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Evaluation of the accuracy of the access cavities prepared by undergraduate dental students

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Purpose: This study aimed to assess the accuracy of access cavities prepared by undergraduate students at a dental faculty.

Methods: Access cavities prepared by students were evaluated (n = 389). Before the evaluation, additional-printed information was given to the students. The data were collected using two forms (Descriptive Data and Access Cavity Preparation Assessment forms). The forms were completed by one researcher who was previously trained. In the form, "1" and "0" points were given for every "yes" and "no" answer. Descriptive statistics (mean, standard deviation, frequency, and percentage) were obtained and statistically analyzed (Mann–Whitney U, Kruskal–Wallis H tests).

Results: The average total achievement score was 66.58. The achievement scores for third-, fourth-, and fifth-year students were 68.19, 58.02, and 73.58, respectively. The highest achievement scores were recorded in the upper and lower premolars (71.74 and 69.56, respectively), and the lowest scores were recorded for the upper molars (59.59). Insufficient removal of the pulp chamber roof (41.1%), unsupported tissues (29%), pulp chamber damage (14.1%), nonidentified canal orifice (17.2%), insufficient removal of lingual shoulders and pulp horns (49.2% and 27%) in anterior teeth, and incomplete removal of decayed tissues (32.8%) were recorded.

Conclusion: Improvement is still necessary for the current preclinical training program, while more clinical experience should be provided for the dental students in clinics.

Keywords: Access cavity preparation, assessment, dental education, dental student, endodontic education.

Introduction

Access cavity preparation is an important step in root canal treatment (1). A well-prepared access cavity ensures the success and ease of the subsequent stages, minimizing procedural errors (2). Most of the errors in access cavity preparation seem to be related to noncompliance with the principles of ideal access cavity preparation and the lack of understanding of internal and external dental morphology (3). It has also been reported that an inadequate access cavity can cause complications such as iatrogenic perforation, ledge formation, canal blockage, instrument separation, and untreated canals, as well as incomplete obturation, which can compromise the hygiene and preparation of the canal and affect the success of the treatment (4,5). In their studies with undergraduate students, Tekin et al. (6) examined iatrogenic errors in root canal treatment.

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The errors were ledge formation (7.8%), perforation (4.1%), instrument separation (3.3%), and apical transportation (3%). Although iatrogenic errors cannot be completely prevented, they can be minimized to a great extent through training and good technical and technological practices (7).

Both dentists and patients prefer the restoration of natural teeth over extraction. In Turkey, most of the root canal treatments are performed by dentists who did not receive any specialty degree. This situation demonstrates the importance of undergraduate education in ensuring the quality of endodontic treatment provided by dentists who do not have a specialty (8), making it imperative for dental students to acquire good endodontic knowledge and skills during their undergraduate education (9).

In the undergraduate curriculum guideline, the European Society of Endodontology and the Association for Dental Education in Europe state that students should become competent in performing quality root canal treatment through their education. They also emphasize the need for acquiring basic skills through appropriate preclinical education and integrating knowledge and skills through clinical observation and clinical practice (10). Studies have reported that most dentists lack adequate knowledge about factors that affect the outcomes of root canal treatment and often overlook basic principles (11,12). It has been reported that root canal treatments performed by general dentists in Europe are of poor standards (13–16). Some of the reasons why root canal treatments performed by dentists are of poor quality are related to students who graduate without adequate knowledge and a complete understanding of the principles (17). The basic requisite for future dentists should be to reach a minimum level of proficiency before graduation (10). In addition, the learning process should not end with graduation and continue throughout professional practice (18).

Although the importance of a properly prepared access cavity for an ideal root canal treatment is a well-known fact, there are few studies in the literature examining this topic from students' perspectives. This issue has been primarily examined in relation to aspects such as the use of different techniques and the assessment of the effectiveness of teaching methods for access cavity preparation (19–21). Studies assessing students' knowledge and skills related to endodontics usually investigate the radiographic quality of the root canal fillings completed by the students and the complications and difficulties encountered during treatment (22,23). An assessment of access cavities prepared at all stages of undergraduate education in endodontics could help improve the quality of clinical performance of students and improve dental education. This study was conducted to evaluate the accuracy of access cavities prepared by undergraduate students in laboratory and clinical conditions in a government dental school.

The hypothesis was that: There is no difference in the success rates of the access cavities prepared by students in their preclinical and clinical practice during the endodontics course.

Materials and Methods

This study was approved by the Ethics Committee of the Selçuk University Faculty of Dentistry (decision date January 28, 2020, and decision no. 04). Students and patients included in the study were informed about the study in person, following which they provided their consent. The present study assessed access cavities prepared by students studying at Selçuk University Faculty of Dentistry during the academic years 2019–2020 and 2020–2021. Different students working in the preclinical and clinical practice phases of the endodontics course of dental faculty participated in the study. Access cavities prepared by third-year students in the preclinical practice phase and those prepared by fourth- and fifth-year students in the clinical practice phase of the endodontics course were included in the study. All the students agreed to participate voluntarily in the study. Cavities that were prepared by the students who previously had these courses, teeth treated with pulp capping, access cavity preparations that were started with indications for endodontic treatment but could not be completed for various reasons, retreated teeth, and access cavity preparations performed in patients with physical and/or mental disabilities that complicated the dental treatment were excluded from the study.

In the dental faculty where the research was conducted, students take endodontic courses in the third, fourth, and fifth years of dental education. The curriculum of the course, which is carried out theoretically and practically, is summarized in Table 1.

Tools

The data were collected using a Descriptive Data Form and an Access Cavity Preparation Assessment Form.

Descriptive Data Form

This form consisted of 19 questions prepared by the researchers based on the existing literature (22,24). The first section had 3 questions about the student and the tooth (education level, sex, tooth number). The second section consisted of 16 questions on the sociodemographic characteristics of patients and the patient-related and tooth-related factors that may affect cavity preparation.

Table 1. Endodontics course curriculum

	Duration
Third-year theoretical course	2 h
Preparation of the crown cavity	
Relationship between external anatomy of teeth and pulp anatomy	
Use of radiography prior to access cavity preparation	
General rules for access cavity preparation	
Characteristics of a properly prepared access cavity	
Root configuration classification	
Access cavity shapes	
Third-year practical course	
Fall semester preclinical laboratory	105 h
Extracted teeth placed on acrylic or plaster models	
Root canal treatment	
Capping a decayed tooth	
Temporary filling application	
All stages of root canal treatment	
Video	
Demonstration on the tooth (Group of 30–35 students)	
From students	
Root canal treatment (at least 1 tooth from each tooth or tooth group)	
Approval (acrylic model, access cavity, root canal length determination X-ray, tug back for master cone, master cone X-ray, and root canal filling X-rays, respectively)	
Spring semester phantom laboratory	
Extracted teeth placed in the phantom models (same procedures as in the fall semester)	
Fourth-year clinical practice	
Endodontic clinical practice first day demonstration stages	
Welcoming the patient	70 h
Taking systemic and dental anamnesis from the patient	
Oral and radiological examination	
Anesthesia	
Access cavity preparation	
Rubber dam use	
Determining the length of the canal	
Canal preparation and irrigation	
Temporary filling of the tooth	
From students	
Root canal treatment (30 canals)	
Approval	
Initial examination	
Access cavity	
Root canal length determination X-ray	
Master cone X-ray	
Canal filling X-ray	
Coronal restoration	
Fifth-year clinical practice	
From students	
Root canal treatment (50 canals)	60 h
Approval	
Initial examination	
Access cavity	
Root canal length determination X-ray	
Master cone X-ray	
Canal filling X-ray	
Coronal restoration	

Access Cavity Preparation Assessment Form

The form consisted 16 questions that were prepared based on the "principles of ideal access cavity preparation" (Fig. 1) (25–27). To evaluate the quality of the access cavities, "yes" and "no" answers were pointed out in the form. Every "yes" was scored "1" and every "no" was scored "0," and a total score was provided. This score was then divided by the number of the criteria evaluated for the relevant tooth (the number of criteria differed for each type of tooth as the criteria related to the tooth varied with preclinical and clinical conditions) and multiplied by 100 to convert it to a percentage. This score indicated the success in percentage form. Accordingly, the minimum achievable score was 0 and the maximum score was 100. The access cavities were assessed based on the percentage obtained. The score of each tooth was calculated using the formula: [(1 x yes)/number of dental criteria] x 100.

The evaluations were carried out, and the forms were completed by one researcher (DK) who was specially trained based on the criteria of ideal access cavity preparation and forms available in the literature (25,27,28). Neither the students nor the researcher used magnification during the study. In cases where the investigator was unsure, it was discussed with a consultant. After the assessments were

ACCESS CAVITY PREPARATION ASSESSMENT FORM (3rd-, 4th- and 5th-year)

1. Has the intact dental tissue been preserved?
( ) Yes ( ) No (intact dental tissue is removed, unnecessary tissue loss)
2. Has the roof of the pulp chamber been completely removed?
( ) Yes ( ) No
3. Has the lingual shoulder been removed from the anterior teeth?
( ) Yes ( ) No
4. Have the pulp horns on the incisal edge been removed from the anterior teeth?
( ) Yes ( ) No
5. Has all the coronal pulp tissue been removed?
( ) Yes ( ) No
6. Have all the canal orifices been identified?
( ) Yes ( ) No

6a. If no, how many canal orifices are identify?
( ) 1 ( ) 2 ( ) 3 or more

7. Has a straight or direct access been opened up to the first curvature of the canal or apical foramen?
( ) Yes ( ) No
8. Have the unsupported dental tissues been removed?
( ) Yes ( ) No
9. Are the walls and floor of the pulp chamber visible? (Are the cavity walls regular or in an outward-projecting form?)
( ) Yes ( ) No
10. Has damage to the floor of the pulp chamber with a bur been avoided?
( ) Yes ( ) No
11. Are the cavity walls regular?
( ) Yes ( ) No
12. Have additional canals in the tooth been explored?
( ) Yes ( ) No
13. Is the cavity large enough for coronal restoration? (For teeth without caries or restoration)
( ) Ideal width ( ) Too wide ( ) Narrow

ACCESS CAVITY PREPARATION ASSESSMENT FORM (4th- and 5th-year)

14. Have decayed tissues been completely removed?
( ) Yes ( ) No
15. Have defective restorations been completely removed?
( ) Yes ( ) No
16. Have the fillings and restorations that prevented direct access to the canals been removed?
( ) Yes ( ) No

Fig. 1. Access cavity preparation form.

completed, the students were informed about their mistakes and all the cavities were then idealized by a trainer to continue further steps of the root canal treatment.

Statistical Analysis

The data were evaluated using SPSS 22.0 software (SPSS, Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test was used to examine if the data were normally distributed, and Levene's test was used to evaluate the homogeneity of variance. The data were summarized in numbers (n), percentages (%), and average ± standard deviation (mean ± SD). For intergroup comparisons, the Mann–Whitney U test was used for comparing quantitative variables between two groups, whereas the Kruskal–Wallis test was used for comparing quantitative variables among multiple groups. A value of $p < 0.05$ was considered statistically significant.

Results

Our findings revealed that 52.2% of the students were females and 47.8% were males. The distribution of the participated students according to the education year were: third year students (33.4%), fourth year students (33.4%) and fifth-year students (33.2%), respectively. The top three locations of the teeth operated for access cavity preparations were the upper premolars (19.3%), the lower molars (17.2%), and the upper molars (16.2%) (Table 2).

In total, 57.9% of the patients were females and 42.1% were males, and the mean patient age was 37.73 ± 14.84 years. Further, the patients had abrasion/attrition/erosion (37.8%), bruxism (29.7%), dental trauma history (4.2%), and patient-related factors that complicated the treatment (10.2%). In the evaluated cavities, the following clinical signs and situations were recorded: caries (69.5%), defective filling (19.7%), diastema (5%), crowding (2.3%), rotation (3.9%), and pulp calcification (3.1%) (Table 3). Table 4 shows the average total achievement score for the access cavities and their distribution based on certain characteristics.

Considering the maximum point is 100 for each cavity, the average total achievement score for the access cavities was recorded as 66.58 ± 21.43. The scores for third-, fourth-, and fifth-year students were 68.19 ± 1.95, 58.02 ± 1.79, and 73.58 ± 1.64, respectively. The difference among the groups was found to be statistically significant ($p< 0.001$). Based on sex, the score was 64.57 ± 1.51 for female students and 68.79 ± 1.55 for male students, revealing a

Table 2. Distribution of students based on introductory data

Introductory data	n	%
Sex		
Female	203	52.2
Male	186	47.8
Year of study		
Third year	130	33.4
Fourth year	130	33.4
Fifth year	129	33.2
Tooth in which the access cavity was prepared		
Upper anterior	61	15.7
Upper premolar	75	19.3
Upper molar	63	16.2
Lower anterior	61	15.7
Lower premolar	62	15.9
Lower molar	67	17.2

Table 3. Distribution of the patients and teeth operated by students in clinical practice according to their characteristics

	n	%
Age (mean ± SD) (years)	37.73 ± 14.84	
Sex		
Female	150	57.9
Male	109	42.1
Bruxism		
Yes	77	29.7
No	182	70.3
Dental abrasion/attrition/erosion		
Yes	98	37.8
No	161	62.2
Dental trauma history		
Yes	11	4.2
No	248	95.8
Patient-related factors that complicated the treatment (poor cooperation/gag reflex, etc.)		
Yes	28	10.8
No	231	89.2
Dental conditions		
Decayed	180	69.5
Filled (defective)	51	19.7
Filled (intact)	24	9.3
Prepared for prosthetic purposes	20	7.7
Prosthetic restoration (removed or fallen)	20	7.7
Other	26	10
Presence of adjacent crowding or diastema		
Diastema	13	5
Crowding	6	2.3
Neither	240	92.7
Presence of rotation in the tooth		
Yes	10	3.9
No	249	96.1
Pulp calcification (preventing the identification of canals)		
Yes	8	3.1
No	251	96.9

Table 4. Total mean achievement scores for access cavities and distribution based on certain characteristics

	Achievement score (mean ± SD)	p
Mean (mean ± sd)	66.58 ± 21.43	-
Year of study		
Third year	68.19 ± 1.95[a]	<0.001
Fourth year	58.02 ± 1.79[b]	
Fifth year	73.58 ± 1.64[c]	
Sex		
Female	64.57 ± 1.51	0.039
Male	68.79 ± 1.55	
General location of the teeth operated for opening an access cavity		
Upper anterior	62.20 ± 2.97[a,b]	0.036
Upper premolar	71.74 ± 2.02[c]	
Upper molar	59.59 ± 3.11[a,d]	
Lower anterior	66.28 ± 2.63[b,c,d]	
Lower premolar	69.56 ± 2.65[b,c]	
Lower molar	68.89 ± 2.45[b,c]	
Bruxism		
Yes	67.16 ± 2.23	0.479
No	65.18 ± 1.60	
Dental abrasion/attrition/erosion		
Yes	68.45 ± 1.95	0.148
No	64.14 ± 1.72	
Dental trauma history		
Yes	58.218 ± 9.177	0.544
No	66.108 ± 1.304	
Presence of patient-related factors that complicated the treatment		
Yes	61.25 ± 3.37	0.173
No	66.32 ± 1.40	
Dental conditions		
Caries		
Yes	66.59 ± 1.49	0.655
No	64.00 ± 2.60	
Filling (intact)		
Yes	65.37 ± 4.10	0.761
No	65.81 ± 1.38	
Filling (defective)		
Yes	67.97 ± 2.99	0.347
No	65.27 ± 1.31	
Prosthetic restoration (removed or fallen)		
Yes	73.88 ± 4.92	0.023
No	65.09 ± 1.35	
Prepared for prosthetic purposes		
Yes	69.18 ± 4.49	0.447
No	65.49 ± 1.37	
Other (trauma fracture, periodontal cause, etc.)		
Yes	58.40 ± 5.04	0.201
No	66.59 ± 1.33	

Superscript letters indicate whether there is a significant difference among groups. The absence of common letters among the groups indicates a significant difference, whereas the presence of at least one common letter indicates the absence of a significant difference.

statistically significant difference ($p< 0.05$). Based on the location of the tooth, the score was 62.20 ± 2.97 for upper anterior teeth, 71.74 ± 2.02 for upper premolar teeth, 59.59 ± 3.11 for upper molar teeth, 66.28 ± 2.63 for lower anterior teeth, 69.56 ± 2.65 for lower premolar teeth, and 68.89 ± 2.45 for the lower molar teeth. The difference between the upper and lower premolars and upper molars was statistically significant ($p< 0.05$).

Table 5 shows the distribution of the access cavities against ideal access cavity preparation criteria. Complete removal of existing caries was provided in 67.2% of the teeth. Complete removal of defective restorations was observed in 74.5% of the teeth, whereas incomplete removal of the roof of the pulp chamber was observed in 41.1%. The lingual shoulder and pulp horns on the incisal edge had been removed in 50.8% and 73% of the anterior teeth. Not all canal orifices had been identified in 17.2% of the teeth. The floor of the pulp chamber had been damaged with a bur in 14.1% of the access cavities, and the presence/absence of additional canals in the tooth had not been investigated during preparation in 76.1% of the access cavities.

Discussion

Access cavity preparation is an important step in root canal treatment. Therefore, in addition to receiving their undergraduate education, students are expected to be capable of preparing ideal access cavities (3,9). A few studies about assessing the access cavities prepared by students are available in the literature (19,29). The present study aimed to assess the access cavities prepared by dental students to contribute to the success of root canal treatments after graduation and improve endodontic education.

Preclinical education prepares the student to care for patients in the clinic. On the other hand, clinical education allows them to gain autonomy in decision-making and implementing treatment decisions. This study included third-year students in preclinical practice, fourth-year students in the first year of clinical training, and fifth-year students in the second year of clinical training with partial experience in endodontic treatment. Few existing studies on this topic have concentrated on the practices of third-year students or compared preclinical and clinical practice (20,29). In this study, access cavities prepared by students at all stages of practical training in endodontics were evaluated. This is important to predict if the students are ready for further clinical experience and to detect at which stage the students are prone to make a mistake.

Morphological traits of the teeth and their location in the mouth can affect the success of access cavity preparation in clinics. Studies about access cavities prepared by students have found differences based on the types of teeth.

Table 5. Distribution of the access cavities against ideal access cavity preparation criteria

Criteria	Yes, n (%)	No, n (%)	Total, n
Have decayed tissues been completely removed?	121 (67.2)	59 (32.8)	180[a]
Have defective restorations been completely removed?	38 (74.5)	13 (25.5)	51[b]
Have the fillings and restorations that prevented direct access to the canals been removed?	68 (94.4)	4 (5.6)	72[c]
Has the intact dental tissue been preserved?	271 (69.7)	118 (30.3)	389
Has the roof of the pulp chamber been completely removed?	229 (58.9)	160 (41.1)	389
Has the lingual shoulder been removed from the anterior teeth?	62 (50.8)	60 (49.2)	122[d]
Have the pulp horns on the incisal edge been removed from the anterior teeth?	89 (73.0)	33 (27.0)	122[d]
Has all the coronal pulp tissue been removed?	234 (60.2)	155 (39.8)	389
Have all the canal orifices been identified?	322 (82.8)	67 (17.2)	389
Has straight or direct access been opened up to the first curvature of the canal or apical foramen?	311 (79.9)	78 (20.1)	389
Have the unsupported dental tissues been removed?	276 (71.0)	113 (29.0)	389
Is the cavity large enough for coronal restoration (for teeth without caries or restoration)?	85 (46.7)	97 (53.3)	182[e]
Are the walls and floor of the pulp chamber visible? (Are the cavity walls regular or in an outward-projecting form?)	255 (65.6)	134 (34.4)	389
Has damage to the floor of the pulp chamber with a bur been avoided?	176 (85.9)	29 (14.1)	205[f]
Are the cavity walls regular?	308 (79.2)	81 (20.8)	389
Have additional canals in the tooth been explored?	93 (23.9)	296 (76.1)	389

[a]Decayed teeth. [b]Teeth with defective restoration. [c]Teeth with filling and restoration. [d]Only anterior teeth. [e]Decay- and restoration-free teeth. [f]Upper premolar, molar, and lower molar teeth.

Previous studies have mainly focused on a single type of tooth, for example, maxillary central, maxillary molar, and mandibular first molar teeth (20,21,29). Only one study (19) investigated all types of teeth, similar to our study. In the aforementioned study, the students were trained either by small-group discussion method or by using a traditional method (90 min lecture incorporating videos). The results of the study showed that while students taught using the small-group discussion method scored higher in practice, there was no significant difference between the two groups in the written test. As a result, the authors concluded that using educational methods involving active student participation may increase the success rates of endodontic treatment and small-group discussion is an effective method. In the present study, the traditional training method was used and no group-discussion method was provided. The traditional method used in our study is different from the one used in the related study, and the details are given in Table 1. Therefore, a reliable comparison between the two studies may not be appropriate. On the other hand, a modification in the current training program seems inevitable.

In the present study, the average achievement score for the access cavities prepared by students in preclinical and clinical practice was 66.58. Existing studies assessing knowledge and skills of dental students in endodontics have primarily focused on the radiographic quality of root canal fillings, complications and difficulties encountered during treatment, and evaluation of the effectiveness of different educational methodologies (20,30,31). Two studies assessing the difficulties encountered by students during root canal treatment reported that 57.9% and 36.8% of the students had difficulty in access cavity preparation. The same studies reported that one of the most challenging issues was the ability to identify canal orifices. Identification of canal orifices is possible with the preparation of an ideal access cavity (23,32). In a meta-analysis study (33) assessing the quality of root canal treatment, it was reported that the radiographic success rate ranged from 13% to 85.12%, with an average of 48.75%. The study results also showed that the quality of the root canal treatments provided by the students was generally poor. There might be several reasons for this. One reason might be the inadequate teaching conditions or insufficient tools for new generation students who are well-equipped with technology. Therefore new teaching plans should be provided by the instructors considering the interests of students and the teaching conditions and tools should be improved by searching for financial support resourches (33). The inadequate quality of root canal treatments reported in these studies might also be attributed to the failure of access cavity preparations, which is a crucial step in endodontic treatment. Our main motivation for assessing access cavities in the present study was to optimize the outcomes of endodontic treatment. This relationship can be demonstrated by the long-term follow-up of patients and the planning of studies to assess clinical success. Therefore, further studies are necessary to investigate these topics.

Studies evaluating various educational methods for increasing the success rates of the access cavities prepared by

students, including one study evaluating the effectiveness of 3D macromodels, have reported that 85% of students found macromodels to be effective tools for endodontics education and practice (20). A study investigating the benefits of using a dental operating microscope found that the group trained with an operating microscope outperformed the group trained without a microscope (21). Vantorre et al. (34) created a reference evaluation protocol based on micro-CT analysis to check the accuracy of the conventional evaluation protocol in evaluating the steps in root canal treatment and found that the conventional evaluation protocol was appropriate for evaluating access cavity preparation. Our study included students undergoing traditional education without any magnification device. Magnification devices are not widely used in undergraduate education because using them carries several disadvantages such as the need for additional training about microscope application, long-lasting learning process, and high costs (35,36). These results demonstrate the importance of using new teaching methods to improve the quality of the interventions performed by students and more efficiently use the time available in colleges of dental medicine.

Studies that radiographically evaluated the quality of canal treatments performed by students in clinical practice found no difference in treatment success rates among studies in different years (22,37,38). However, one study found fifth-year students to be more successful than fourth-year students (39). Another study evaluating procedural errors made during canal treatment reported that fourth-year students caused more complications than fifth-year students. Our study evaluated the access cavities prepared by third-year students in preclinical training and fourth- and fifth-year students in clinical practice. The scores achieved by the third-, fourth-, and fifth-year students were 68.19, 58.02, and 73.58, respectively, and the difference among them was statistically significant ($p< 0.001$) (hypothesis was rejected). Lower scores among fourth-year students compared with fifth-year students might be due to a lower level of clinical experience. On the other hand, the fact that fourth-year students performed worse than third-year students might be explained by the disadvantages resulting from performing operative treatments on patients for the first time in a clinical setting during training. These disadvantages include stress due to performing a procedure on a patient for the first time, patient-specific factors that can complicate the treatment (limited mouth opening, gag reflex, etc.), and the presence of fluids in the environment.

Regarding the relationship between access cavities and types of teeth, only one study evaluated the access cavities prepared by students in all types of teeth. The study found no significant difference among different types of teeth (19). Studies making radiographic evaluations of canal treatments reported higher achievement scores in anterior teeth than in posterior teeth (22,33,40,41). Further, Khabbaz et al. (22), Barrieshi-Nusair et al. (40), and Elsayed et al. (42) reported higher achievement scores in maxillary teeth than in mandibular teeth. In the present study, the highest achievement scores were obtained in the upper premolars and lower premolars (71.74 and 69.56, respectively). This result can be explained by the mesiodistal and buccolingual symmetry of the access cavities opened in these teeth and the straight line of movement of the bur from the occlusal aspect of the tooth up to the pulp chamber when opening the access cavity (25). The lowest score in this study was obtained in the upper molars (59.59). This can be explained by the location of the upper molars, which have a very complex root canal anatomy, and the common difficulty in locating the second mesiobuccal canal (25,43).

Although it might look simple to open an access cavity in a tooth with little or no clinical crown, the treatment is complicated by the potential presence of calcified pulp in the teeth of people with caries or extensive restorations (25). Therefore, our study also evaluated the effects of several dental conditions, such as caries, filling, and prosthetic restorations, on the success rates of access cavity preparation. Statistical analysis revealed that the presence of caries and fillings in the tooth did not affect the success rates ($p > 0.05$), whereas the presence of removed or fallen prosthetic restorations did ($p< 0.05$). The access cavities prepared in the preclinical laboratory were not included in the statistical analysis for that part because intact teeth were used during the preclinical training program.

The most common errors made by students during root canal treatment include ledge formation, perforated furcation, apical transportation, and apical perforation (31,33,37). Failure to remove the lingual shoulder in the anterior teeth may cause the file to deviate from the canal in the apical region, resulting in ledge formation (25). In the present study, lingual shoulders were not removed in 49.2% of the anterior teeth. Further, the floor of the pulp chamber was damaged with a bur in 27% of the upper molars and 13.4% of the lower molars during access cavity preparation. Two separate studies reported that 47.2% and 33% of students had difficulty in removing the roof of the pulp chamber (23,32). These results were similar to those of our study, which found that the roof of the pulp chamber could not be completely removed in 41.1% of the access cavities. Kaplan et al. (23) and Mandorah et al. (32) reported that 67% and 61.9% of students, respectively, had

difficulty locating canal orifices. In our study, 82.8% of the students were able to identify all canal orifices. We assume that this difference between our study and other studies might be due to the different methods used for data collection.

Our study used observational evaluation by a specialized dentist with a postgraduate degree, whereas other studies used student-reported surveys for evaluation. Khabbaz et al. (22), Abdulrab et al. (30), and Alhekeir et al. (44) reported that most of the iatrogenic errors made by students during root canal treatment occurred in the molar teeth (54.1%, 63.96%, and 65%, respectively). These results are in line with the results of our study in that the lowest success rates in removing the entire coronal pulp tissue, identifying all canal orifices, and assuring straight or direct access to the apical foramen or the first curvature of the canal were in the upper and lower molars. In addition, errors such as incomplete removal of decayed tissues and irregular cavity walls were mostly observed in the upper molars.

This study was planned to improve the preclinical and clinical endodontic practice of the students working in a government dental school by determining their ability to prepare access cavities. There are several limitations to this study. The time calculation for cavity preparation was not recorded. The order in which the students used the burs was also not confirmed because the study was depending on a cooperation based on mutual trust (they were asked to follow the theoretical lectures which were given during the training). The use of a rubber dam during the access cavity preparation could not be provided because of several other reasons. On the other hand, this study is the first study to evaluate dental students' practice based on their theoretical knowledge and the first study to evaluate the effect of training on clinical practice. Further studies are extremely necessary to improve endodontic practice and training.

Conclusions

Within the limitations of this study, the following results were drawn:

1. An achievement score of 66.58 was recorded for the access cavities prepared by dental students in preclinical and clinical practice.
2. Among all the students, fifth-year students obtained the highest score, followed by the third- and fourth-year students, showing that clinical experience increases the success rate.
3. Preclinical training programs should be improved by using group-discussion programs, advanced technologies, such as 3D teeth that mimic the pulp chamber anatomy, virtual reality, and artificial intelligence techniques.

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