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Original article

Evaluation of the Accuracy of the Access Cavities Prepared by Undergraduate Dental Students at Tripoli University

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Abstract
Access cavity efficiency is essential and a critical component of the clinical abilities needed for successful root canal treatment. It requires precise, professional hand skills, as well as a holistic cavity design based on radiographic interpretation and the clinical appearance of the accessible tooth. This study aimed to evaluate the quality of access cavity modalities performed by undergraduate dental students (n=73) at the Faculty of Dentistry, University of Tripoli. Students' access cavities, as well as the strengths and limitations of access cavity preparation in pri-clinic, were visually and radiographically assessed. The data were analyzed using descriptive statistics, frequencies, and percentages. Independent samples t-tests were used to compare the performance of male and female students in each of the parameters studied. The results indicated that students with relative skill in access and absence of overhangs received the highest score of 1.63 out of the evaluated features. Furthermore, the flaring score of 1.37 indicates a reasonable mastery of this aspect of the method. Nonetheless, the scores for Morphology (1.15) and Coronal Preservation (1.27) suggest areas that require further development and training. Undergraduate students demonstrate acceptable proficiency, particularly in achieving proper access and minimizing structural overhangs. However, the variation in scores for morphology and coronal root preservation indicates that these areas require further attention and need curricular enhancements and more targeted preclinical training to allow for full skill.
Keywords. Access cavity, Overhangs, the flaring, Morphology, and Coronal Preservation.

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Introduction

Root canal therapy is required to treat or prevent apical periodontitis [1]. To ensure successful outcomes, every stage of the therapy must be completed correctly [2]. The access cavity preparation is one of the most critical clinical steps and must be completed with great caution and accuracy. If not done appropriately, the following management of the root canal system can be significantly put at risk [3]. So, proper access cavity preparation is an essential stage in root canal therapy [4]. A well-designed access cavity promotes the success and ease of future steps while minimizing the procedural mistakes [3]. Conversely, inadequate access might result in untreated, poorly disinfected canals that are challenging to shape and seal [5]. As a result, the majority of the access cavity preparation errors appear to be caused by a failure to follow the principles of optimum access cavity preparation and a lack of knowledge regarding internal and external dental morphology [6]. It is additionally known that an improperly prepared access cavity can cause significant clinical problems such as accidental perforation, ledge formation, canal obstruction, instrument separation, neglected canals, and incomplete obturation. These issues can compromise canal cleanliness and preparation and affect the outcome of treatment [7].

Numerous studies show that the quality of root canal therapy is essential, as it influences the long-term outcome of the treated teeth [8]. Therefore, students must recognize the importance of proper access cavity preparation because it is the first and most crucial step in the treatment process. An optimum access involves removing the entire roof and shoulder in a straight-line pathway to the apical third of the root canal. This free straight-line access is critical for effective canal instrumentation because it reduces the risk of procedural errors while also improving cleaning efficiency [9]. Dental students receive both theoretical knowledge and hands-on practical skills in their dental course. Practical skills are acquired using phantom heads, which simulate the patient's oral cavity, providing trainees with operational and motor abilities that would not be achievable otherwise [10]. Pre-clinical training is an important educational stage for dental students to become acquainted with the procedures and techniques that they would later use in a clinical situation [11]. Given the importance of preclinical training in dental school, any improvement is strongly recommended, and new technology may significantly support this development [12].

Extracted human teeth are commonly employed in preclinical endodontic training due to their cost-effectiveness, the ability to replicate a wide range of anatomical variances and pathological conditions, and useful haptic feedback for tactile development. Sensitivity and physical dexterity are essential for successful endodontic operations [13]. These tactile skills are critical for performing successful endodontic procedures. Recent studies show that extracted human teeth are employed for endodontic instruction in 82.1% of dental schools in Italy, 73% in England, and 100% in Spain [15]. Despite their advantages, the use of extracted teeth has restrictions. Improved dental health and therapeutic options for previously extracted teeth have

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led to a decrease in the need for practice [16]. The use of extracted teeth raises ethical considerations and requires precautions to prevent cross-contamination, necessitating strict handling and sterilization protocols [16]. Additionally, natural teeth's lack of uniformity may interfere with classroom exercises and may complicate standardized assessments and educational outcomes [17]. To address these challenges, more advanced artificial root canals have been introduced to the market, ranging from canals with various shapes and dimensions in transparent resin blocks to plastic typodonts that simulate human dentition [18, 19]. Medical students can improve their skills by using accurate 3D-printing technology that mimics the tactile sensation of natural tissues [20]. The benefits of adopting 3D printed teeth include the theoretically unlimited availability of tooth replicas and the elimination of variation in natural teeth [21, 22].
The majority of research evaluating endodontic therapies has been undertaken at dentistry schools and among practitioners to measure treatment quality. A few research studies on assessing student-prepared access cavities have been published in the literature [23-25]. The current study aims to evaluate the access cavities performed by undergraduate dental students, to enhance the quality of endodontic education, and ultimately contribute to the success of future root canal treatments performed in clinical practice.

Methods

Study design

This cross-sectional, descriptive study was designed to evaluate the strengths and weaknesses of access cavity preparation during preclinical endodontic training. The evaluation focused on root canal treatment performed by fourth-year dental students at the College of Dentistry, University of Tripoli, during the 2024 academic year. A total of 73 artificial (3D-printed trans parent teeth) maxillary central incisors were assessed after the first training on performing RCT by preclinical students. The sample included 53 female and 20 male students, and all procedures were carried out in the endodontic and conservative dentistry laboratory at the University of Tripoli.

Tooth instrumentation and access preparation

Access to the pulp chamber was achieved using carbide round burs. All procedures were performed by students under supervision and were subsequently evaluated for quality of access cavity preparation. Two experienced endodontists, each with over ten years of clinical practice in endodontics. Independently assessed the quality of the access cavity preparations.

Assessment Tools and Parameters

The evaluators used a periodontal probe and visual inspection under optimal lighting to assess the following key parameters: 1) Access cavity morphology; 2) Flaring of the access cavity walls; 3) Adequacy of canal access; 4) Absence of overhangs and dentinal triangles; and 5) Preservation of the coronal part of the root.
A standardizedradiographic imaging was performed for accuracy in evaluating the last point of the scores (Coronal root preservation) with a dental X-ray unit (Gendex Expert DC KaVo, Germany) was used withsetting of70 k V p, 10 m A, and an exposure time of 0.25 seconds, employing a digital sensor (Gendex GXS-700, USA). The paralleling technique was used to obtain bucco-lingual radiographs. For each tooth, two radiographs were taken with the X-ray tube angled 20° horizontally and mesially.

Evaluation criteria

Each parameter was scored on a scale from 0 to 3; this criterion was the previous study [26], as indicated in Table 1.

Table 1. Evaluation parameters for access cavity preparation.

Observable elements	Criteria	Scale Score			
		4 points Ideal quality	**3 pointsAcceptable quality**	**2 points Poor quality**	**1-point Unacceptable quality**
Shape of the access cavity (Ant)	**Morphology**	The triangle shapes. All walls complied with the shape (centralised)	triangular shape and only two walls complied with the shape	Maybe a triangle's shape or their shape, and only one wall complied with the shape	Other shapes and no walls complied with the shape.
	Flaring of the access cavity walls	Occluso-divergent concerning the axis of the tooth.	Occluso-divergent (only two walls)	Occluso-divergent (one wall)	Occluso-convergent without respect to the axis of the tooth.
	Access to canals and absence of	The canal entrance was visible	One side of the canal entrance was not visible	More than one side of the canal	It was not visible

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	overhangs and dentinal triangles			entrance was not visible	
	Preservation of the coronal part of the root (visual + +radiographic)	Ideal size without cervical ledge	Small size without cervical ledge	Large without ledge	Large with dentinal ledge

Statistical Analysis

Descriptive statistics, including means, standard deviations, frequencies, and percentages, were used to summarize the data. Independent samples t-tests were conducted to compare the performance of male and female dental students across the evaluated parameters of access cavity quality.

Results

Objective 1: Assess the general level of performance in access cavity preparation among dental students.

The results of the overall evaluation of access quality are presented in Table 2. The mean score for morphology was 1.15 ± 0.97, suggesting a moderate level of acceptable access cavity morphology. The mean score for flaring of the cavity walls was 1.37 ± 0.94, a level of flaring achieved in cavities. Furthermore, the mean score for access to canals and the absence of overhangs was 1.63 ± 0.92, reflecting a generally good level of access to the area with minimal presence of overhangs. Lastly, the mean score for coronal root preservation was 1.27 ± 1.65, demonstrating variability in students' ability to preserve the coronal portion root structure during access preparation.

Table 2. Performance Assessment of Access Cavity Preparation Among Dental Students

Parameter	(Mean ± SD)
Morphology	1.15 ± 0.97
Flaring	1.37 ± 0.94
Access & Absence of Overhangs	1.63 ± 0.92
Coronal Root Preservation	1.27 ± 1.65

Objective 2: Compare the performance of male and female dental students in these key areas.

In Table 3, the assessment of access cavity quality was conducted based on four key parameters: morphology, flaring, access to canals and absence of overhangs, and coronal root preservation. In terms of morphology, the mean score for male students was 1.30 ± 1.03, while female students achieved a mean score of 1.09 ± 0.95. Statistical analysis revealed no significant difference between the groups, with a p-value of 0.422.

In terms of flaring, male students recorded a mean score of 1.55 ± 1.00, compared to 1.30 ± 0.91 for female students. No statistically significant difference was found between the groups, as indicated by a p-value of 0.316.

Regarding access to canals and the absence of overhangs, male students recorded a higher mean score of 1.90 ± 1.02 than female students, 1.53 ± 0.87, but this difference was also not statistically significant between the groups, with a p-value of 0.125. Lastly, the mean score for coronal root preservation was 1.25 ± 1.12 for male students and 1.28 ± 1.82 for female students. Similar to the other parameters, no statistically significant difference was observed between the groups, with a p-value of 0.940.

Table 3. Comparison of Access Cavity Qualityscores by gender

Parameter	Male (Mean ± SD)	Female (Mean ± SD)	P –value
Morphology	1.30 ± 1.03	1.09 ± 0.95	0.422
Flaring	1.55 ± 1.00	1.30 ± 0.91	0.316
Access & Absence of Overhangs	1.90 ± 1.02	1.53 ± 0.87	0.125
Coronal Root Preservation	1.25 ± 1.12	1.28 ± 1.82	0.940

Objective 3: Identify the strengths and weaknesses of dental students in accessing cavity preparation.

The analysis of dental students' performance in access cavity preparation revealed varying levels of proficiency across the assessed parameters. The highest mean score was recorded in the category of access

to canal and Absence of Overhangs (mean =1.63), indicating that students possess a relatively strong ability to provide adequate canal access while minimizing structural interferences. Additionally, the Flaring score of 1.37 reflects a reasonable understanding of proper cavity wall tapering. Nevertheless, the scores for Morphology (mean =1.15) and Coronal Preservation (mean =1.27) highlight areas that require further emphasis in pre-clinical training to ensure balanced skill acquisition.

Discussion

The endodontic access cavity is an essential part of successful endodontic therapy. Insufficient access may result in missed canals that have not been treated or cleaned properly, which may be difficult to form and seal. As a result, before obtaining their college education, students are required to be able to prepare suitable access cavities [1-3]. Considering the lack of research on assessing the technical quality of the endodontic access cavities prepared by students throughout their pre-clinic training. The goal of the current study was to evaluate the access cavities created by dental students to improve educational outcomes and ultimately enhance the quality of patient care post-graduation.

In the present study, no statistically significant difference was found between male and female students in access cavity performance. The results were similar to the study of Balto et al. [27], and Sjögren et al [28] discovered no gender-related variations in endodontic treatment results. However, the results contrast with findings from Elhakim [29] and Al Yahya [30], whose studies at King Saud University (KSU) indicated gender-related variations. This might be connected to the extensive physical force employed by the male (as opposed to the female) students in treatment; all endodontic treatments should be performed softly to prevent the rate of errors.

The results of the study revealed that 73% of the students' access cavities were technically unacceptable. There is no comparable assessment utilizing the same technique and criteria in the endodontic literature, making comparison difficult. The only research available at this point compared evaluations of access cavities performed using the conventional model vs. a novel ultra-conservative approach using visual aids such as loupes and a dental operating microscope [3]. This finding was different from the study of Ndiaye (2023) [31]. The result concerning the frequency of technically insufficient access cavities could potentially be due to students' lack of experience, associated with performance anxiety during pre-clinical exercises.

Overall, the findings highlight the need for specific teaching techniques and practical training to strengthen students' clinical competence. Students show relative proficiency in Access and Absence of Overhangs, which achieved the highest mean score of 1.63. This suggests a reasonable understanding of the importance of clear canal access and the removal of structural obstructions. Additionally, the Flaring parameter received a moderate score of 1.37, indicating a fair grasp of the concept of tapered canal entry. Nonetheless, the lower scores in Morphology (1.15) and Coronal Preservation (1.27) highlight areas that require additional attention and development. better irrigant penetration, debris suspension, and tactile control are improved by straight-line access to the apical region. The majority of problems that happen during root canal instrumentation may be prevented by removing any overhangs [32]. The present study showed that the absence of overhangs obtained the best score of 1.63. Good the root canals is critical to the success of endodontic treatment. As a result, proper access preparation is critical for the therapy's completion. This finding was similar to the study of Ndiaye et al. (2023) [31] and different from the results of Rehman et al. (2016) [32]. Not removing the overhangs may result in instrument navigation, impede irrigation, and discoloration of the anterior crown or possibly bacterial contamination of the canal area, which should be thoroughly cleaned. In summary, this study underscores the need for targeted instructional strategies and enhanced simulation-based training to improve student competency in endodontic access cavity preparation. Emphasis should be placed on cavity morphology and coronal preservation, alongside reinforcing positive practices already demonstrated in canal access and overhang removal.

An endodontic access cavity is prepared by creating an occluso-divergent cavity to facilitate straight-line access to the root canal and allow for efficient instrumentation, irrigation, and obturation. The study revealed a mean flaring score of 1.37, indicating an inadequate knowledge of this component of the method. This deficiency may compromise the overall success of endodontic therapy by hindering proper canal access and subsequent treatment steps. This finding differed from the results of Ndiaye et al. (2023) [31] and Rehman et al. (2016) [32]. The observed morphology shape errors indicate that the students had difficulties determining what marks were required for establishing the best access cavity on the occlusal, palatal, and labial surfaces. In this study, the biggest mistake made by the students during their handling of the access cavities was in access cavity morphology. This result was similar to the results of Rehman et al. (2016) [32] and different from the study of Ndiaye (2023) [31]. The weakness in the present study may harm the subsequent steps of endodontic treatment (cleaning, shaping, irrigation, and root canal filling).

Increasing the number of laboratory sessions ensures better learning outcomes and A significant factor improving learning skills is dependent on quality instruction and the ability to identify and overcome challenges [33]. To improve preclinical practice, students must interact with staff members by identifying problems during preparation and providing feedback when each tooth is accessed. The study found a

significant frequency of unacceptable access cavities, which could be attributable to factors such as limitation in study design, subjective variability in scoring criteria and radiographic interpretation, lack of clinical experience among undergraduate students, endodontic course of study, or inadequate training tools and equipment.

Overall, these interventions aim to bridge the gap between theoretical knowledge and clinical execution, fostering improved outcomes in root canal therapy and advancing the readiness of dental students for clinical practice, particularly in taper achievement and access cavity morphology. Continuous assessment and feedback will be essential in guiding students toward improved performance and greater confidence in their clinical skills as future dental professionals.

Conclusion

The assessment of fourth-year dental students' performance in access cavity preparation reveals a foundational understanding of essential clinical competency, alongside identifiable areas that warrant curricular enhancement. The analysis indicates that while students are achieving basic competency in key parameters, suggests a need for enhanced training and practice in this critical aspect of the procedure.

In terms of access cavity quality, students demonstrate relative proficiency, particularly in achieving adequate access and minimizing overhangs. However, the variability in scores for morphology and coronal root preservation indicates that these areas need targeted instructional reinforcement and further focus in the curriculum to ensure comprehensive skill development. The comparative analysis between male and female students shows no statistically significant difference in access cavity preparation, confirming that gender did not influence the quality of performance in this cohort. In light of these findings, the following recommendations are proposed: Enhanced Pre-clinical Instruction: Curriculum development should place greater focus on access cavity morphology and coronal root preservation through the use of visual aids, detailed demonstrations, and structured feedback. Also, formative Assessment and Feedback: Continuous assessment strategies, accompanied by timely and constructive feedback, are essential to help students recognize and correct procedural errors.

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