap occurrence and the number of treatment visits in an undergraduate student clinic in the Dental College at King Saud University.

Materials and methods

The ethics committee at King Saud University, College of Medicine (Institutional Review Board Project No. E-20-4876) approved the present study. The methodology was slightly modified from the study performed by Haug et al.¹³ Undergraduate dental students at King Saud University spend 5 years studying dentistry. In the fourth year, dental students start their first endodontic clinical course. They are required to minimally complete root canal treatment on 2 anterior teeth, 2 premolars (one with a single canal and the other with 2 canals), 2 molars (one maxillary and one mandibular), and a retreatment case (the tooth should have 1 or 2 canals). All teeth endodontically treated by undergraduate dental students in their fourth year at the College of Dentistry, Girls University Campus at King Saud University over 2 years (2018-2019) were selected for this study. Patients who received endodontic treatment in undergraduate fourth-year clinics in 2018 and 2019 were identified by using the electronic patient system (SALUD, Dublin, Ireland). Minimal-, moderate-, and high-difficulty cases⁸ that were started and finished by the same student were included. Retreatment cases were excluded. A total of 588 teeth were treated by the classes of 2018 (56 students) and 2019 (56 students). Four investigators (3 dental interns and 1 endodontist) extracted and evaluated the registered data for any mishap that was not already flagged; the 3 interns extracted and evaluated the registered data and the endodontist reevaluated the data. Preoperative, initial working length, master cone, and final radiographs were evaluated for any unidentified mishaps. The following mishaps were included: gouging, loss of working length (ledge or blockage), cervical or furcation perforation, instrument separation, apical transportation, over-instrumentation (beyond the radiographic apex), strip perforation, overfilling (≥ 2 mm from the radiographic apex),

or underfilled obturation (≥ 2 mm from the radiographic apex).

All endodontic treatments were performed at the Undergraduate Endodontic Clinic supervised by endodontist instructors with a 4:1 student-to-instructor ratio. Patients were randomly assigned to undergraduate students without any previous knowledge of the student's competency level. Clinical and digital radiographic (Planmeca Romexis, Planmeca Oy, Helsinki, Finland) examinations were performed at the first visit using periapical radiographs. The diagnosis was established according to the AAE diagnosis classification,¹⁴ treatment planning, and acquisition of patient consent. All cases were classified according to the AAE case difficulty assessment form.⁸

Then, an access cavity was made, and the canals were located. The working length was estimated using apex locators and then confirmed with a radiograph to be approved by the instructor. Then, the instrumentation method and the size of the master apical file were discussed with the instructor. The instrumentation technique was selected for each case according to the student's preference as long as the use of engine-driven instrumentation does not exceed 50% of the required cases. Engine-driven instrumentation was performed using ProFile nickel-titanium rotary files (DENTSPLY Maillefer, Switzerland), whereas hand instrumentation was performed using stainless steel K-files (DENTSPLY Maillefer, Switzerland). The irrigant used was 1% sodium hypochlorite solution (NaOCl). In addition, 17% ethylenediaminetetraacetic was used in calcification and before obturation to remove the smear layer. The use of intracanal medicaments was decided by the supervisor according to the case situation and diagnosis. The cold lateral compaction technique was used for obturation using standardised gutta-percha master cones (SureDent Co., Gyeonggi-Do, Korea) and accessory cones (Spident Co., Ltd, Korea) with AH Plus Sealer (Dentsply Maillefer, Ballaigues, Switzerland). Then the patients were referred for final restoration.

Patients were followed up a minimum of 3 months later. Four radiographs were taken: preoperative radiograph, initial working length radiograph, master apical cone radiograph, and the final radiograph. The number of visits varied between students and between different cases for each student. Each treatment session could last up to 180 minutes.

After obtaining the final radiograph, each student completed the self-evaluation form. This step was performed for each endodontically treated tooth. Then, the form was discussed with the instructor to review any endodontic mishap and grade and anticipate the prognosis according to the treatment provided.

Statistical analysis

SPSS software version 22 was used to analyse the data. A descriptive analysis was performed. Correlation analyses were performed to test the association and the link of each type of mishap with the case difficulty type, the instrumentation technique, tooth type, and the number of visits. A chi-square test was performed to determine the association between the case difficulty and instrumentation technique and between the instrumentation technique and the type of

teeth. A point-biserial correlation was used to determine the relationship between the number of visits and the case difficulty and the instrumentation technique. To assess the relationship between the number of visits and mishaps, Spearman's rank-order correlation was used. To determine any differences in mishaps between cases with different difficulty levels, a Mann-Whitney U test was applied. To compare the number of treatment visits and the occurrence of mishaps across tooth types, one-way analysis of variance was performed. To test the strength of the association between different types of mishaps, correlation analysis was performed. A P value $\leq .05$ was defined as significant.

Results

A total of 586 teeth, including 267 treated with stainless steel hand files (45.6%) and 319 teeth treated with engine-driven profile files (54.4%), were included in this study. There were 269 cases considered to have minimal case difficulty (45.9%), and 317 cases were assessed as moderate- to high-difficulty (54.1%). There were 185 anterior teeth (31.6%), 212 premolars (36.2%), and 189 molars (32.3%). The number of visits ranged from 1 to 8 visits per tooth: 97 teeth (16.6%) were treated in 1 visit, 116 teeth (19.8%) were treated in 2 visits, 140 teeth (23.9%) were treated (23.9%) in 3 visits, 158 teeth (27%) were treated in 4 visits, 50 teeth (8.5%) were treated in 5 visits, 16 teeth (2.7%) were treated in 6 visits, 8 teeth (1.4%) were treated in 7 visits, and 1 tooth (0.2%) was treated in 8 visits.

Of the 586 teeth, 205 were reported as having mishaps (34.98%). Of the 205 teeth with mishaps, 129 teeth (22.01%) had 1 endodontic mishap, 56 teeth had 2 mishaps (9.55%), 17 teeth had 3 mishaps (2.9%), and 3 teeth had 4 mishaps (0.51%). The reported mishaps were underfilling (77 teeth/13.13%), overfilling (71 teeth/12.11%), apical transportation (58 teeth/9.89%), gouging (23 teeth/3.9%), ledges (21 teeth/3.58%), zipping (17 teeth/2.9%), blockage (11 teeth/1.87%), instrument separation (7 teeth/1.19%), and lateral perforation and overinstrumentation (2 teeth each/0.34%). Fifteen teeth required endodontic retreatment (2.55%).

Given that 76 teeth of the 205 teeth (12.96%) had more than one mishap, correlation analysis was applied to test the strength of the associations amongst the types of mishaps. Underfilled obturation was positively correlated with ledge occurrence ($r_s = 0.278$, $P = .000$), canal blockage ($r_s = 0.318$, $P = .000$), and canal transportation ($r_s = 0.09$, $P = .03$). Cases that needed retreatment were positively correlated with ledge occurrence ($r_s = 0.143$, $P = .001$), canal blockage ($r_s = 0.137$, $P = .001$), overinstrumentation ($r_s = 0.176$, $P = .000$), and underfilled obturation ($r_s = 0.192$, $P = .000$).

There were only 6 difficult cases; therefore, moderate and difficult cases were combined to perform the statistical analysis. Our results showed that mishaps occurred in moderate- to high-difficulty cases (133/64.8%) more frequently compared with minimal-difficulty cases (72/35.12%), with a statistically significant difference ($P = .000$). Ledges, underfilled obturations, zipping, and cases requiring endodontic retreatment were significantly associated with moderate- to high-difficulty cases (P values = .036, .002, .004, and .038, respectively;

Table 1 – The frequency of teeth with different mishap occurrence amongst cases with different difficulties and its association.

Endodontic mishaps	Case difficulty		P values
	Minimal No. (%)	Moderate-high No. (%)	
Gouging	13 (56.50%)	10 (43.50%)	.312
Ledge	5 (23.80%)	16 (76.20%)	.036*
Blockage	5 (45.50%)	6 (54.50%)	.959
Apical transportation	20 (34.50%)	38 (65.50%)	.059
Underfilling	23 (29.90%)	54 (70.10%)	.002*
Overfilling	28 (39.40%)	43 (60.60%)	.221
Needs retreatment	3 (20.00%)	12 (80.00%)	.038*
Zipping	2 (11.80%)	15 (88.20%)	.004*

* Significant at P value $\leq .05$.

Table 1). Molar teeth showed a higher mishap occurrence (87/42.43%) than premolar teeth (75/36.57%) and anterior teeth (43/21%), with statistically significant differences noted amongst them ($P = .000$). Ledges, underfilled obturations, and zipping were significantly associated with molars (P values = .011, .016, and .012, respectively), and overfilled obturations were significantly associated with premolars ($P = .036$; Table 2).

Premolars were significantly categorised in the engine-driven instrumentation group (151 teeth/47.33%) compared to anterior teeth (129 teeth/40.44%) and molars (39 teeth/12.23%) with statistically significant differences noted ($P = .000$). Minimal-difficulty cases were mainly instrumented with engine-driven instrumentation (178/66.18%) compared to hand instrumentation (91/33.82%; $P = .000$). Moderate- to high-difficulty cases were mainly instrumented with hand instrumentation (176/55.52%) compared to engine-driven instrumentation (141/44.48%; $P = .000$). There were 7 teeth (1.2%) that had instrument separations. Five of these teeth were instrumented with hand files, and 2 were instrument with rotary profiles. All of these teeth were categorised as moderate- to high-difficulty cases (4 maxillary first molars, 1 maxillary first premolar, 1 mandibular first molar, and 1 mandibular second molar). No significant association was

Table 2 – The frequency of teeth with different endodontic mishap occurrence amongst different types of teeth and its association.

Endodontic mishaps	Tooth type			P values
	Anteriors No. (%)	Premolars No. (%)	Molars No. (%)	
Gouging	7 (30.4%)	10 (43.5%)	6 (26.1%)	.731
Ledge	3 (14.3%)	5 (23.8%)	13 (61.9%)	.011*
Blockage	1 (9.1%)	6 (54.5%)	4 (36.4%)	.235
Apical transportation	12 (20.7%)	20 (34.5%)	26 (44.8%)	.057
Underfilling	15 (19.5%)	28 (36.4%)	34 (44.2%)	.016*
Overfilling	13 (18.3%)	30 (42.3%)	28 (39.4%)	.036*
Needs retreatment	1 (6.7%)	6 (40.0%)	8 (53.3%)	.071
Zipping	2 (11.8%)	4 (23.5%)	11 (64.7%)	.012*

* Significant at P value $\leq .05$.

Table 3 – Percentages of endodontic mishaps occurrence amongst instrumentation types and their associations.

Endodontic mishaps	Instrumentation technique		P values
	Hand instrumentation No. (%)	Engine-driven instrumentation No. (%)	
Gouging	10 (43.5%)	13 (56.5%)	.84
Ledge	13 (61.9%)	8 (38.1%)	.125
Blockage	3 (27.3%)	8 (72.7%)	.22
Apical transportation	26 (44.8%)	32 (55.2%)	.91
Underfilling	33 (42.9%)	44 (57.1%)	.625
Overfilling	40 (56.3%)	31 (43.7%)	.051
Needs retreatment	9 (60%)	6 (40%)	.251
Zippering	9 (52.9%)	8 (47.1%)	.528

Significant at P value $\leq .05$.

noted between any mishaps and the type of instrumentation technique (Table 3).

Molars showed a significantly higher number of treatment visits (4.13 ± 1.104) required to complete the endodontic procedure ($P = .000$) than premolars (3.01 ± 1.226) and anterior teeth (2.01 ± 1.021). The moderate- to high-difficulty cases had a significantly higher number of treatment visits (3.49 ± 1.27) compared with the minimal-difficulty cases (2.38 ± 1.24) ($P = .000$). Teeth instrumented with hand instrumentation showed significantly higher treatment visits (3.26 ± 1.45) than teeth treated with engine-driven profile instrumentation (2.89 ± 1.35 ; $P = .001$). A significant positive correlation was noted between having endodontic mishaps and an increased number of treatment visits, except for gouging (Table 4).

Discussion

The extracted data of the present study showed that cases were classified into 2 types of case difficulties. In addition, treatment visits ranged from 1 to 8 visits, two different instrumentation techniques were used (either step-back technique using hand files or crown down technique using engine-driven rotary files), and different endodontic mishaps occurred. Therefore, knowing the relationship between these variables might help improve undergraduate clinic education

Table 4 – The association between the increasing number of treatment visits and the different endodontic mishaps.

Endodontic mishaps	Pearson correlation coefficient	P values
Gouging	-0.052	.213
Ledge	0.124	.003*
Blockage	0.139	.001*
Apical transportation	0.134	.001*
Underfilling	0.182	.000*
Overfilling	0.128	.002*
Needs retreatment	0.125	.002*
Zippering	0.139	.001*

* Significant at P value $\leq .05$.

in endodontics and properly select clinical cases for the undergraduate dental students to minimise mishap occurrence. The results of the present study showed that the existence of endodontic mishaps was associated with the AAE case difficulty level⁸ and the number of treatment visits; more mishaps occurred in moderate- to high-difficulty cases and in cases with a higher number of treatment visits. The type of instrumentation technique based on the use of hand files or rotary files was not associated with mishap occurrence. Endodontic treatment is considered a challenging procedure for undergraduate students. Our study showed that 65% of endodontically treated teeth had acceptable quality with no endodontic mishaps, which was consistent with previous studies in different dental schools.^{4,5,7,13,15-17} On the other hand, some studies have reported lower percentages.¹⁸⁻²²

Our results showed that 54.1% of the cases in the undergraduate student clinic were in the moderate- to high-difficulty category, and molar teeth were significantly represented in that category. Endodontic mishaps existed more often in the moderate- to high-difficulty cases, and this finding was consistent with previous studies.^{7, 16-22} Huag et al. employed a different categorisation system in their study. In total, 52.9% of their cases were categorised as having a high difficulty level, and 47.1% of the cases were classified with moderate difficulty level. Molars were significantly represented in the high-difficulty category.¹³ In our study, ledges ($P = .036$), underfilled obturation ($P = .002$), and zippering ($P = .004$) were significantly associated with moderate- to high-difficulty cases and molar cases compared to minimal-difficulty cases. This finding could be attributed to the complex canal anatomy of molars, the high number of canals, narrow canals, root length, and root curvature.^{13,23} Ledges are created in canals when the working length and the original pathway of the canal have been lost and are primarily related to canal curvature.²⁴ Previous studies reported that the use of Gates-Glidden to maintain straight-line access helps decrease the occurrence of ledges.²⁵ Furthermore, the use of step-down or passive step-back instrumentation methods has been reported to prevent ledge formation.²⁴ Underfilled obturation commonly arises after incomplete mechanical instrumentation due to incorrect working length measurement, canal blockage, or ledge formation.²⁶ Canal blockage with debris is attributed to instrumentation without copious irrigation and recapitulation of canal patency.²⁶ Zippering is defined as the apical transportation of a curved canal. Zippering is attributed to failure to precurve the files, forcing large and stiff instruments in curved canals, and the use of improper shaping techniques.²⁷ The use of the incremental filing technique, precurving files, and flexible files might prevent the occurrence of zippering.²⁷ Moreover, the use of nickel-titanium files is associated with a significant reduction in procedural errors compared to stainless steel files.^{28,29} Our study showed that the most common endodontic mishap reported amongst all cases was underfilling (77 teeth/13.13%), and this event was positively correlated with ledge occurrence ($r_s = 0.278$, $P = .000$), canal blockage ($r_s = 0.318$, $P = .000$), and canal transportation ($r_s = 0.09$, $P = .03$). Ledges, canal blockage, and transportation typically result in a loss of working length and consequently lead to underfilled obturations.²⁶

Five of the 7 teeth that had instrument separations were instrumented with hand files. This finding contradicted previous studies that showed that engine-driven file separation is more common than hand file separation.^{13,30} Several studies have shown that instrument separation is not related to clinical experience.^{31,32} Therefore, our findings could be attributed to the difficulty level of the case.

The results of the present study showed that moderate- to high-difficulty cases had a higher number of treatment visits than minimal difficulty cases. Moreover, we found a significant positive correlation between endodontic mishaps and increases in the number of visits. These results are consistent with previous studies.^{13,33,34} This finding could be attributed to the need for more time to manage moderate difficulty cases and teeth with endodontic mishaps.³⁵

Gradually altering students' case complexity during their endodontic training should lead to improved performance. AAE case difficulty assessment in an undergraduate clinic will help undergraduate students properly select their cases and refer difficult cases to postgraduate students or specialists and therefore avoid endodontic mishaps. This process will allow them to become competent, either as undergraduate students or as general practitioners after graduation, in the decision-making of the level of competency needed for a specific procedure.

Conclusions

Endodontic mishaps and the number of treatment visits are correlated with the case difficulty level. The AAE case difficulty assessment form is an essential and helpful educational tool in undergraduate clinics to prevent possible endodontic mishaps and to anticipate the number of treatment visits. Additionally, this tool should be implemented in the decision-making regarding the level of competency needed for a specific procedure in the undergraduate clinic and by general dentists after graduation.

Conflict of interest

None disclosed.

Supplementary materials

Supplementary material associated with this article can be found in the online version at [doi:10.1016/j.identj.2022.01.001](https://doi.org/10.1016/j.identj.2022.01.001).

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