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Original Article

Retrospective audit for quality assessment of root fillings performed by undergraduate dental students in clinics

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الملخص

أهداف البحث: تقييم الجودة الفنية لسد قناة الجذر التي يقوم بها طلاب المرحلة الجامعية.

طرق البحث: تم تقييم سجلات 347 مريضًا خضعوا للعلاج اللبي من قبل الطلاب الجامعيين في جامعة القصيم بين عامي 2018 و 2020 باستخدام معايير موحدة على أساس طول التجويف والكثافة والاستدقاق. تم تضمين جميع الأسنان التي تلقت علاجا لبيا أساسيا والتي تم تصويرها بعد الانسداد صورا شعاعية محيطة بالذروة تصور الطول الجذري الكامل بالإضافة إلى 2-3 ملم من المنطقة المحيطة بالحوصلة في الدراسة.

النتائج: تم تقييم إجمالي 653 قناة من 397 سنا. كان القاطع المركزي العلوي هو السن الأكثر تقييما (15.1%). بشكل عام، تم اعتبار 80.2% من القنوات التي تم تقييمها مقبولة في معايير التقييم الثلاثة. تتميز الأسنان العلوية ذات الدلالة الإحصائية بجودة سد أفضل. كانت القناة الوسطى اللغوية هي الأقل جودة في المعايير الثلاثة.

الاستنتاجات: كانت الجودة الفنية لسد قناة الجذر التي أجراها طلاب المرحلة الجامعية في جامعة القصيم مقبولة في غالبية الحالات التي تم تقييمها. من بين العوامل التي تم تقييمها لجودة السد، لوحظ النقص الأكثر شيوعا هو من حيث التحكم في الطول. التدابير مطلوبة لتحسين جودة طول السد.

الكلمات المفتاحية: التدقيق؛ التعليم؛ الجودة؛ حشوات قناة الجذر؛ طلاب المرحلة الجامعية.

Abstract

Objectives: To evaluate the technical quality of root canal obturations performed by undergraduate students.

Methods: The records of 347 patients who underwent endodontic treatment by undergraduate students of Qassim University between 2018 and 2020 were assessed using standardised criteria based on obturation length, density and taper. All teeth that received primary endodontic treatment and had post-obturation periapical radiographs depicting the entire radicular length and the 2—3-mm periradicular area were included in the study.

Results: A total of 653 canals of 397 teeth were evaluated. The maxillary central incisor was the most commonly assessed tooth (15.1%). Overall, 80.2% of the evaluated canals were deemed acceptable based on all three assessment criteria. Maxillary teeth had significantly better obturation quality than the mandibular teeth. The mesio-lingual canal had the lowest quality in all three criteria.

Conclusions: The technical quality of root canal obturations performed by undergraduate students in Qassim University was acceptable in the majority of the evaluated cases. Among the evaluated parameters of obturation quality, length control was the most frequently observed deficiency. Additional measures are therefore required to improve the quality of the obturation length.

Keywords: Audit; Education; Quality; Root canal fillings; Undergraduate students

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Introduction

Root canal treatment (RCT) is the principal constituent of comprehensive oral care. The aim of RCT is chemo-mechanical cleaning, shaping, and three dimensional obturation of the root canal system to provide the optimal environment for periapical healing and prevent further progression of periapical pathosis.[1] Today, more people are interested in retaining permanent natural teeth as a result of increasing average age. Therefore, general dental practitioners are expected to provide quality RCT. Considering this, undergraduate dental students should have adequate theoretical knowledge and acquire optimum clinical skills for performing endodontic procedures during undergraduate pre-clinical and clinical training.[2]

The European Society of Endodontology (ESE) and the association for dental education in Europe have listed the ability to perform RCT as one of the core competencies that dentists are expected to achieve before graduation.[3–5] This makes it challenging for those involved in teaching endodontics to undergraduate students as they must impart the necessary cognitive and psychomotor skills to their students.[5] Intensive undergraduate training is required to produce graduates who can perform RCTs of acceptable quality.[6,7]

In KSA, dental colleges are largely involved in the provision of dental services to the community; this is achieved primarily via Dental teaching hospitals and dental camps instituted during community outreach programs. Most of these dental services are usually performed by students, and RCT is one of the most common procedures performed. To ensure that the delivered treatments are safe for patients, it is necessary to conduct periodic evaluation of the education program. The program must have a system of assessment to evaluate students' clinical performance.[8,9] The technical quality of RCT is assessed by utilizing radiographic methods at this stage.[1]

In Qassim University, students receive a didactic, practical course on endodontics comprising a one-year pre-clinical experience period with acrylic and extracted teeth during their third academic year, followed by a two-year clinical experience period with real patients during their fourth and fifth academic years. This course includes teaching students how to perform RCT via the step back technique using hand files and via the crown down technique using rotary files. Assessments of the obturation and RCT are made clinically as well as radiographically since the success of the procedure is highly dependent on specific radiographic findings.[10] According to the ESE guidelines for radiographic evaluation, the judgment of the quality of endodontic treatment is made by evaluating the canal obturation in terms of taper, density and apical extension within 0.5–2 mm of the radiographic apex.[11]

To ensure both patient safety and superior quality of the educational program, it is important to assess students' performance.[8,9] An audit of the obturation radiographs is an important tool for quality assurance and evaluation of students' performance in dental education.[12,13] The audit process involves the evaluation of the radiographs acquired during clinical practice, according to the established standard criteria.[14] Despite the significance of performing RCT during clinical training, data on the evaluation of technical quality of RCTs performed by clinical students in KSA is scant. Hence, the aim of the current study was to evaluate the technical quality of root canal obturations performed by undergraduate students in Qassim University using the radiographic criteria utilised by Fong et al., which is consistent with the ESE guidelines.[2,11]

Materials and Methods

The current study was approved by the institutional review board of the College of Dentistry at Qassim University, KSA (Code#: ST/6079/2020). A clinical audit was carried out retrospectively. The clinical dental records of 347 patients who underwent endodontic treatment by undergraduate students between 2018 and 2020 were assessed. The study included teeth that received primary endodontic treatment, either single or multi-rooted, and had post-obturation periapical radiographs depicting the entire radicular length and the 2–3-mm periradicular area. Endodontic procedures for which the post-obturation periapical radiographs were not available or those with poor-quality radiographs were excluded.

The protocol followed by the students for performing RCT included acquisition of intraoral periapical radiographs, before commencing treatment, for the diagnosis and determination of the estimated working length. Subsequently, the affected tooth was isolated with a rubber dam and local anaesthetic agent was administered to induce anaesthesia. This was followed by preparation of the endodontic access cavity, measurement of the working length using Ingle's radiographic method of working length determination and/or DentaPort Zx apex locators (J. Morita Corp, Japan) before initiating the cleaning/shaping of canals. The cleaning/shaping was done either with the crown down technique using a rotary files and the ProTaper Next system (Dentsply Sirona) or with the step back technique using stainless steel standardised hand K-files (Dentsply Maillefer). Intracanal irrigation was done with 3% sodium hypochlorite (Henry Schein) and EDTA (MD-Cleanser, Meta Biomed), and non-setting calcium hydroxide (Metapaste, Meta Biomed) was placed as the intracanal medicament for multiple visit cases. Root canal obturation with rotary instrumentation was performed using corresponding ProTaper Next Gutta percha points (GPP; Dentsply, Sirona), and that with manual instrumentation was performed using the standardised 2% taper GPP (Dentsply) with cold lateral condensation technique. AH-26 Plus (Dentsply) was used as the sealer for obturation.

Assessment of the intraoral periapical radiographs (IOPAR) was carried out using the assessment criteria described by Fong et al.[2] The root canal obturations were assessed based on lateral adaptation, taper, and length parameters. Two experienced endodontists (MQJ and MHA) assessed the quality of the post-obturation radiographs after calibration to enhance inter-evaluator reliability. Twenty IOPAR that were later excluded from the study were utilised for inter-examiner calibration. A Hewlett Packard

(HP) Pavilion dv6 laptop with a 16″ LCD screen and a resolution of 1366 × 768 pixels was used for assessing radiographs in a dark room. The contrast and brightness of the image were adjusted using the software's image processing tool (Dentsply Sirona Imaging Software) to ensure optimal visualization.

Statistical analysis

The data were collected and coded into a Microsoft Excel sheet and later transferred to SPSS software version 23 (Chicago, IL, USA) for statistical analysis. Descriptive data were recorded as percentages and frequencies. The Cohens Kappa test (K-value) was utilised to determine the inter-evaluator reliability for the three parameters evaluated. The K-values were acceptable for all the three parameters, i.e., 0.83 for length, 0.89 for density, and 0.92 for taper. A chi-square test of association was used to explore the level of association among the variables under study. The P-value was set at <0.05.

Results

A total of 347 patient records were evaluated (397 teeth: 141 mandibular and 256 maxillary teeth), including 653 root canals based on the criteria of lateral adaptation, taper, and length parameters (Table 1, Figure 1). Maxillary central incisors (15.11%) were the most examined teeth, with the

Table 1: Summary of evaluation criteria utilised for assessing the technical quality of root filling on the periapical radiographs (adopted from Fong et al., 2018).

| Parameter	Length		Lateral adaptation		Taper	
Criteria	Acceptable	Unacceptable	Acceptable	Unacceptable	Acceptable	Unacceptable
	Root filling terminating 0 −2 mm from radiographic Apex	Root filling extending beyond the radiographic apex (overfilled) or ≥2 mm away from apex (underfilled)	Voids absent, homogenous root filling, good condensation	Voids present, heterogeneous root filling, poor condensation	Consistent taper from orifice to apex	No consistent taper from orifice to apex
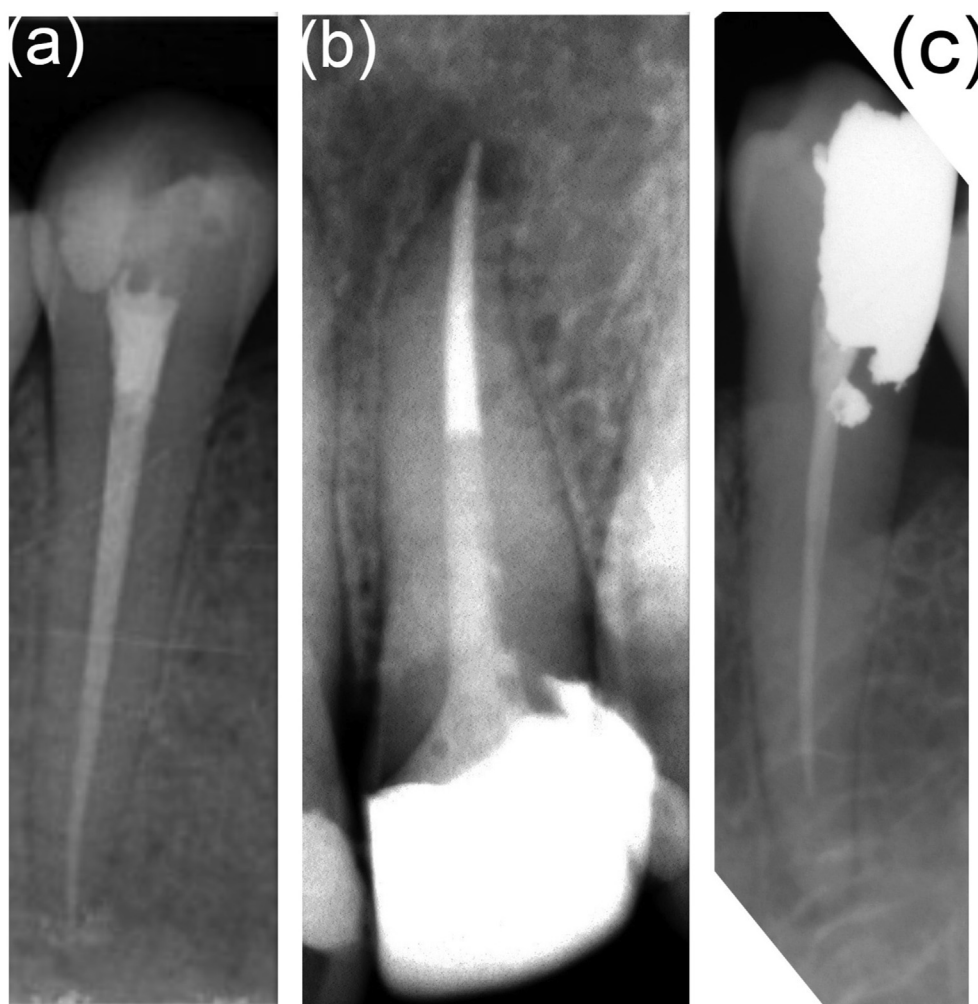
Figure 1: Representative periapical radiographic images of the individual parameters evaluated in the current audit: (a) acceptable density, taper, and length, (b) overfilled root canal, and (c) unacceptable density, taper, and length.

Table 2: Study samples distribution according to jaw type, tooth location, tooth type, and canal location.

	N	Percentage (%)
Jaw Type		
Maxilla	256	64.5
Mandible	141	35.5
Tooth Location		
Anterior	151	38%
Posterior	246	62%
Tooth Type		
Maxillary central	60	15.11%
Maxillary lateral	38	9.57%
Maxillary canine	20	5.04%
Maxillary 1st premolar	45	11.33%
Maxillary 2nd premolar	51	12.85%
Maxillary 1st molar	33	8.31%
Maxillary 2nd molar	9	2.27%
Mandibular central	11	2.77%
Mandibular Lateral	8	2.02%
Mandibular Canine	14	3.53%
Mandibular 1st Premolar	14	3.53%
Mandibular 2nd Premolar	35	8.82%
Mandibular 1st molar	42	10.58%
Mandibular 2nd molar	17	4.28%
Canal Location		
Mesial	7	7.1%
Distal	61	9.3%
Palatal	99	15.2%
Buccal	58	8.9%
One canal	239	36.60%
Mesio-lingual	52	8%
Mesio-buccal	96	14.7%
Disto-buccal	41	16.3%

Table 3: Cumulative quality of root filling based on tooth type.

Tooth Type	Acceptable	Unacceptable	Total Canals
Anterior	122 (80.8%)	29 (19.2%)	151
Premolar	167 (82.3%)	36 (17.7%)	203
Molar	235 (78.6%)	64 (21.4%)	299
Total	524 (80.2%)	129 (19.8%)	653

Table 4: Quality of the root fillings based on the length, density, and taper criteria.

Criteria		N (percentage)
Length	Acceptable	563 (86.2%)
	Unacceptable	90 (13.8%)
Density	Acceptable	581 (89%)
	Unacceptable	72 (11%)
Taper	Acceptable	614 (94%)
	Unacceptable	39 (6%)

teeth with single canal representing 36.60% of the whole sample. Table 2 presents the sample distribution.

The results show that 524 (80.2%) of the 653 canals evaluated were deemed acceptable in all three assessment criteria (Table 3). Analysis of individual criteria revealed that 563 (86.2%) canals had an acceptable length, with 11 (1.68%) canals described as over-obturated and 79 (12.09%) canals described as under-obturated. A total of 581 (89%) canals had acceptable obturation density, and 614 (94%) canals had good taper (Table 4).

Comparisons based on jaw type revealed that the maxillary teeth had better, statistically significant quality than the mandibular teeth in all three criteria ($P < 0.05$). However, comparisons based on tooth type showed a significant difference in taper alone—the taper of the anterior teeth canals was found to be significantly better than that of the molar teeth canals ($P = 0.01$) (Table 5).

In the maxillary teeth, the length quality was the lowest for lateral incisors (76.31%), the density quality was the lowest for first molars (88%), and the taper quality was the lowest for first premolars (93.1%). In contrast, in the mandibular teeth, the length quality was the lowest for lateral incisors (62.5%), the density quality was the lowest for first premolars (64.29%), and the taper quality was the lowest for first molars (85.16%) (Table 6).

Analysis of the quality of root canal fillings based on canal type showed that the mesio-lingual canal had the lowest quality in all the three criteria (length [76.9%], density [82.7%], and taper [80.8%]) (Table 7). The data presented in Table 7 show that the disto-buccal canal had the most acceptable length quality (97.6%), followed by one canal (87.4%). An acceptable density was most frequently noted in mesial roots (100%), followed by buccal roots (94.8%). However, acceptable taper quality was more frequent in mesial canals (100%), followed by one canal (97.5%).

Over-obturation was noted in the mandibular central incisor (n = 1), mandibular lateral incisor (n = 1), maxillary lateral incisors (n = 3), maxillary central incisors (n = 2), palatal canals of maxillary first molars (n = 2), palatal canal of maxillary 2nd molar (n = 1), distal canal of mandibular first molar (n = 1), maxillary 2nd premolar (n = 1), and distal canal of the lower second molar (n = 1).

Instrument separation was observed in the mandibular lateral incisor (n = 1), maxillary canine (n = 1), disto-buccal canal (n = 1) and palatal canal (n = 1) of maxillary first molar, and mesio-buccal canal of mandibular first molar (n = 1) and mandibular second molar (n = 1). The incidence of missed canals was documented in the mandibular first molar (n = 1) and second premolar (n = 1).

Table 5: Tooth and jaw type-wise quality of the root fillings based on length, density, and taper criteria.

Variables	Length		Density		Taper	
	Acceptable	Unacceptable	Acceptable	Unacceptable	Acceptable	Unacceptable
Maxilla	354	45	363	36	384	15
Mandible	209	45	218	36	230	24
	P = 0.02		P = 0.04		P = 0.003	
Anterior	132 (87.4%)	19 (12.6%)	135 (89.4%)	16 (10.6%)	149 (98.7%)	2 (1.3%)
Premolar	176 (86.7%)	27 (13.3%)	184 (90.6%)	19 (9.4%)	191 (94.1%)	12 (5.9%)
Molar	255 (85.3%)	44 (14.7%)	262 (87.6%)	37 (12.4%)	274 (91.6%)	25 (8.4%)
	P = 0.80		P = 0.56		P = 0.01	

Table 6: Quality of root canal fillings according to tooth type.

	Length		Density		Taper	
	Acceptable	Unacceptable	Acceptable	Unacceptable	Acceptable	Unacceptable
Upper central (n = 60)	55 (91.66%)	5 (8.33%)	55 (91.66%)	5 (8.33%)	59 (98.33%)	1 (1.66%)
Upper lateral (n = 38)	29 (76.31%)	9 (23.68%)	34 (89.47%)	4 (10.53%)	38 (100%)	0 (0%)
Upper canine (n = 20)	19 (95%)	1 (5%)	19 (95%)	1 (5%)	20 (100%)	0 (0%)
Upper 1st premolar (n = 87)	72 (82.76%)	15 (17.24%)	80 (91.95%)	7 (8.05%)	81 (93.1%)	6 (6.9%)
Upper 2nd premolar (n = 67)	62 (92.53%)	5 (7.47%)	62 (92.53%)	5 (7.47%)	64 (95.52%)	3 (4.48%)
Upper 1st molar (n = 100)	92 (92%)	8 (8%)	88 (88%)	12 (12%)	96 (96%)	4 (4%)
Upper 2nd molar (n = 27)	25 (95.59%)	2 (4.41%)	25 (95.59%)	2 (4.41%)	26 (96.30%)	1 (3.70%)
Lower central (n = 11)	10 (90.90%)	1 (9.1%)	9 (81.81%)	2 (18.19%)	10 (90.90%)	1 (9.1%)
Lower lateral (n = 8)	5 (62.5%)	3 (37.5%)	7 (87.5%)	1 (12.5%)	8 (100%)	0 (0%)
Lower canine (n = 14)	14 (100%)	0 (0)	11 (78.57%)	3 (21.43%)	14 (100%)	0 (0%)
Lower 1st premolar (n = 14)	10 (71.43%)	4 (28.57%)	9 (64.29%)	5 (35.71%)	12 (85.71%)	2 (14.29%)
Lower 2nd premolar (n = 35)	32 (91.43%)	3 (8.57%)	33 (94.28%)	2 (5.72%)	34 (97.14%)	1 (2.86%)
Lower 1st molar (n = 128)	100 (78.12%)	28 (21.88%)	105 (82.03%)	23 (17.97%)	109 (85.16%)	19 (14.84%)
Lower 2nd molar (n = 44)	38 (86.36%)	6 (13.64%)	44 (100%)	0 (0%)	43 (97.72%)	1 (2.28%)

Table 7: Quality of root canal fillings according to root canal type.

	Length		Density		Taper	
	Acceptable	Unacceptable	Acceptable	Unacceptable	Acceptable	Unacceptable
Mesial (n = 7)	6 (85.7)	1 (14.3)	7 (100)	0 (0)	7 (100)	0 (0)
Distal (n = 61)	52 (85.2)	9 (14.8)	54 (88.5)	7 (11.5)	57 (93.4)	4 (6.6)
Palatal (n = 99)	85 (85.8)	14 (14.2)	87 (87.9)	12 (12.1)	90 (90.9)	9 (9.1)
Buccal (n = 58)	48 (82.7)	10 (17.3)	55 (94.8)	3 (5.2)	56 (96.5)	2 (3.5)
One canal (n = 239)	209 (87.4)	30 (12.6)	212 (88.7)	27 (11.3)	233 (97.5)	6 (2.5)
Mesio-lingual (n = 52)	40 (76.9)	12 (23.1)	43 (82.7)	9 (17.3)	42 (80.8)	10 (19.2)
Mesio-buccal (n = 96)	83 (86.5)	13 (13.5)	87 (90.6)	9 (9.4)	90 (93.8)	6 (6.2)
Disto-buccal (n = 41)	40 (97.6)	1 (2.4)	36 (87.8)	5 (12.2)	39 (95.1)	2 (4.9)
	P = 0.24		P = 0.60		P = 0.001	

Discussion

The quality of root canal obturation is an important determinant of the outcome of RCT, especially when it is impossible to achieve complete reduction of bacterial load.[15] In the present audit, root canal obturations performed by undergraduate students were evaluated based on the existing ESE guidelines,[16] which recommend obturation to terminate at 0.5−2 mm from the apex with an adequate taper and without voids.[10,17]

Most of the RCTs provided by the undergraduate students were of acceptable quality, irrespective of the tooth type. A similar frequency of acceptable root canal obturations were reported in the clinical audits conducted by Lynch & Burke and Al-Yahya.[18,19] However, others have reported a much lower frequency of acceptable root canal obturations, which might be due to the differences in the assessment criteria, study setting, and sample variations.[2,20,21]

The results of the current audit also showed a higher frequency of acceptable obturations in maxillary teeth than in the mandibular teeth. This finding is consistent with the audit reports of Elsayed et al., AbuMostafa et al. and Elemam et al.[7,22,23] A possible explanation could be the inclusion of a greater number of maxillary teeth in the sample. While maxillary teeth are generally more challenging to treat due to vision constraints, the most frequently evaluated tooth was the central incisor, which

could explain why obturation quality remained acceptable despite this challenge.

There was no significant difference in obturation quality between the anterior (80.8%) and posterior teeth (78.6%). This finding is contradictory to that reported by Balto et al., Chueh et al. and Kumar et al., who reported higher acceptability among anterior teeth.[20,24,25] However, Fong et al. reported a similar finding whereby no significant difference was observed between the anterior and posterior teeth.[2] The only parameter that significantly differed between the anterior and posterior teeth was taper (p = 0.01).

Among the different parameters used for assessing the quality of obturation, taper (94%) was the most frequently achieved parameter in the present audit. Similar findings were reported by Fong et al.[2]; however, others—Al-Anesi et al. (14.2%) and Alhablain et al. (54.1%)—have reported a much lower frequency of cases with adequate taper.[1,26] When individual canals were compared for adequacy of taper, a significant difference was observed with respect to the location of canal. The mesio-lingual canal in mandibular molars was most frequently identified as unacceptable while the single canals were the most acceptable in terms of taper. This could be due to improved instrument control in single wide canals.

The length or apical extension of obturation parameter had the most serious implication on treatment outcome.[10] With respect to the parameter of length, a much higher

frequency of acceptable cases (86.2%) were identified when compared with other studies by Al-Anesi et al. (53.4%), Balto (67.4%) and Fong et al. (72%).[1,20,2] Similar results were reported by Alhablain et al. (89.6%), who conducted an audit in the same university.[26] The improved length control exhibited in the cases can be attributed to the combined use of an apex locator with radiograph for working length determination.[27]

The most common obturation technique used in this study was the lateral compaction technique, which is the most common technique students are trained for in dental schools.[28] This can have implications on the frequency of voids detected on the radiographs. However, most of the obturations (89%) in the present audit had adequate density, which agrees with Fong et al. (90%) but disagrees with Balto et al. (34.9%).[2,20]

Since the included teeth in this study were treated by undergraduate students who start providing endodontic treatment from the fourth year when they are limited to treating only single rooted teeth before being permitted to work on multi-rooted teeth during their fifth year, the single rooted teeth represented in upper central incisors were the most examined teeth in this study.

The current study reports minimal iatrogenic errors. This can be attributed to the incorporation of rotary NiTi instrumentation at the undergraduate level. Likewise, previous studies have documented reduced iatrogenic errors during endodontic treatment when students utilised NiTi instruments for root canal preparation.[18,29]

The increasing use of rotary NiTi instruments during undergraduate training could explain the improved radiographic quality of obturations.[30] However, it must be mentioned that radiographic evaluation has some inherent limitations, such as image distortion and anatomic noise, which can become more evident when the calibration is inadequate or when the projections are not standardised. For instance, the evaluated obturation length can be falsely deemed unacceptable in cases when the foramen location does not coincide with the projected location of the apex. Similarly, when assessing density, an evaluator can falsely assign acceptability in a case where overzealous use of a radiopaque sealer has masked the voids in obturation. Hence, there is a chance of under or over estimation of the quality of obturation when relying on 2-dimensional radiographic imaging.

Finally, it is worth mentioning that even if the radiographic quality of obturation is an important factor that affects the outcome of RCT, it may not exactly reflect the disinfection protocol taken during treatment. Such an audit of the quality of root canal obturation by undergraduate students is an important tool of quality assurance in dental schools. These audits help to identify areas of deficiency and suggest a need to review the curriculum requirements.

Conclusion

The technical quality of root canal obturations performed by undergraduate students in Qassim University was found to be acceptable in the majority of the evaluated cases. The undergraduate dental students were exposed to an adequate variety of cases in relation to tooth type. Among the evaluated parameters of obturation quality, the most frequent deficiency was observed in terms of length control. Considering this, measures should be taken to improve the quality of the obturation length.

Recommendations

It is recommended to perform periodic audits of the obturation radiographs every two years. This will aid in the maintenance of the educational program quality and evaluation of students' performance. Moreover, it will help identify the areas that require improvement.

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Conflict of interest

The authors have no conflicts of interest to declare.

Ethical approval

Study approval was acquired from the Dental Research Institutional Review Committee on 15 October 2020 (ST/6079/2020) at the dental school of Qassim University, KSA.

Authors contributions

MQJ conceived and designed the study, analysed the data, prepared tables, derived results, and carried out the final editing of the manuscript. UAB did the write up for the Abstract and Discussion and obtained final approval of the manuscript. MHA conducted manuscript review, data analysis, and data collection. SDD did the write up and literature search. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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