

## Radiographic assessment of the quality of root canal fillings performed by senior dental students

Adnan Asaad HABIB, Mazen Deib DOUMANI, Mohammad Zakaria NASSANI, Enass SHAMSY, Basma Safwan JTO, Hiba Ahmad ARWADI, Sagal Ahmad MOHAMED

### ABSTRACT

**Objective:** To evaluate the radiographic technical quality of root canal fillings performed by senior dental students at Alfarabi colleges for dentistry, Kingdom of Saudi Arabia.

**Methods:** Radiographic assessment was conducted for 246 teeth (390 root canals) endodontically treated by senior dental students to evaluate the quality of root canal fillings. Three criteria were evaluated to assess the technical quality of root canal fillings: length, density, and taper. The root canal filling was considered acceptable if it had an adequate length with no voids and consistent taper from the orifice to the apex. Statistical analysis was conducted using Kruskal–Wallis, Mann–Whitney, and chi-square tests ( $P=0.05$ ).

**Results:** Acceptable root canal fillings were detected in 127 (32.6%) patients. The frequency of an acceptable root canal filling was the highest for the upper anterior teeth (40%). There were significant differences in the length and density among the types of teeth ( $P<0.05$ ). However, there was no significant difference in the taper among the types of teeth ( $P>0.05$ ).

**Conclusion:** The quality of root canal fillings performed by senior undergraduate dental students at AlFarabi colleges for dentistry was acceptable in 32.6% of patients. This outcome enhanced the poor performance of undergraduate dental students in the area of endodontics.

**Keywords:** Density, length, root canal fillings, quality, taper

### HIGHLIGHTS

- Teaching endodontics to undergraduate students is one of the most complicated tasks for dental academics and one of the greatest challenges across all dental branches.
- The radiographic criteria of an acceptable root canal filling includes adequate length with no voids visible within the material or between the material and the root canal walls and consistent taper from the orifice to the apex.
- The amount of pre-clinical and clinical teaching in endodontics at the dental schools influences the skill and competence of practitioners or endodontists to achieve accurate root canal treatment.

### INTRODUCTION

One of the most important aims of a root canal filling is to prevent the reinfection of root canals that have been biomechanically instrumented, irrigated, disinfected, and obturated (1). According to the American Association of Endodontists (AAE), there are clinical and radiographic criteria for judging the technical success of a root canal filling (2). Clinically, for a case to be considered successful, routine tests such as palpation, percussion, periodontal probing, and visual inspection of the final coronal restoration should reveal normal findings during periodical follow-up visits.

The following three criteria should be radiographically assessed: length, shape, and density (2).

According to the guidelines of the European Society of Endodontology (ESE), the radiographic criteria of an adequate root canal treatment includes a prepared root canal with a consistent taper from the orifice to the apex and an obturated root canal that is completely without voids between the canal filling and canal walls. It is important that the root canal filling should be placed as close to the apical constriction as possible, i.e., within 0.5–2 mm of the radiographical apex (3).

Teaching endodontics to undergraduate students is one of the most complicated tasks for dental academics and one of the greatest challenges across all dental branches (4). The main educational purpose of endodontics is to successfully consolidate skill and knowledge as a base for graduates to become proficient and competent in clinical work (3).

Generally, dental curricula in most dental schools worldwide comprise pre-clinical training in endodontics during inaugural classes, where students are trained to perform root canal treatment on

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From the Department of Restorative Dental Sciences (A.A.H. ✉ adnanhabib71@hotmail.com, M.D.D., B.S.J., H.A.A., S.A.M.) AlFarabi College for Dentistry and Nursing, Riyadh, Saudi Arabia; Department of Prosthetic Dental Sciences, (M.Z.N.), AlFarabi College for Dentistry and Nursing, Riyadh, Saudi Arabia; Department of Dental Health Care, (E.S.), Inaya Medical College, Riyadh, Saudi Arabia

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extracted teeth; however, during advanced classes, students clinically perform nonsurgical root canal treatment of anterior and posterior teeth (5, 6, 7, 8).

The quality of root canal fillings performed by dental students is well documented in the literature (9, 10, 11, 12, 13, 14) with different results in term of the acceptability of root canal fillings ranging from 13% reported by Hayes et al 2001 (9) to 84.1% reported by Kelbauskas et al 2009 (15).

The objective of the present study is to assess the radiographic technical quality of root canal fillings performed by senior dental students at Alfarabi college for dentistry and nursing, KSA and compare the results of our study with those of other investigations conducted in this area of endodontics.

## MATERIALS AND METHODS

This study was based on pooled data from the radiographic unit of Alfarabi college for dentistry. In total, 246 records of patients who had received root canal treatment by undergraduate students during 2016–2017 were selected to evaluate the radiographic quality of the root canal fillings. The inclusion criterion for this selection was all root canal treatments performed by 6th year undergraduate dental students on adult patients with completely formed teeth.

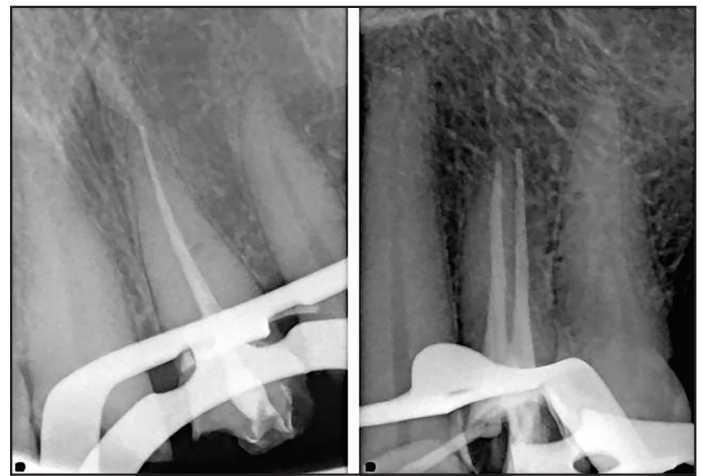
All selected endodontics records had at least three high-quality radiographs, including the preoperative working length determination and postoperative radiographs. All selected radiographs were digital and displayed the entire length of the root and the periapical area, and the mesial and distal angulated radiographs were included for multi-rooted teeth.

The radiographic technical quality of the root canal fillings was independently evaluated by two expert endodontists, and the result was recorded when there was an agreement between the two examiners. The intra-examiner reliability was calculated by rechecking a random sample of 5% (19) of the total root canals previously examined. A 95% agreement was found, indicating that the scoring methods were reliable. The inter-examiner reproducibility was determined by calculating the kappa values, which were  $>0.9$ , indicating a high degree of inter-examiner agreement.

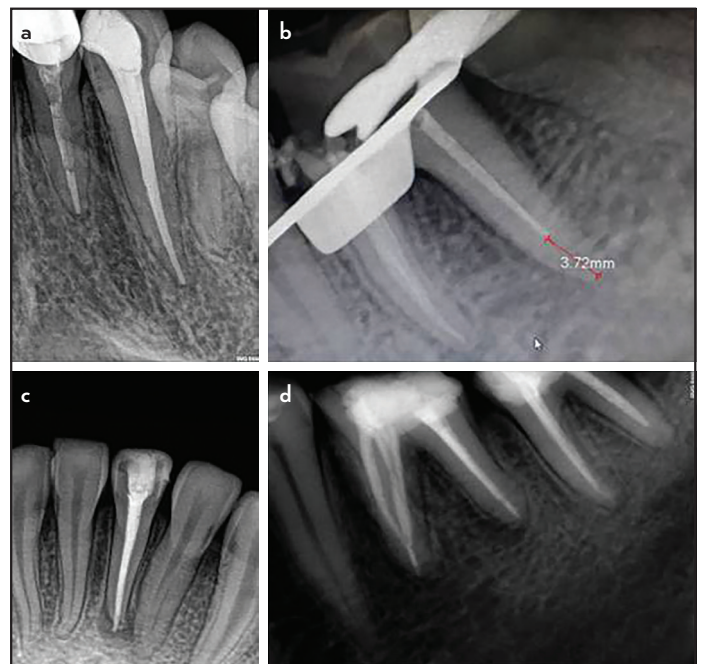
To assess the technical quality of root canal fillings, three criteria were evaluated as follows:

- Length of root canal filling, which includes four parameters: root filling ending  $\leq 2$  mm from the radiographic apex, root filling ending  $> 2$  mm from the radiographic apex, root filling beyond the radiographic apex (over filling), or root filling at the radiographic apex (flush).
- Density of root canal filling, which includes two parameters: the presence or absence of voids in the root filling or between the root filling and root canal walls.
- Taper of the root canal filling, which includes two parameters: consistent taper from the orifice to the apex or no consistent taper from the orifice to the apex.

Finally, the technical quality of the root canal fillings considered acceptable if the root filling ended  $\leq 2$  mm from the ra-



**Figure 1.** Criteria for acceptable root canal fillings: adequate length, no voids, and consistent taper



**Figure 2. a-d.** Criteria for unacceptable root canal fillings (a) Consistent taper, no voids but inadequate length (flush). (b) Inadequate length (short, i.e.,  $> 2$  mm). (c) Inadequate length (over filling). (d) No consistent taper and presence of voids

diographic apex with no voids visible within the material or between the material and the root canal walls and consistent taper from the orifice to the apex (Figure 1).

In contrast, the technical quality of the root canal fillings was considered unacceptable when one or more of the aforementioned parameters were absent (Figure 2).

All root canal treatments evaluated in this study were conducted by students in an aseptic field with rubber dam isolation using the step-back technique for the root canal preparation and the cold lateral condensation technique for the root canal filling.

Each root canal assessed in this study was instrumented with the step-back technique using stainless steel manual K-files of 0.02 taper (Mani Inc., Tochigi-Ken, Japan). All canals were in-

**TABLE 1.** The frequency and percentage of the length of root canal fillings according to the tooth type

	Tooth Type		Length of root canal filling			
	Teeth Number	Canal Number	Short		Over Filling	Flush
			≤2 mm	>2 mm		
Upper Molars	15	46	34 14.7%	7 9.2%	2 7.4%	3 5.5%
Lower Molars	41	129	60 25.9%	38 50.0%	11 40.7%	20 36.4%
Upper Incisors	70	70	48 20.7%	8 10.5%	1 3.7%	13 23.6%
Lower Incisors	36	37	24 10.3%	2 2.6%	5 18.5%	6 10.9%
Upper Premolars	43	67	42 18.1%	13 17.1%	5 18.5%	7 12.7%
Lower Premolars	41	41	24 10.3%	8 15.5%	3 11.1%	6 10.9%
Total	246	390	232 100%	76 100%	24 100%	58 100%

**TABLE 2.** The frequency and percentage of the density of root canal fillings according to the tooth type

	Tooth Type		Density of root canal filling	
	Teeth Number	Canal Number	No Voids	Voids
Upper Molars	15	46	12 6.1%	34 17.7%
Lower Molars	41	129	69 34.8%	60 31.2%
Upper Incisors	70	70	38 19.2%	32 16.7%
Lower Incisors	36	37	21 10.6%	16 8.3%
Upper Premolars	43	67	38 19.2%	29 15.1%
Lower Premolars	41	41	20 10.1%	21 10.9%
Total	246	390	198 100%	192 100%

strumented to the working length till a size #35 apically and a size #70 coronally. The working length was determined by an apex locator (Root ZX; Morita, Tokyo, Japan) and confirmed by a periapical radiograph. Gates-Glidden burs numbers 2, 3, and 4 in most cases were used in the coronal third of the root canals in order to facilitate straight line access. The root canals were irrigated with 2.5% NaOCl and 17% EDTA (MDCleaner, META Biomed, Korea). All root canals were obturated during a next appointment with gutta-percha points (ALPHA-DENT, North Hamlin Avenue, Lincolnwood, USA) and an AH plus sealer ((Dentsply De Trey GmbH, Konstanz, Germany) using the cold lateral condensation technique. All gutta-percha cones and spreaders were of 2% taper. At least five radiographs were taken at different steps during the treatment: preoperative radiograph, initial file radiograph, cleaning and shaping radiograph, master cone radiograph, and obturation radiograph.

**TABLE 3.** The frequency and percentage of the taper of root canal fillings according to the tooth type

	Tooth Type		Taper of root canal filling	
	Teeth Number	Canal Number	Consistent taper	No consistent taper
Upper Molars	15	46	21 9.4%	25 15.1%
Lower Molars	41	129	69 30.8%	60 36.1%
Upper Incisors	70	70	37 16.5%	33 19.9%
Lower Incisors	36	37	25 11.2%	12 7.2%
Upper Premolars	43	67	44 19.6%	23 13.9%
Lower Premolars	41	41	28 12.5%	13 7.8%
Total	246	390	224 100%	166 100%

All assessed radiographs in this study were obtained using a dental X-ray unit (Kodak, Carestream Health, USA) and a digital sensor (Fona, Ševčenkova 34, Slovak Republic).

The data were analyzed with descriptive statistical methods including the Kruskal–Wallis, Mann–Whitney, and chi-square tests ( $P=0.05$ ) using the SPSS software (SPSS version 13.0, SPSS, Chicago, IL, USA). The level of significance was set at 0.05.

## RESULTS

In this study, 390 root canal fillings from 246 patients were examined to assess the technical quality of the root canal fillings. The detailed results of the three criteria used to evaluate the technical quality of the root canal fillings according to the tooth type are presented in Tables 1, 2, and 3.

Of the 390 root canal treatments performed by 6th year undergraduate dental students, acceptable root canal fillings

**TABLE 4.** Evaluation of root canal fillings as acceptable or unacceptable according to the tooth type

Tooth Type	Teeth		Acceptable	Unacceptable
	Number	Canal Number		
Upper Molars	15	46	15 3.8%	31 7.9%
Lower Molars	41	129	39 10.0%	90 23.1%
Upper Incisors	70	70	28 7.2%	42 10.8%
Lower Incisors	36	37	13 3.3%	24 6.2%
Upper Premolars	43	67	18 4.6%	49 12.6%
Lower Premolars	41	41	14 3.6%	27 6.9%
Total	246 100%	390 100%	127 32.6%	263 67.4%

**TABLE 5.** The frequency and percentage of acceptable criteria among all teeth

	Length	Density	Taper
Frequency	232	198	224
Percentage	59.48%	50.76%	57.43%

were detected in 127 (32.6%) patients, whereas unacceptable root canal fillings were detected in 263 (67.4%) patients. According to the tooth type, the number of accepted cases was distributed as follows: 15 (32.6%) in upper molars, 39 (30.2%) in lower molars, 28 (40%) in upper incisors, 13 (35.1%) in lower incisors, 18 (26.8%) in upper premolars, and 14 (34.1%) in lower premolars (Table 4). The frequency of an acceptable root canal filling in the same tooth type was significantly lesser in upper premolars, lower premolars, upper molars, and lower molars ( $P < 0.05$ ).

The percentage of root canal fillings with acceptable length was 59.48%, with acceptable density was 50.76%, and with consistent taper was 57.43%. The length of a root canal filling was the best criteria performed by the undergraduate students, followed by taper and density (Table 5).

The frequency of an adequate length of a root canal filling (root filling ending  $\leq 2$  mm from the radiographic apex) was higher for lower molars (60/25.9%) than for lower incisors and lower premolars (24/10.3%). There was a significant difference in the length of the root canal filling among the types of teeth ( $P = 0.031$ ).

In terms of density of the root canal filling, the presence of voids was most frequent in lower molars (60/31.2%) than in lower incisors (16/8.3%). The best result for density (no voids) was obtained for upper molars (12/6.1%). There was a significant difference in the density of the root canal filling among the types of teeth ( $P = 0.02$ ).

The frequency of no consistent taper from the orifice to the apex was the highest for lower molars (60/36.1%) and lowest for lower incisors (12/7.2%). There was no significant difference in the taper of the root canal filling among the types of teeth ( $P = 0.094$ ). The detailed results of the Kruskal–Wallis test for evaluating the association between the quality of the root canal filling criteria and tooth type are presented in Table 6.

The comparison of length and density of the root canal filling among all tooth types revealed that the density of the root canal filling was significantly better for upper molars than for other teeth ( $P < 0.05$ ); the length of the root canal filling was significantly worse for lower molars than for upper premolars and upper incisors ( $P < 0.05$ ). In addition, there was no significant difference in the density and length among other tooth types ( $P > 0.05$ ). The detailed results of the Mann–Whitney test for comparing the length and density of root canal fillings among all tooth types are presented in Table 7.

## DISCUSSION

It has been reported that the technical quality of root canal treatment may affect the outcome of root canal treatment and the health of periradicular tissues (16, 17, 18). A successful endodontic therapy is usually associated with root canal fillings that end within 2 mm of the radiographic apex and are of adequate homogeneity with no voids (19, 20).

Several studies have shown that the standard of root canal treatment performed by undergraduate students and general dental practitioners is poor (9, 6, 21, 22). Therefore, the present study was conducted to evaluate the technical quality of root canal fillings performed by senior dental students in XXXXX colleges (KSA) and compare our results with those of previous studies.

In this study, the criteria used to evaluate the quality of root canal fillings and categorize root fillings as acceptable or unacceptable were length, density, and taper. These criteria have been used in many previous studies (6, 8, 10, 13, 14).

In our study, out of 390 root canal treatments performed by 6th year undergraduate dental students, acceptable root canal fillings were detected in 32.6% of patients. This result is similar to that of Moussa-Badran et al 2008, Er et al 2006, Chueh et al 2003 (12, 23, 24). The rate of acceptable cases in these studies was 33%, 30.3%, and 30%, respectively. However, the result of the present study was not in agreement with that of studies by Khabbaz et al 2010, Unal et al 2011, Barrieshi-Nusair et al 2004, Lynch and Burke 2006, Kelbauskas et al 2009, and Roman-Richon et al 2014 (5, 7, 10, 11, 15, 25). The rate of successful cases in these studies was higher than that obtained in our study: 54.8%, 73.7%, 47.4%, 63%, 84.1%, and 44%, respectively. However, the rate of acceptable cases was lower in studies by Balto et al 2010, Hayes et al 2001, Elsayed et al 2011: 23%, 13%, and 24.2%, respectively.

In our study, the length of root canal fillings was the best criteria performed by the undergraduate students; this result is similar to that of Balto et al 2010, Roman-Richon et al 2014, Moradi and Gharechahi 2013 (6, 25, 26) but was not in agreement with the result of the study by Elemam et al 2015 (8).

**TABLE 6.** The detailed results of the Kruskal–Wallis test to evaluate the association between the quality of root canal filling criteria and tooth type

Tooth Type	Quality of root canal filling					
	Length		Density		Taper	
	Mean Rank	P-value	Mean Rank	P-value	Mean Rank	P-value
Upper Molars	164.96		243.63		218.48	
Lower Molars	217.60		190.20		203.20	
Upper Incisors	182.81		188.04		204.43	
Lower Incisors	192.57	0.031	183.82	0.020	175.74	0.094
Upper Premolars	187.47		183.96		179.44	
Lower Premolars	197.66		199.38		174.33	

**TABLE 7.** The detailed results of the Mann–Whitney test to compare the length and density of root canal filling among all tooth types

Tooth type	Length Density P-value P-value	Tooth type	Length Density P-value P-value
Upper molars	0.002	Lower molars	0.244
Lower molars	0.001	Lower incisors	0.726
Upper molars	0.200	Upper premolars	0.602
Upper premolars	0.001	Lower premolars	0.424
Upper molars	0.108	Upper premolars	0.736
Lower premolars	0.029	Upper incisors	0.776
Upper molars	0.373	Upper premolars	0.813
Upper incisors	0.003	Lower incisors	0.997
Upper molars	0.217	Lower premolars	0.439
Lower incisors	0.005	Upper incisors	0.577
Lower molars	0.047	Lower premolars	0.827
Upper premolars	0.668	Lower incisors	0.484
Lower molars	0.291	Upper incisors	0.702
Lower premolars	0.600	Lower incisors	0.808
Lower molars	0.024		
Upper incisors	0.914		

The percentage of root canal fillings with consistent taper was 57.43%, which was lower than that reported by Balto et al 2010, Elemam et al 2015, Roman-Richon et al 2014 (6, 8, 25). The high percentage of root canal fillings with consistent taper (71%) reported by Roman-Richon et al 2014 (25) may be due to the instrumentation of root canals using rotary files.

The percentage of adequate density of root canal fillings in the current study was 50.76%, which was lower than that reported by Elemam et al 2015, Kelbauskas et al 2009, and Roman-Richon et al 2014 (8, 15, 25). The rates of adequate density in these studies were 75.8%, 79.5%, and 69%, respectively. However, our result was higher than that reported by Balto et al 2010 (6) and Moussa-Badrán et al 2008 (12). In these studies, 34.9% and 42.7% of cases, respectively, had a dense root canal filling without voids.

It is well known that the anatomy and the root canal therapy of anterior teeth are less complicated than those of posterior teeth, particularly the maxilla. The frequency of an acceptable root canal filling in this study was the highest for the upper anterior teeth (40%), followed by the lower anterior teeth (35.1%); this result was consistent with that of previous studies (5, 6, 8, 12).

A wide range of results has been obtained from different studies evaluating the quality of root canal fillings performed by dental students or general practitioners. In fact, several factors may impact these outcomes. The methodology, criteria, and parameters varied among different studies. Some studies radiographically assessed only the length and density of root canal fillings but omitted the taper variable (5,7,12). However, other studies have incorporated the taper variable (6,8,13,14,25). Procedural errors have also been radiographically assessed to evaluate the quality of root canal fillings (5,6,11). There is an association between the rate of acceptable root canal fillings and the practitioners performing the root canal treatment. The percentage of acceptable root canal fillings was 91% when the root canal treatment was performed by an endodontist (27). Lower rates were obtained when the root canal treatment was performed by general practitioners (22,28) and senior (5,6) or inaugural dental students (8,14). Some studies have concluded that the percentage of technical success was highly improved with the rotary instrumentation of root canals (15,25).

This study and several previous studies has shown poor performance of undergraduate students in the root filling area; this may be due to the complications of root canal treatment and lack of basic experience, in addition to poor skill of many dental students in this branch of dentistry.

It is conceded that the skill and competence of practitioners or endodontists to achieve accurate root canal treatment may be linked to the amount of pre-clinical and clinical teaching in endodontics at dental schools. Some commissions such as AAE and ESE have formulated treatment guidelines in the area of endodontics that are intended to represent current good practices through which graduates would shortly be expected to serve the community.

## CONCLUSION

The quality of root canal fillings performed by senior undergraduate dental students at Alfarabi colleges for dentistry and nursing, Riyadh (KSA) was acceptable in 32.6% of patients. This outcome enhanced the poor performance of undergraduate dental students in the area of endodontics.

## Disclosures

**Conflict of interest:** No conflict of interest was declared by the authors.

**Ethics Committee Approval:** This study has been conducted in full accordance

with the World Medical Association Declaration of Helsinki, with an approval from the Ethics Committee in Alfarabi colleges for dentistry and nursing, Riyadh, Saudi Arabia. (Ref. 00219/2017).

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