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Original article

Radiographic Assessment of the Quality of Root Canal Fillings Performed by undergraduate Dental Students in Tripoli, Libya: A Pilot Study

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Abstract
The success of endodontic treatment is remarkably affected by the radiographic technical quality of the canal(s) filling. The pilot study aimed to assess the root canal fillings performed by fourth-year students at the College of Dentistry, University of Tripoli, Libya, during the 2024 academic year. Undergraduate preclinical dental students performed a root canal treatment on 73 single-rooted artificial teeth. For root canal preparation, the step-back method was used with hand-held instruments made of stainless-steel files with a 0.02 taper and up to the master apical file 30. Normal saline solution was then used for irrigation. The cold lateral condensation method was used to fill each root canal. After that, the teeth were gathered and radiographically assessed using three quality criteria (length, density, and taper). Descriptive statistics, including frequencies and percentages, were used to summarize the data. The study's findings showed that the general caliber of root canal fillings was poor. Nonetheless, almost 50% of the research sample (63%) had adequate length, 40% had adequate density, and 43% had adequate taper. In the case of Taper, nearly half of the cases (49%) were rated as very insufficient. Overall, the performance of male and female dental students in root canal filling was comparable, with no statistically significant differences observed in length, density, or taper. The assessment of dental students' performance in root canal filling reveals a foundational understanding of essential clinical skills, alongside identifiable areas for improvement. The comparison between male and female students showed no statistically significant differences in performance in root canal filling, suggesting that both groups are equally positioned in their clinical training.
Keywords. Endodontic Treatment, Undergraduate, Radiographically, Criteria.

Introduction

A crucial part of complete dental care is root canal treatment [1]. The last step in endodontic treatment is obturation of the root canal system, which aims to effectively seal the entire root canal system with a material that is compatible with the body. A three-dimensional obturation of the radicular space is needed to stop coronal and apical leaks and to separate and cover any irritants that are still in places that can't be reached, like vaults or dentinal tubules [2]. Numerous parameters have been found to connect with the outcome of primary endodontic therapy [3-5]. The quality of root canal treatment is one of these factors, and it may be examined in a variety of ways [6-7], although radiography is typically and most frequently used as the evaluation method [8]. The radiographic evaluation of three criteria is necessary to determine the technical quality of the root canal filling; these factors include the length, taper, and density of obturation [9]. It is essential to ensure that the root canal is completely and flawlessly filled, with no spaces or gaps between the obturating material and the canal wall. Additionally, the filling's distance from the radiographic apex should be between 0.5 and 2 mm [10].

The length of the obturating material related to the radiographic end and its density (lack of spaces within the obturating material) are the two primary technical variables used to radiographically evaluate the quality of a root canal filling [12]. A lot of research measuring the skill level of undergraduate students' root canal fillings found a large percentage of poor root canals, indicating problems in clinical performance as a need for improved instructional programs [13-15]. The assessment of RCT technical skills by undergraduate preclinical dentistry students generates interest in numerous countries with different educational systems [16-18]. The level of clinical performance for students will be enhanced and dentistry education will be improved with regular examination of preclinical endodontic student success results [16]. Despite the importance of completing preclinical root canal treatments, however aren't many studies that evaluate preclinical students' technical skills [17,18].

Enhancing RCTs in Libya can be accomplished by focusing on undergraduate students' education and training. The technical proficiency of root canal therapy procedures carried out by dentistry students at Libya's University of Tripoli, however, has not been evaluated in any previous research. Therefore, the present research aimed to examine the technical level of root canal obturations in artificial teeth done by preclinical undergraduate students at the University of Tripoli, Libya's College of Dentistry; utilizing radiographic criteria.

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Methods

Study design

The purpose of this pilot study was to assess the technical quality of root canal fillings performed by fourth-year University of Tripoli College of Dentistry students. during the 2024 academic year. A total of 73single-rooted artificial teeth was evaluated after the first training on performing root canal treatment by preclinical students (53 female and 20 male) at Tripoli University.

Tooth instrumentation

Carbide round burs were used to gain access to the pulp chamber, and the working length was ascertained.; then the stepback technique was used to prepare the root canal using stainless steel files and hand instruments of 0.02 taper (K-files, Dia-Dent Corp, Chung-cheong-buk-do, Korea) and instrumented up to file 30 (MAF). The solution of normal saline was used for irrigation, and then Using gutta-percha points of 0.02 taper and the cold lateral condensation technique, all root canals were filled. (Sure-Endo, Sure-Dent Corp, Gyeonggi-do, Korea) and zinc oxide eugenol (ZOE) sealer (Zinconol, Prevest DenPro, Jammu, India).

Radiographic procedures

The radiographic procedure was performed using a dental X-ray unit (Gendex Expert DC KaVo, Germany) at 10 mA, 70 kVp, and 0.25 s exposure time and a digital sensor (Gendex GXS-700, USA). Buccolingual radiographs of artificial teeth were obtained using the paralleling technique. 20° horizontal mesial angulations of the X-ray tube were used (2 directions radiograph per each tooth). The images were evaluated by two endodontists with more than 20 years of experience in endodontics. The postoperative radiographs were evaluated to assess the quality of the root canal obturation.

Evaluation criteria

The evaluation criteria were length, density, and taper of root canal filling. Each parameter was scored as 0, 1, 2, or 3, which modified criteria from previous studies [2.18.19] as shown in Table 1.

Table 1. Evaluation parameters for root canal obturation.

Observable elements	**Criteria**	**Scale Score**			
Root canal filling		Excellent: 3 points	Satisfactory: 2 points	Unsatisfactory: 1 point	Very insufficient: 0 point
	Length	Root canal filling (RF) ending 0.5 -1 mm short of the radiographic apex (adequate)	(RF) ending at the radiographic apex (tip-to tip) or 1-2 mm shorter than the radiographic apex	(RF) beyond the radiographic apex or (RF) 1 to 2 mm from the radiographic apex".	(RF) beyond the radiographic apex or (RF) > 2 mm from the radiographic apex". Or more than 3mm root short
	Density	Homogeneous (RF), good condensation with no visible voids	Not bad condensation with no visible voids	Bad condensation or 1visible void present	Non-homogeneous (RF), poor condensation or voids present.
	Taper	Consistent and uniform taper from the coronal to apical area with a reflection of the original shape of the canal	Consistent but under tapering or prep from the coronal to apical end	over tapering or prep from the coronal to apical end	Non-consistent taper

Statistical analysis

Descriptive statistics, including 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 in each of the assessed parameters: root canal filling length, density, and taper.

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Results

Assessment of Dental Students' Root Canal Performance

The general level of performance in root canal filling among dental students was assessed based on three parameters: length, density, and Taper. The results are showed in Table 2. The evaluation of dental students' work on root canal fillings revealed variability across the evaluated parameters. The majority of cases for length were rated as satisfactory (48%), followed by very insufficient (35.5%) and excellent (15%), with only 1.5% deemed unsatisfactory. The mean score for length was 1.42 ± 1.13, indicating a moderate level of performance overall. For density, the highest proportion of cases were classified as unsatisfactory (38%), while 33% were rated as satisfactory, 7% as excellent, and 22% as very insufficient. The mean score for density was 1.25 ± 0.88, reflecting a slightly lower performance compared to length. In the case of taper, nearly half of the cases (49%) were rated as very insufficient, while 39% were satisfactory, 4% were excellent, and 8% were unsatisfactory. The mean score for taper was 0.97 ± 1.03, indicating the lowest performance among the three parameters. These findings highlight the need for targeted training and practice to improve dental students' skills in root canal procedures, particularly in achieving optimal taper and density.

Table 2. Performance Assessment of Obturation Among Dental Students

Parameter	Category	Number of Cases (n)	Percentage (%)	Mean ± SD
Length	Excellent	11	15%	1.42 ± 1.13
	Satisfactory	35	48%	
	Unsatisfactory	1	1.5%	
	Very Insufficient	26	35.5%	
Density	Excellent	5	7%	1.25 ± 0.88
	Satisfactory	24	33%	
	Unsatisfactory	28	38%	
	Very Insufficient	15	22%	
Taper	Excellent	3	4%	0.97 ± 1.03
	Satisfactory	28	39%	
	Unsatisfactory	6	8%	
	Very Insufficient	36	49%	

Compare the performance by both men and women dental students in these key areas.

The comparison of root canal filling performance between male and female dental students revealed no statistically significant differences across the evaluated parameters. For length, male students had 20% of cases rated as excellent, 45% as satisfactory, and 35% as very insufficient, with no cases classified as unsatisfactory. Female students had 13% of cases rated as excellent, 49% as satisfactory, 2% as unsatisfactory, and 36% as very insufficient. The mean scores for length were 1.50 ± 1.19 for males and 1.40 ± 1.12 for females, with no significant difference (p = 0.729).

In terms of density, male students had 5% of cases rated as excellent, 25% as satisfactory, 60% as unsatisfactory, and 10% as very insufficient. Female students had 13% of cases rated as excellent, 49% as satisfactory, 2% as unsatisfactory, and 36% as very insufficient. The mean scores for density were 1.25 ± 0.72 for males and 1.25 ± 0.94 for females, with no significant difference (p = 0.984).

For taper, male students had 5% of cases rated as excellent, 40% as satisfactory, and 55% as very insufficient, with no cases classified as unsatisfactory. Female students had 4% of cases rated as Excellent, 49% as Satisfactory, 11% as unsatisfactory, and 47% as very insufficient. The mean scores for taper were 0.95 ± 1.10 for males and 0.98 ± 1.01 for females, with no significant difference (p=0.909).

Overall, the performance of male and female dental students in root canal filling was comparable, with no statistically significant differences observed in length, density, or taper. Both groups demonstrated similar levels of performance, indicating that gender does not significantly influence the outcomes in these key areas. However, the results highlight areas for improvement, particularly in achieving higher rates of excellent and satisfactory outcomes, especially in taper and density as shown in table 3.

Table 3. Comparison of Root Canal Filling Performance Between Male and Female Dental Students

Parameter	Category	Male (n = 20)	Female (n = 53)	P-value
Length	Excellent	4 (20%)	7 (13%)	0.729
	Satisfactory	9 (45%)	26 (49%)	
	Unsatisfactory	0 (0%)	1 (2%)	
	Very Insufficient	7 (35%)	19 (36%)	
	Mean ± SD	1.50 ± 1.19	1.40 ± 1.12	
density	Excellent	1 (5%)	7 (13%)	0.984
	Satisfactory	5 (25%)	26 (49%)	

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	Unsatisfactory	12 (60%)	1 (2%)	
	Very Insufficient	2 (10%)	19 (36%)	
	Mean ± SD	1.25 ± 0.72	1.25 ± 0.94	
Taper	Excellent	1 (5%)	2 (4%)	0.909
	Satisfactory	8 (40%)	26 (49%)	
	Unsatisfactory	0 (0%)	6 (11%)	
	Very Insufficient	11 (55%)	25 (47%)	
	Mean ± SD	0.95 ± 1.10	0.98 ± 1.01	

Discussion

The technical aspect of root canal treatment is reflected in the positive relationship between the root canal treatment success rate and good obturation quality [10]. Therefore, measuring the quality of RCTs carried out by undergraduate students is essential to evaluating endodontic training in all institutions. In this study, single-rooted artificial teeth were prepared by fourth-year students after training on them for three weeks in pre-clinic in the conservative department at the School of Dentistry, Tripoli University, Libya, during 2024. The quality of root canal therapy is assessed by radiographic study of the obturation length, density, and tapered root canal preparation. If we arrange the quality of work in the present study, we will find that the highest scores were for reaching the appropriate length, followed by density, and finally came the taper; nearly half of the teeth (49%) in the taper were categorized as very insufficient, and this indicates that students continue to develop their clinical skills in obtaining the proper taper during procedures, suggesting statistically significant areas for improvement.

This study showed that 49% of teeth had overall adequate root canal filling; this result was similar to (46.3%) in Yemen [2], (45%) in Iran [12], and (47.4%) in Jordan [19]. On the other hand, the results percentage was lower (54.1%) in Iran. [20] (55%) in Greece, [21] (55.3%) in Greece, [22] (63%) in Ireland, [23] (79.47%) in Turkey, [24] (80%) in Glasgow, [25] and (81%) in Saudi Arabia [26]. The result in the present study was higher than the results of (29.2%) in Jordan [27], (23%) in Saudi Arabia [13], (24.2%) in Sudan [28], (30.3%) in France [15], (32.5%) in Iran [29], (33%) in Turkey [30], (34.8%) in Taiwan [31], and (13%) in Cardiff. [32] Differences in the results among studies may be attributed to different study designs; type of teeth treated (artificial, extracted, or patient); single-canal teeth as in present study [25] or both single-canal and multiple-canal teeth [13-15,19]; the single-rooted teeth have better significant results than multi-rooted teeth [2, 20, 26] because single-rooted teeth are thought to be easier to work on and have a greater success rate. In addition, the criteria used to evaluate quality of treatment may have a significant impact on the results, length, and density only [33] or length, density, and taper as in present study [13,19].

According to San Tos et al. [34], preserving a suitable apical extension and adjusting the master gutta-percha cone at the critical apical zone are two of the difficulties associated with root canal filling. The length or apical extension of the obturation characteristic had a most significant effect on treatment results [15]. Comparing the present study with studies that included the anterior teeth, such as in the current study, we will find that the percentage of root fillings with adequate length in the present study was 63%, which is a moderate level of performance overall, indicating that students are achieving a basic level of performance in attaining adequate working lengths. These results are close to those reported (63.1%) in Trinidad [35] and (62.7%) in Greece [22] and less than the results (72.3%) in Saudi Arabia [26], (72.4%) in Jordan [19], (95.7%) Malaysia [36], and (94%) in Saudi Arabia [18]. Indeed, the endodontic treatment in this study was provided by undergraduate students, whereas in the previous studies, the root canal treatment was carried out by undergraduate and postgraduate students, residents, and endodontic consultants or in private or government clinics. This could be due to the high number of cases presented in government and private hospitals leading to increased experience of the dentists in general, or due to the high number of required root canal treatments during training in most curricula of universities, as in Saudi Arabia.

On the other hand, present results were higher in quality of length than found in Yemen (53%) [2], Portuguese (46%) [37], Saudi (34.48%) [38], Polish (48.9%) [39], Swedish (30%) [40], and German (14%) teeth. [41], some of these studies, which may have the lowest percentage in length quality, were on societies that collected data from x-rays and patient records, which may result in errors that may have occurred during the recording of the data because they were on an entire society, city, or country, and this differs from current study, which is a specific number of students and teeth that are artificial and not on patients. The density of the root filling is another important factor that affects the result or prognosis of endodontic therapy. Inadequate density in the root canal is an indication of improper gutta-percha condensation. Lateral condensation technique with gutta-percha might lead to voids in root canals with insufficient flaring [42].

Root canal failure may follow insufficient density as a result of the root filling's microleakage [43]. Insufficient density is a sign of improper gutta-percha condensation in the root canal. In the current study, images with mesial or distal angulations were proposed for the detection of voids, particularly between root canal walls and filling material. Kirkevang et al., [44] found that the rate of apical periodontitis was significantly

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influenced by the presence of voids in root canal filling. The frequency of adequate density of the treated teeth in present study (40%) reflects a lower performance compared to length, which indicates that students generally demonstrate an acceptable level of density in their root canal filling. This finding is more than the results of (27%) [36], (23.1%) [2], (31.7%) [13], and (31%) [20].

The significant prevalence of inadequate density among undergraduate students may be attributed to their inexperience applying sufficient force while employing hand or finger spreaders in non-flared or minimally flared canals. Furthermore, the high frequency of insufficient fill density could be due to a shortage of accessory gutta-percha sites during the lateral condensation phase [21]. The current result was in contrast to the findings of previous studies, which reported that adequate density was achieved in 92% [19], 96.3% [45], and 84% [36]. In regards to the obturation method used in the current study, cold lateral compaction of gutta-percha is the method most frequently taught globally due to its low cost and controlled positioning of the root filling material [46]. However, because this obturation looks at creating an inconsistent mass of gutta-percha and increases the possibility of void emergence, particularly in minimally flared root canals, it may have a detrimental effect on the quality of root fillings [21]. Conversely, heated vertical compaction produces a uniform mass of gutta-percha that might seep into imperfections in the canal [47]. According to one study, using the warm vertical obturation technique produced more uniform channel fills for novice students [48].

The taper parameter of the root canal filling is delimited, as even tapers from the coronal aera to the apical point are similar to the distinct outline of the original canal [49]. In the present study, the percentage with very insufficient is much greater than the previous two factors, which makes it the lowest in quality work. Inadequate taper was the most common cause for the fall. The percentage of adequate taper in present study was 43% for students, revealing that they are having difficulty getting their root canal fillings to have the proper taper, which is the lowest performance among the three parameters. This was higher than in another study in Yemen (34%) [2] and much less than (98.33%) [45], (81%) [36], (88%) [18], and (96%) [38]. This variation may be due to the more subjective assessment involved in evaluating this factor. Stainless steel hand K-files and the step-back technique were used for all endodontic procedures included in this study, along with the cold lateral compaction method. These previous studies have used stainless steel hand K-files and the step-back technique; however, the use of nickel–titanium files can produce noticeably better outcomes. The cleaning and shaping of the root canal system was transformed when Ni-Ti rotary devices were introduced to endodontic practice [21].

The results of the current study require modifications to endodontic courses in order to improve the technical quality of root canal therapy delivered by undergraduate dental students. This type of change may include increasing the preclinical training durations and progressively introducing new technologies, such as nickel-titanium rotary systems and heated gutta-percha procedures, into the curricula. It would be ideal to conduct the same research in the future to ensure the stability of the new educational programs.

Conclusion

The assessment of dental students' performance in root canal filling reveals a foundational understanding of essential clinical skills, alongside identifiable areas for improvement. The analysis indicates that while students are achieving basic competency in key parameters such as length and density in root canal filling, the taper score suggests a need for enhanced training and practice in this critical aspect of the procedure. The comparative analysis between male and female students shows no statistically significant differences in performance in root canal filling, suggesting that both groups are equally positioned in their clinical training. Overall, the findings underscore the importance of targeted educational strategies and practical training to bolster the students' clinical competencies, particularly in taper achievement. Continuous assessment and feedback will be essential in guiding students toward improved performance and greater confidence in their clinical skills as future dental professionals.

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Conflicts of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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المستخلص

يتأثر نجاح العلاج اللبي بشكل ملحوظ بالجودة الفنية الشعاعية لحشوة القناة (القنوات). هدفت الدراسة التجريبية إلى تقييم حشوات قناة الجذر التي أجراها طلاب السنة الرابعة في كلية طب الأسنان، جامعة طرابلس، ليبيا، خلال العام الدراسي 2024. أجرى طلاب طب الأسنان ما قبل السريري الجامعي علاج قناة الجذر على 73 سنًا اصطناعيًا أحادي الجذر. لتحضير قناة الجذر، تم استخدام طريقة التراجع مع أدوات يدوية مصنوعة من ملفات من الفولاذ المقاوم للصدأ بتدوير 0.02 وصولا للملف القمي الرئيسي 30. ثم تم استخدام محلول ملحي عادي للري. تم حشو جميع قنوات الجذر باستخدام تقنية التكثيف الجانبي البارد. ثم تم جمع الأسنان وتقييمها شعاعيًا بناءً على ثلاثة معايير للجودة (الطول والكثافة والتدريج). تم استخدام الإحصائيات الوصفية، بما في ذلك الترددات والنسب المئوية، لتلخيص البيانات. كشفت نتائج الدراسة أن الجودة العامة لحشوات قناة الجذر كانت رديئة. ومع ذلك، كان لدى أكثر من نصف عينة الدراسة (63%) طول كافٍ، وكان لدى 40% كثافة كافية، وكان لدى 43% تدريج كافٍ. وفي حالة التدريج، تم تصنيف ما يقرب من نصف الحالات (49%) على أنها غير كافية للغاية. بشكل عام، كان أداء طلاب طب الأسنان الذكور والإناث في حشو قناة الجذر قابلاً للمقارنة، مع عدم ملاحظة أي فروق ذات دلالة إحصائية في الطول أو الكثافة أو التدريج. يكشف تقييم أداء طلاب طب الأسنان في حشو قناة الجذر عن فهم أساسي للمهارات السريرية الأساسية، إلى جانب مجالات يمكن تحديدها للتحسين. أظهرت المقارنة بين الطلاب الذكور والإناث عدم وجود فروق ذات دلالة إحصائية في الأداء في حشو قناة الجذر، مما يشير إلى أن كلتا المجموعتين في وضع متساوٍ في تدريبهما السريري.

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