

Endodontic Procedural Errors and Associated Factors among Undergraduate Dental Students: A Cross-sectional Study

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ABSTRACT

Aims and background: To assess the procedural errors committed by undergraduate students at RAK College of Dental Sciences, during root canal treatments and the factors associated with these errors.

Materials and methods: In this cross-sectional study, 180 self-administered questionnaires were distributed, each comprising 26 questions, among 4th and 5th-year students. Participants were requested to report their endodontic mishaps based on feedback from their supervisors. The questionnaire assessed the frequency and types of procedural errors, considering patient, operator, and tooth-related factors. Data were collected tabulated and analyzed using the Chi-square test.

Results: A total of 124 root canal-treated teeth exhibiting iatrogenic errors done by students were assessed. Out of which, 53% were performed by 5th-year students, and 69% were conducted by female operators. About 62% of errors occurred in the upper teeth and 68% in the posterior teeth. The most prevalent errors during the rubber dam isolation step were soft tissue trauma (21%) and isolation leakage (20%), significantly associated with limited mouth opening, excessive salivation, and tooth malalignment ($p < 0.05$). Apical blockage (15%) emerged as the most frequent error during instrumentation phase, showing a significant association with canal dimension and curvature ($p < 0.05$). For access cavity and obturation phases, under-extended cavity (9%), and under-extended filling (11%) were the most reported errors, respectively.

Conclusion: Tooth isolation emerges as a particularly challenging aspect for dental students, particularly when dealing with patients exhibiting limited mouth opening and excessive salivation.

Clinical significance: Clinical instructors should caution the undergraduates about the heightened risk of endodontic procedural errors when dealing with patients exhibiting limited mouth opening, excessive salivation, tooth malalignment, and narrow canals. Addressing these challenges is crucial for enhancing the proficiency of undergraduate students in performing successful root canal treatments.

Keywords: Apical blockage, Endodontic treatment, Endodontic procedural errors, Endodontic mishaps, Rubber dam isolation, Undergraduate dental students.

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INTRODUCTION

Root canal treatment is known to have a favorable outcome, as various studies have indicated success rates between 85 and 97% over a long-term follow-up period.¹ Nonetheless, performing a root canal treatment can be quite challenging due to some tooth-related factors. These factors encompass complexities arising from the intricate morphology of the tooth, along with variations in the number, shape, and positioning of roots and canals.² These variations impose limitations on accessing the canal system and make the procedure more challenging and time-consuming. Moreover, patient-related factors, such as anxiety, limited mouth opening, excessive salivation, and difficulties in achieving adequate anesthesia, also contribute to the intricacy of the treatment.³

Root canal treatment can pose greater challenges for undergraduate dental students. Their limited experience and dependence on conventional tools and techniques can lead to an increased risk of procedural errors.⁴ These errors, encompass missed canals, insufficient canal preparation, perforations, instrument separation, overextended or under-extended filling, and incomplete removal of infected pulp. The occurrence of these mishaps can adversely impact treatment outcomes and can manifest at any treatment stage including diagnosis, tooth isolation, access cavity preparation, instrumentation, obturation, or post-space preparation.⁵

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Endodontic Procedural Errors and Associated Factors among Undergraduate Dental Students: A Cross-sectional Study.

We are carrying out an evaluation survey of the endodontic mishaps made by undergraduate students of RAK College of Dental Sciences. Thank you for taking the time to fill this survey. It shall not take more than 10 minutes:

Confidentiality: All information is completely confidential and will not be exposed to public.
 Consent: I have read and I understand the provided information and I had the opportunity to ask questions. I voluntarily agree to take part in this study.

The Questionnaire

Section 1: Patient-related data:

- i) Age group: 13–25 26–40 41–55 56–70
- ii) Gender: Male Female
- iii) Mouth opening: Normal Limited
- iv) Excessive salivation: Yes No

Section 2: Tooth related data:

- i) Tooth number: -----.
- ii) Tooth alignment: Normal Malposition
- iii) Number of roots and canals: -----.
- iv) Degree of root curvature: Straight Minimal Server
- v) Canal dimension: Very wide Normal Narrow Obliterated

Section 3: Operator-related data:

- i) Gender: Male Female
- iii) Year of study: 4th year 5th year
- iii) Number of cases you have accomplished so far: -----.

Section 4: Procedural errors				
		Yes	No	Others
1) Isolation-related errors				
	A. Un-centralized rubber dam sheet			
	B. Soft tissue trauma			
	C. Leakage			
2) Access cavity-related		Yes	No	Others
	A. Missed canal			
	B. Underextended			
	C. Overextended			
3) Cleaning and shaping-related errors:		Yes	No	Others
	A. Apical blockage			
	B. Ledge			
	C. Zipping and transportation			
	D. Instrument separation			
	E. Sodium hypochlorite accident			
4) Obturation-related errors		Yes	No	Others
	A. Overextended filling			
	B. Underextended filling			
	C. Non-dense filling			

Thank you for your participation, please return your completed questionnaire to the-----.

If you have any questions about the questionnaire, you can contact-----.

Fig. 1: The self-administered questionnaire

Multiple studies,^{6–8} have shown that the acceptable quality of root canal treatment conducted by undergraduate students varies between 33 and 70%. Thus, it has been recommended to determine and discuss the case difficulty level utilizing the American Association of Endodontists (AAE) classification (<http://www.aae.org/caseassessment/>) with the instructor prior to the treatment. This allows for the determination of an appropriate treatment strategy and the prediction of potential mishaps.⁴ However, even after adequate preoperative analysis and direct supervision by instructors, endodontic mishaps by dental students are still likely to occur and cannot be completely avoided. Therefore, it is imperative to make every effort to minimize such incidents. The assessment of endodontic treatments conducted by dental students has been a central theme in numerous studies, exploring various facets and dimensions including treatment outcome,⁹ quality of treatment,¹⁰ factors associated with treatment quality,¹¹ students' perception of difficulties,¹² and their confidence level to treat difficult cases.¹³ To the best of our knowledge, there are only two studies^{14,15} that have evaluated the endodontic performance of dental students in the United Arab Emirates (UAE).

Procedural error assessment can help in knowing the main difficulties encountered by students during root canal treatment which in turn can help in improving teaching strategies during preclinical and clinical teaching. To date, no publication has addressed the associations between endodontic mishaps encountered by undergraduate dental students and various factors, such as patient, operator, and tooth-related factors. The current

study aims to evaluate the procedural errors reported by undergraduate students at Ras Al-Khaimah (RAK) College of Dental Sciences, Ras Al-Khaimah Medical and Health Sciences University (RAKMHSU) in the UAE, while performing root canal treatments and to explore the factors associated with these errors.

MATERIALS AND METHODS

This cross-sectional study was designed in accordance with the STROBE Statement checklist of items reported. The study received approval from the institutional Ethics and Research Committee (RAKMHSU-REC-026-2021/22-UG-D) and was conducted during the academic year 2021/2022 from December 2021 to April 2022. By adopting a confidence interval of 95%, and a margin of error of 5%, the predicted sample size was 120 cases.

A self-administered questionnaire consisting of 26 questions in English was developed by the authors and underwent validation by three endodontic specialists (Fig. 1). Questions were structured as either multiple-choice or yes/no. The questionnaire comprised four sections: Section 1 for patient-related data (four questions), Section 2 for tooth-related data (five questions), Section 3 for operator-related data (three questions), and Section 4 for procedural errors (fourteen questions). The procedural errors section was further subdivided into rubber dam isolation-related, access cavity-related, cleaning and shaping-related, and obturation-related errors. Written consent was obtained from the students, ensuring their voluntary participation in the survey and the confidentiality of the data.

A total of 180 questionnaires were distributed to 90 students at RAK College of Dental Sciences, in the UAE. All 4th and 5th-year students were included in the study. Among them, 55 students were in the 4th year, and 35 were in the 5th year. Each student received two hard copies of the questionnaire and was requested to fill them out while treating the next two endodontic cases (one questionnaire for each case). They were also asked to report their procedural errors in the questionnaire based on the comments and observations provided by their clinical supervisors. The inclusion criteria comprised completed root canal treatments done by 4th or 5th-year students. Exclusion criteria included incomplete treatments, cases not supervised by clinical instructors, retreatment cases, and instances where treatment was carried out by more than one student. Each answer in the first three sections received a score ranging from 1 to 4. In the 4th section, a score of 1 was assigned to the answer "Yes," a score of 2 was assigned to the answer "No," and the answer "Others" was not given a score. Incomplete or multiple answers for a question were not taken into consideration.

The data were analyzed using statistical software (SPSS, 24.0; SPSS Inc., Chicago, IL, USA). The demographic information of the participants was analyzed in frequency. The correlation of errors with different factors was analyzed using the Chi-square test at a 95% confidence level ($p < 0.05$).

RESULTS

A total of 124 completed questionnaires were received out of 180 distributed, resulting in a response rate of 69%. Among the participants, 32% were male and 68% were female students. The majority of the cases (69%) were treated by female students. Among the reported cases, 53% of cases were treated by 5th-year students, and the remaining 47% of cases were treated by 4th-year students. Among the treated cases, 68% of patients were male and the most frequent (59%) age of the patients was between 26 and 40 years old. In 7% of cases, patients presented with limited mouth opening, 14% with excessive salivation, and 6% with a malpositioned or rotated tooth. The most frequently treated teeth were the lower right first molars (10.5%) followed by the upper right first premolars (8.9%). Regarding the dimensions of the canals, reports showed that 15% were considered narrow, 78% as normal, and 6% as wide. In terms of canal configuration, Vertucci type I represented 58%, followed by type III (15%), and type II (12%). Regarding the degree of curvature, in 60% of cases, the canals were straight, 39% were mild curvature and in 1%, it was reported as severely curved. Procedural errors were most common in the posterior teeth (68%) and upper arch (62%). The most frequently reported error was isolation-related and was more commonly reported by female students (21%) than by male students (14%), and by 5th-year students (21%) than by 4th-year students (18%).

Rubber Dam Isolation-related Errors

Soft tissue trauma (21%) was the most common error in the isolation step. The prevalence of soft tissue trauma was significantly associated with the degree of mouth opening (67% of patients with limited opening compared with 17% of patients with normal opening) and the amount of salivation ($p \leq 0.05$). Female students and 5th-year students had higher rates of soft tissue trauma, 24%, and 23%, respectively. Isolation leakage accounted for 20% of reported cases, with a significant association with limited mouth opening (67%) and tooth malalignment (71%) ($p \leq 0.05$). Female students reported a higher prevalence of isolation leakage (22%)

compared with male students (16%), while the 4th-year students had a slightly lower prevalence (18%) than the 5th-year students (23%) (Table 1).

Access Cavity-related Errors

The most common reported error in the access cavity preparation step was the under-extended cavity (9%). A breakdown of the data by student gender and year showed that male students had a higher prevalence of under-extended access cavity preparation at 11% compared with female students at 8%. Fourth-year students had a higher prevalence of under-extension at 12% compared with 5th-year students at 6% (Table 2).

Instrumentation-related Errors

The most common reported error in the cleaning and shaping step was apical blockage (15%) with a significant association with canal dimension and degree of canal curvature ($p \leq 0.05$). The prevalence of apical blockage was higher in patients with limited mouth opening (22%) compared with normal mouth opening but without significant association. Female students reported a higher prevalence of canal blockages (19%) compared with male students (8%). Fourth-year students experienced a lower apical blockage rate (7%) compared with 5th-year students (23%). Sodium hypochlorite accidents were reported in 3% of cases, significantly associated with the young age group (13–25 years) ($p \leq 0.05$). Fourth-year students reported a lower prevalence of hypochlorite accidents (2%) compared with 5th-year students (5%) (Table 3).

Obturation-related Errors

The most commonly reported error related to obturation was the under-extended root filling, with a frequency of 11%. This error was reported in 11% of teeth treated by female students and 13% of teeth treated by male students. Fourth-year students had a lower prevalence of under-extended filling at 7% compared with 5th-year students at 15%. On the other hand, the overextended filling was reported in 6% of cases, with 7% of teeth treated by female students and 3% of teeth treated by male students. Non-dense filling and voids were reported in 5% of cases, with 6% of teeth treated by female students and an equal percentage of teeth treated by male students (Table 4).

DISCUSSION

While a dental college primarily serves as an educational institution that provides clinical training for dental students by treating patients, ensuring patient safety and the quality of treatment should remain the highest priority. This becomes particularly crucial in endodontic treatments, which involve a certain level of complexity, and a heightened risk of procedural errors. Avoiding such errors necessitates advanced clinical skills and experience.⁴ Consequently, dental students should perform the treatment with the utmost skill, ethical behavior, and meticulous attention to all details and procedure steps, under close supervision from their clinical instructors.^{12,16}

At RAK College of Dental Sciences, students received direct supervision from experienced instructors, specialists, and faculty members, with a student-instructor ratio of 1:7. Also, standard treatment protocols and guidelines regarding the use of rubber dam isolation are followed in all root canal procedures to ensure patient safety and maintain an aseptic environment.¹⁷ The curriculum encompasses both preclinical and clinical years,

Table 1: Frequency of procedural errors and the associated factors in tooth isolation among undergraduate dental students

Isolation-related errors	Total number (%)	Patient-related factor		Operator-related factor		Tooth-related factors		Frequency (%)	p-value			
		Variables	Frequency (%)	Variables	p-value	Variables	Frequency (%)			Variables	Frequency (%)	
Soft tissue trauma	26 (21%)	Age group	13-25	4 (16%)	Operator gender	Male	5 (13%)	Tooth alignment	Normal	0.156	23 (20%)	
			26-40	15 (21%)		Female	21 (24%)		Malposed			0.143
		Patient gender	41-55	4 (21%)	Academic year	4th	11 (19%)	Tooth alignment	Malposed	0.785		
			56-70	3 (43%)		5th	15 (23%)					
			Male	16 (19%)								
	Leakage	25 (20%)	Age group	Female	10 (25%)	Operator gender	Male	6 (16%)	Tooth alignment	Normal	0.420	20 (17%)
				Normal	20 (17%)		Female	19 (22%)		Malposed		
			Mouth opening	Limited	6 (67%)	Academic year	4th	11 (19%)	Tooth alignment	Malposed	0.785	
				Present	7 (39%)		5th	15 (23%)				
				Absent	19 (18%)							
Un-centralized rubber dam	20 (16%)	Age group	13-25	5 (20%)	Operator gender	Male	5 (13%)	Tooth alignment	Normal	0.550	18 (15%)	
			26-40	12 (16%)		Female	15 (17%)		Malposed			0.357
		Patient gender	41-55	5 (26%)	Academic year	4th	10 (18%)	Tooth alignment	Malposed	0.084		
			56-70	3 (43%)		5th	15 (23%)					
			Male	17 (20%)								
	Excessive salivation	20 (16%)	Age group	Female	8 (20%)	Operator gender	Male	5 (13%)	Tooth alignment	Normal	0.515	18 (15%)
				Normal	19 (17%)		Female	15 (17%)		Malposed		
			Mouth opening	Limited	6 (67%)	Academic year	4th	10 (18%)	Tooth alignment	Malposed	0.084	
				Present	6 (33%)		5th	15 (23%)				
				Absent	19 (18%)							
Excessive salivation	20 (16%)	Age group	13-25	4 (16%)	Operator gender	Male	5 (13%)	Tooth alignment	Normal	0.550	18 (15%)	
			26-40	14 (19%)		Female	15 (17%)		Malposed			0.29%
		Patient gender	41-55	2 (11%)	Academic year	4th year	9 (16%)	Tooth alignment	Malposed	0.90		
			56-70	0 (0%)		5th year	11 (17%)					
			Male	11 (13%)								
Excessive salivation	20 (16%)	Age group	Female	9 (23%)	Operator gender	Male	5 (13%)	Tooth alignment	Normal	0.550	18 (15%)	
			Normal	17 (15%)		Female	15 (17%)		Malposed			0.29%
		Mouth opening	Limited	3 (33%)	Academic year	4th year	9 (16%)	Tooth alignment	Malposed	0.90		
			Present	3 (17%)		5th year	11 (17%)					
			Absent	17 (16%)								

*Significant ($p \leq 0.05$)

Table 2: Frequency of procedural errors and the associated factors in access cavity preparation among undergraduate dental students

Access cavity errors	Total number (%)	Patient-related factor		Operator-related factors		Tooth-related factor		Frequency (%)	p-value			
		Variables	Frequency (%)	Variables	p-value	Variables	Frequency (%)			Variables	Frequency (%)	
Under-extended access	11 (9%)	Age group	13-25	2 (8%)	0.704	Operator gender	Male	4 (11%)	0.667	11 (9%)	0.395	
			26-40	8 (11%)		Female	7 (8%)	Malposed	0 (0%)			
	Patient gender		41-55	1 (5%)		4th	7 (12%)					
			56-70	0 (0%)	0.760	Academic year	5th	4 (6%)	0.458			
	Mouth opening		Male	7 (8%)								
			Female	4 (10%)	0.331							
	Excessive salivation		Normal	11 (10%)								
			Limited	0 (0%)	0.593							
	Over-extended access	7 (6%)	Age group	13-25	0 (0%)	0.077	Operator gender	Male	1 (3%)	0.623	7 (6%)	0.774
				26-40	4 (6%)		Female	6 (7%)	Malposed	0 (0%)		
Patient gender			41-55	3 (16%)		4th	4 (7%)					
			56-70	0 (0%)	0.447	Academic year	5th	3 (5%)	0.866			
Mouth opening			Male	6 (7%)								
			Female	1 (3%)	0.110							
Excessive salivation			Normal	6 (5%)								
			Limited	1 (11%)	0.110							
Missed canal		2 (2%)	Age group	13-25	0 (0%)	0.542	Gender	Male	1 (3%)	0.549	2 (2%)	0.727
				26-40	1 (1%)		Female	1 (1%)	Malposed	0 (0%)		
	Patient gender		41-55	1 (5%)		4th	2 (4%)					
			56-70	0 (0%)	0.588	Academic year	5th	0 (0%)	0.303			
	Mouth opening		Male	1 (1%)								
			Female	1 (3%)	0.690							
	Excessive salivation		Normal	2 (2%)								
			Limited	0 (0%)	0.557							
	Mouth opening		Present	0 (0%)								
			Absent	2 (2%)								

*Significant ($p \leq 0.05$)

Table 3: Frequency of procedural errors and the associated factors in cleaning and shaping among undergraduate dental students

Instrumentation errors	Patient-related factors		Operator-related factors		Tooth-related factors		p-value	p-value			
	Total number (%)	Variables	Frequency (%)	p-value	Variables	Frequency (%)					
Apical blockage	19 (15%)	Age group	13-25	6 (24%)	0.412	Gender	Male	3 (8%)	0.127	19 (16%)	0.247
		Gender	26-40	10 (14%)			Female	16 (19%)			0 (0%)
			41-55	3 (16%)							
			56-70	0 (0%)							
Ledge formation	9 (7%)	Age group	Male	14 (17%)	0.547	Academic year	4th	4 (7%)	0.050	1 (50%)	0.023*
			Female	5 (13%)			5th	15 (23%)			5 (26%)
			Normal	17 (15%)	0.551					10 (10%)	
			Limited	2 (22%)							3 (13%)
			Present	3 (17%)	0.864					6 (8%)	0.015*
			Absent	16 (15%)							13 (27%)
			13-25	3 (12%)	0.614	Gender	Male	2 (5%)	0.569	9 (8%)	0.447
			26-40	4 (6%)			Female	7 (8%)			0 (0%)
			41-55	1 (5%)							
			56-70	1 (14%)							
			Male	5 (6%)	0.417	Academic year	4th	4 (7%)	0.955	0 (0%)	0.800
			Female	4 (10%)			5th	5 (8%)			2 (11%)
			Normal	8 (7%)	0.644					7 (7%)	
			Limited	1 (11%)							0 (0%)
			Present	0 (0%)	0.199					0 (0%)	0.197
			Absent	9 (9%)							3 (4%)
NaOCL accident	4 (3%)	Age group	13-25	3 (12%)	0.049*	Gender	Male	1 (3%)	0.803	4 (3%)	0.619
			26-40	1 (1%)			Female	3 (4%)			0 (0%)
			41-55	0 (0%)							
			56-70	0 (0%)							
			Male	3 (4%)	0.752	Academic year	4th	1 (2%)	0.671	0 (0%)	0.001*
			Female	1 (3%)			5th	3 (5%)			1 (5%)
			Normal	3 (3%)	0.164					1 (1%)	0.316
			Limited	1 (11%)							2 (29%)
			Normal	3 (3%)						1 (1%)	
			Limited	1 (11%)							3 (6%)
			Normal	3 (3%)						0 (0%)	
			Limited	1 (11%)							3 (6%)

*Significant ($p \leq 0.05$)

Table 4: Frequency of procedural errors and the associated factors in obturation among undergraduate dental students

Obturation-related errors	Patient-related factors		Operator-related factors		Tooth-related factor		p-value	Frequency (%)	p-value			
	Total number (%)	Variables	Frequency (%)	p-value	Variables	Frequency (%)						
Under-extended obturation	14 (11%)	Age group	13-25	2 (8%)	0.936	Gender	Male	5 (13%)	0.662	14 (12%)		
		26-40	9 (12%)	Female	9 (11%)	Female	9 (11%)	0.662	0 (0%)	0.331		
	Gender	41-55	2 (11%)	0.754	Academic year	4th	4 (7%)	Canal dimension	0.342	Obliteratered	1 (50%)	
		56-70	1 (14%)			5th	10 (15%)				Narrow	1 (5%)
Over-extended obturation	7 (6%)	Mouth opening	Normal	12 (10%)	0.282	Degree of curvature	Straight	9 (12%)	0.841	Minimal	5 (10%)	
			Limited	2 (22%)								Severe
	Excessive salivation	Present	0 (0%)	0.102	Gender	Male	1 (3%)	Tooth alignment	0.334	Normal	6 (5%)	
		Absent	14 (13%)			Female	6 (7%)					Malposed
	Non-dense obturation	6 (5%)	Age group	13-25	2 (8%)	0.569	Academic year	4th	3 (5%)	0.953	Obliteratered	0 (0%)
				26-40	5 (7%)			5th	4 (6%)			
		Gender	41-55	0 (0%)	0.830	Gender	Male	3 (5%)	Canal dimension	0.953	Normal	4 (4%)
			56-70	0 (0%)			Female	2 (5%)				
	Non-dense obturation	6 (5%)	Mouth opening	Normal	7 (6%)	0.446	Degree of curvature	Straight	5 (7%)	0.783	Minimal	2 (4%)
				Limited	0 (0%)							
Excessive salivation		Present	1 (6%)	0.986	Gender	Male	1 (3%)	Tooth alignment	0.446	Normal	6 (5%)	
		Absent	6 (6%)			Female	5 (6%)					Malposed
Non-dense obturation	6 (5%)	Age group	13-25	0 (0%)	0.440	Academic year	4th	3 (5%)	0.958	Obliteratered	0 (0%)	
			26-40	4 (6%)			5th	3 (5%)				Narrow
	Gender	41-55	1 (5%)	0.954	Gender	Male	3 (5%)	Canal dimension	0.958	Normal	4 (4%)	
		56-70	1 (14%)			Female	3 (5%)					Wide
Non-dense obturation	6 (5%)	Mouth opening	Normal	5 (4%)	0.363	Degree of curvature	Straight	6 (8%)	0.119	Minimal	0 (0%)	
			Limited	1 (11%)								Severe
	Excessive salivation	Present	0 (0%)	0.301	Gender	Male	0 (0%)	Tooth alignment	0.301	Normal	0 (0%)	
		Absent	6 (6%)			Female	6 (6%)					Malposed

*Significant (p ≤ 0.05)

including hands-on experience in conducting over 20 root canal treatments. This approach aligns with the recommendations of the European Dental Society.¹⁸ In the 4th year, the students undertake root canal treatments in anterior and premolar teeth, employing the step-back technique for mechanical preparation and cold lateral condensation for obturation. While the 5th-year students are allowed to perform root canal treatments in upper premolars and molars, as well as non-surgical retreatment in single-rooted teeth utilizing rotary systems after receiving condensed training on such systems.

Despite all the previous precautions, preparations, and training that dental students undergo, they may encounter mishaps while performing root canal treatment, and such incidents cannot be avoided entirely. However, a comprehensive analysis of these mishaps, along with identifying associated factors, can assist in reducing their occurrence frequency. Such an approach can also enhance the quality of treatment and clinical teaching strategies, as well as help dental students develop critical thinking skills and a sense of responsibility for minimizing their errors and successfully meeting their clinical requirements.¹²

Analysis of data revealed that the majority of procedural errors occurred in the upper arch (62%) and posterior teeth (68%). This finding is consistent with previous studies by Alhekeir et al.,¹⁹ and Balto et al.,²⁰ that have also reported a higher frequency of dental student mishaps in the posterior teeth. A clear association was found between the type of tooth and the incidence of procedural errors in a previous study by Davey et al.¹³ Despite 5th-year students representing 53% of the participants, they were responsible for 61% of the reported errors, the prevalence of errors was comparatively lower among 4th-year students than 5th-year students. One possible explanation for this is that in their 4th year, students have their first clinical attempt with root canal treatment and typically perform simpler procedures on single-rooted anterior teeth and premolars. At this stage, students frequently seek guidance from their clinical instructors. In contrast, the 5th-year students may feel more confident in treating complicated cases.¹³ These results are consistent with a previous study conducted in two Saudi Dental Schools by Abdulrab et al.²¹

Rubber dam isolation is worldwide recognized as a mandatory requirement for ensuring patient safety and adherence to clinical guidelines during root canal procedures. Its use is not only recommended in dental practice but also carries a medico-legal concern for both the patient and the dentist.²² In dental schools, there should be a strong emphasis on highlighting the benefits of using rubber dam isolation.²³ The current study showed that among the difficulties faced by students during the rubber dam isolation step, clamp selection and adaptation were particularly challenging and resulted in soft tissue trauma in almost 21% of cases. In addition, patients with limited mouth opening and excessive salivation showed a significant association with soft tissue trauma and isolation leakage. Isolation leakage was also a common error and shows a significant association with malpositioned teeth.

In the current study, canal blockage or difficulty in maintaining canal patency was the most commonly reported instrumentation-related error (15%), followed by ledge formation (7%). In a study by Eleftheriadis and Lambrianidis,⁸ it was found that the frequency of ledged formation in the undergraduate dental clinic was the most common instrumentation error followed by root perforation and it was significantly greater in molars than in anterior teeth. A significant correlation was found between canal dimensions, degree of curvature, and the prevalence of apical blockage during

root canal therapy. As a result, the 4th-year students had a lower occurrence of canal blockages at 7% compared with 5th-year students at 23%. This could be due to the fact that 4th-year students primarily treat root canals that are straighter and wider compared with those encountered by 5th-year students. Similarly, in a previous study by Balto et al.,²⁰ the prevalence of instrumentation errors such as root perforation was higher in 5th-year students (3% of cases) compared to the 4th-year students (0.3% of cases). Likewise, Hendi et al.,²⁴ found that teeth treated by 5th-year students showed a significantly higher prevalence of instrumentation errors such as apical transportation, ledge, and apical perforation.

Although students express a preference for rotary instrumentation,²⁵ the traditional step-back technique and hand files made of stainless steel or nickel–titanium are utilized in college for cleaning and shaping in the preclinical course as well as the first semester of the clinical year (4th year). In the 5th year, the students are incorporating both manual and rotary files for mechanical preparation. The rationale behind this is that compared with rotary files, instrumentation with hand files is considered a safer approach for inexperienced students and helps them to develop the necessary tactile skills.²⁶ When Pettiette et al. compared the effect of using different types of hand files, they found that the incidence of endodontic procedural errors by dental students was significantly reduced when they used the hand files made of nickel–titanium.²⁷

The literature does not provide a clear understanding of the risk factors associated with the extrusion of sodium hypochlorite (NaOCl) from the root apex, commonly referred to as a hypochlorite accident.²⁸ Özdemir et al.²⁹ found that the probability of hypochlorite accidents increased with the number of treatment visits, while the preoperative condition of teeth did not have an impact on the extrusion of NaOCl. The present study findings indicate a low prevalence of reported hypochlorite accidents, which may be attributed to the obligatory use of side vent needles during irrigation, along with continuous instructions not to wedge the needle inside the canal. However, it is important to note that a significant correlation exists between hypochlorite accidents and both the age group of patients (13–25 years old) and the size of the canal. In particular, teeth with very wide canals were found to have a higher prevalence of hypochlorite accidents (29%) compared with teeth with normal dimensions (1%). This correlation can be attributed to the fact that young permanent teeth often have wider canals and apical foramen.³⁰

In the current study, the most commonly reported obturation error was the under-extended filling, with a frequency of 11% of treated cases, followed by under-filling in 6% of cases. In contrast, when Yousuf et al.³¹ evaluated teeth treated by the postgraduate trainees they found that 22.7% of teeth were overfilled, and 8.9% were underfilled, while the selection of the appropriate size and controlling the length of the master gutta percha cone were the common obturation challenges faced by undergraduates at Salman bin Abdulaziz University, Saudi Arabia.³² The 4th-year students had a lower prevalence of under-extended filling compared with 5th-year students. A similar study conducted at Sharjah University, UAE assessed the quality of root canal filling performed by undergraduates. The study found that the percentage of acceptable cases treated by 4th-year students (41.9%) was higher than the percentage of acceptable cases treated by 5th-year students (27.4%).¹⁴ On the contrary, the 5th-year students did more acceptable root fillings compared with the 4th-year students in a study conducted at the Dental School of the University of Athens.³³

The present study had limitations, such as the limited number of reported cases and a relatively small participant sample. Additional research in the future is essential, involving direct examination by specialists to assess endodontic procedural errors made by dental students and the factors associated with these errors. This investigation encompasses a substantial sample size of cases and students across multiple nations.

CONCLUSION

The study found associations between the incidence of rubber dam isolation errors—specifically and various patient-related factors, such as the degree of mouth opening, excessive salivation, and tooth alignment. It also highlighted the association between the prevalence of apical blockage and tooth-related factors including canal dimensions and degree of curvature. Notably, the study revealed a significant association between sodium hypochlorite accidents and the younger age group. Given these findings, it is recommended to provide dental students with more laboratory training and clinical guidance specifically focusing on the rubber dam isolation step.

DISCLOSURE

All authors have made a substantive contribution to this manuscript, and all have reviewed the final paper prior to its submission.

This article has not been published and is not being considered for publication elsewhere.

Ethics Committee Approval

This study was approved by the RAKMHSU Research and Ethics Committee Ras Al Khaimah, UAE Number: RAKMHSU-REC-026-2021/22-UG-D.

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