

Radiographic Assessment of the Quality of Root Canal Treatments Performed by Practitioners with Different Levels of Experience

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This retrospective cross-sectional study was conducted to radiographically evaluate the quality of root canal treatment (RCT) performed by practitioners with different levels of experience at the Arar Dental Center, North Region, Saudi Arabia. A total of 170 periapical radiographs of root canal fillings (RCFs) were used to assess the technical quality of 376 root canal performed by the practitioners at Arar Dental Center. The length of each RCF was categorized as acceptable, overfilled, and underfilled on the basis of their relationship to the radiographic apex and surrounding structures. The density and taper of the fillings were evaluated on the basis of the presence of voids and the uniform tapering of the fillings, respectively. Root canal obturation (RCOs) was compared between practitioners. Chi-square analysis was then conducted to determine significant differences between RCF length, density and tapering in different areas of dental arches, different canal positions, and different levels of practitioner experience. Of the total number of canals, 202 (53.7%) were found in males, and 219 (58.2%) were in the maxillary arch. A total of (267; 71%) of the RCFs were located in the posterior reign. All of the parameters of the RCFs significantly differed among various areas of dental arches, canal locations, and practitioners with different levels of experience ($P < 0.001$) except the RCO density between different arches ($P = 0.137$). The technical quality of RCFs performed at the Arar Dental Center was acceptable in 63% of all cases. The length of RCFs was acceptable in the majority of cases performed by consultants and specialists, but this parameter was acceptable only in 46.4% cases carried out by general dental practitioners (GDPs). The underfilling rates reported by GDPs (43.6%) were higher than those presented by consultants (13%) and specialists (18.8%). Almost all of the cases were acceptable in terms of density and tapering among all of the practitioners. The poor density and tapering qualities of RCFs were respectively found in 24.2% and 22.3% of the cases performed by GDPs. Evaluating the quality of RCTs delivered by practitioners in any dental service center offers vital information for health service authorities. This evaluation helps improve the trend in RCT services provided by endodontists with the aid of additional new endodontic equipment and materials. This study provides insights into relevant services in terms of the standards of care in endodontic treatment.

Keywords: Cross sectional study, density, periapical radiographs, practitioners, radiographic assessment, root canal treatment, tapering.



Root canal treatment (RCT) is a meticulous procedure that requires focus and precision because it is performed in a confined space, such as the root canal system of a tooth¹. A high success rate of RCT is obtained by well-trained dental practitioners under strict operating conditions that may not reflect actual situations in a typical dental clinic².

The technical quality of RCTs is commonly assessed through radiographic evaluation (3-4), and this method is important because the quality of RCO greatly affects the prognosis of therapy⁵⁻⁶. The technical quality of RCO is determined by different factors, such as distance between an end and a root apex, uniformly tapered canal from coronal to apical ends, dense RCO without voids, and presence of filling materials 0.5–2 mm below the radiographic apex⁷⁻⁸. Furthermore, each 1 mm loss of working length in teeth with apical periodontitis increases the failure rate by 14%⁹. Overfilling and underfilling of RCO also compromise the success rate of RCTs¹⁰.

The quality of RCTs has been performed by graduate students were examined. An acceptable quality of RCTs has been reported in Jazan, Qassim, Riyadh Elm, and Madinah¹¹⁻¹⁴ cities, but an unacceptable quality of RCTs has been obtained in KSU¹⁵ and Al Farabi¹⁶⁻¹⁷ in Riyadh City. The quality of RCTs is also adequate in other cities and countries, such as Sharjah in UAE, Malaysia, Palestine, India, Jordan, and Libya¹⁸⁻²³. However, the quality of RCTs has been rarely compared and investigated among consultants, specialists, and general practitioners with different levels of experience²⁴⁻²⁷.

In Arar City, North Region, Saudi Arabia (SA), RCT services are provided by several practitioners at the Dental Specialist Center. In this center, seven clinics for RCTs are available, and practitioners with different levels of experience are employed. This cross-sectional study aimed to radiographically evaluate the quality of RCTs provided by practitioners with different levels of experience at the Arar Dental Center, Southern Region, SA. This work also intended to compare the quality of RCFs in relation to dental arch area, number of canals in each subject and level of practitioner's experience.

Subjects and methods

This retrospective cross-sectional study was conducted among subjects who visited

endodontic clinics at the Arar Specialist Dental Center, North Region, SA, for RCTs. The current study was conducted in full accordance with the World Medical Association Declaration of Helsinki, and ethical approval was granted by the Ethics Committee of the Director of the Health Affairs in the region.

Data were collected from the subjects' radiographic files at the RCF clinics. All of the RC cases performed by endodontic consultants, specialists, and many GDPs from December 2017 to April 2018 were evaluated. The treated subjects were referred from either diagnostic clinics in the center or from other governmental polyclinics in the region.

The quality of the RCTs was evaluated on the basis of existing preoperative and postoperative periapical radiographs by using CLINIVIEW Imaging 10.2.6 (Kavo Keer Online Privacy, Germany). Subjects aged more than 18 years from both genders were included. The following cases were excluded: cases with incompletely formed root apices, cases of RCT re-treatment, poor radiographic images revealing deformities, those who had surgical procedures, such as cyst enucleation or apicectomy, and clinical cases without a post-obturation radiograph after either a temporary or permanent restoration was placed. Postoperative radiographs were compared with preoperative radiographs until an agreement was achieved.

The qualities of RCOs were assessed on the basis of length, density, and tapers of RCFs (Table 3)^{8,13,15,22,27}. Each original periapical digital image was manipulated by the investigator to enhance the contrast and brightness of the image until the subjectively clearest image of the quality of RCT and surrounding periapical structures was obtained. Other factors, such as operator (consultant, specialist, and GDP), gender, and number of canals, arch, and position, of the tooth with RCT were registered.

The obtained radiographic data were summarized as frequencies and percentages and subsequently entered in a personal computer and analyzed using SPSS version 20.1 for Windows (SPSS IBM, Inc., Chicago, Illinois, USA) to collect results. Descriptive statistics and chi-square test were performed, and significance level was set at $P < 0.05$.

RESULTS

This study included 376 endodontic-treated canals from the 170 examined periapical radiographs. Of these cases, 202 (53.7%) were males, and 219 (58.2%) were located in the maxillary arch. The frequencies of the RCFs found in the anterior and posterior regions were 109 (29%) and 267 (71%), respectively. The number of single canals and the number of multiple canals were 153 (40.7%) and 223 (59.3%), respectively. The patient's age ranged from 18 years to 62 years with a mean age of 33.84 years and a standard deviation of 13.7.

Regarding the length of the RCFs, the higher frequency and percentage were in males in the underfilled category (91; 45%), and (161; 72.2%) in acceptable multiple canals, while acceptable RCFs among females were (121; 69.5%), and single canal (45; 29.4). Additionally, the density was high in the RCFs (159; 91.4%), acceptable in females and 196 (87.9%) in multiple canals, while the tapering of the RCFs was acceptable in (184; 91.1%) in males and (148; 96.7%) in single canals. The RCTs performed by consultants, specialists, and GDPs were 69 (18.4%), 96 (25.5%), and 211 (56.1%), respectively. Over 80% of the cases were acceptable RCFs in terms of density and tapering, whereas 54.8% were acceptable in terms of the length of RCFs.

In Table 3, the percentage and frequency of the acceptable length of the quality of RCFs were high in the mandible (111; 70.7%), anterior teeth (87; 79.8%), consultants (48; 69.6%) and specialists (60; 62.5%). The overfilled length of RCFs was low in all of the variables, accounting for (18; 18.8%) among specialists and (21; 10%) among GDPs. The underfilled quality of RCTs was

higher among the GDPs (92; 43.6%), posterior teeth (111; 41.6%) and maxillary arch (90; 41.1%). All of the variables significantly differed in terms of the quality of RCF lengths ($P < 0.001$).

The frequency and percentage of RCFs (Table 3) with acceptable densities were higher in the mandible (134; 85.4%) and anterior teeth (103; 94.5%) than in the maxilla (173; 79%) and posterior teeth (204; 76.4%) (Table 3). At different levels of experiences, the acceptable density was higher among the three levels of experiences: consultant (69; 100%), specialist (78; 81.3%), and GDPs (160; 75.8%) than the poor quality of the same parameter. The densities of the RCFs were acceptable in (173; 79%) cases in the maxillary arch and in (134; 85.4%) in the mandibular arch. A significant difference in the density of the RCF length was noted among all of the variables ($P < 0.001$) except between arches ($P = 0.137$).

The percentage of the acceptable tapering of RCFs was above 90% in the maxillary arch and posterior teeth compared with the poor quality of the tapering of RCF in the mandibular arch (24.4%) and anterior teeth (33.9%) (Table 3). In terms of the level of experience, the proportion of RCFs with acceptable RCFs was high (69; 100%) among consultants but low at (12; 12.5%) among specialists and (47; 22.3%) GDPs. The tapering of RCFs ($P < 0.001$) significantly differed among all of the parameters (Table 3).

DISCUSSION

This work is to objectively identify and investigate the quality of RCTs performed by endodontists with different levels of experience from Arar Specialist Dental Center. The radiographic parameters of the quality of RCT

Table 1. Radiographic evaluation criteria for the quality of root canal fillings (8, 13, 15, 22, 27)

Criteria	Criteria	Definition
Length of the RCF	Acceptable	Root canal filling ends 0.2 mm short of the radiographic apex
	Overfill	Root canal filling beyond the radiographic apex
	Underfill	Root canal filling ends >2 mm short of the radiographic apex
Density of the RCF	Acceptable	Homogeneous root canal filling, good condensation, no visible voids.
	Poor	Non-homogeneous root canal filling, poor condensation or voids present
Taper of the RCF	Acceptable	Consistent and uniform taper from the coronal to the apical part of the filling, with reflection of the original shape of the canal
	Poor	Inconsistent taper from the coronal to the apical part of the filling

Table 2. The descriptive of the quality of the root canal fillings among gender and numbers of canals

Quality of RCF / Parameter	Length of the filling				Density		Taper		Overall	
	Acceptable	Overfilled	Undefined	Acceptable	Poor	Acceptable	Poor	Acceptable	Unacceptable	
Parameter	206 (54.8%)	51 (13.6%)	119 (31.6%)	307 (81.6%)	69 (18.4%)	317 (84.3%)	59 (15.7%)	236 (63%)	140 (37%)	
Gender										
Males	85 (42.1%)	26 (12.9%)	91 (45.0%)	148 (73.3%)	54 (26.7%)	184 (91.1%)	18 (8.9%)	148 (73.2%)	54 (26.8%)	
Females	121 (69.5%)	25 (14.4%)	28 (16.1%)	159 (91.4%)	15 (8.6%)	133 (76.4%)	41 (23.6%)	146 (83.9%)	28 (16.1%)	
Number of canals										
Single	45 (29.4%)	18 (11.8%)	90 (58.8%)	111 (72.5%)	42 (27.5%)	148 (96.7%)	5 (3.3%)	108 (71.2%)	45 (29.8%)	
Multiple	161 (72.2%)	33 (14.8%)	29 (13.0%)	196 (87.9%)	27 (12.1%)	169 (75.8%)	54 (24.2%)	186 (83.5%)	37 (16.5%)	

Table 3. The frequency and percentage of RC length, density and tapering in relation to arch, canal position and level of experiences

Parameters	Length of the RCF			P value	Density of the RCF			P value	Tapering of the RCF			P value
	Acceptable	Overfilled	Undefined		Acceptable	Poor	Acceptable		Poor	Acceptable	Poor	
Arch												
Maxilla	95 (43.3%)	34 (15.5%)	90 (41.1%)	.000*	173 (79.0%)	46 (21.0%)	0.137	198 (90.4%)	21 (9.6%)	0.000*		
Mandible	111 (70.7%)	17 (10.8%)	29 (18.5%)		134 (85.4%)	23 (14.6%)		119 (75.8%)	38(24.4%)			
Canal position												
Anterior	87 (79.8%)	14 (12.8%)	8 (7.3%)	.000*	103 (94.5%)	6 (5.5%)	.000*	72 (66.1%)	37 (33.9%)	.000*		
Posterior	119 (44.6%)	37 (13.9%)	111 (41.6%)		204 (76.4%)	63 (23.6%)		245 (91.8%)	22 (8.2%)			
Level of experience												
Consultant	48 (69.6%)	12 (17.4%)	9 (13.0%)	.000*	69 (100%)	0 (00.0%)	.000*	69 (100%)	0 (0.0%)	.000*		
Specialist	60 (62.5%)	18 (18.8%)	18 (18.8%)		78 (81.3%)	18 (18.8%)		84 (87.5%)	12 (12.5%)			
GDP	98 (46.4%)	21 (10.0%)	92 (43.6%)		160 (75.8%)	51 (24.2%)		164 (77.7%)	47 (22.3%)			

*significant differences

were established in accordance with European guidelines and previous studies on the outcome of RCFs^{8, 15, 22, 27}. Evaluations were performed using postoperative periapical radiographs.

In Table 2, most of the RCFs were in the posterior region (56.1%) from both arches because the majority of endodontic single canal teeth were treated in the primary health center in accordance with the regulations of the Ministry of Health in KSA. This result agreed with the findings of²⁵, who reported that 63% of the teeth have multiple roots. Additionally, the majority of RCTs were performed by GDPs (56.1%) because they have a larger number of clinics in our center than a consultant and two specialists. This result was also consistent with those described in previous studies^{25, 27, 28}.

Overall, the RCF canals with an acceptable quality in this study were 63%, which was similar to other results obtained by graduate students in Qassim (69%) and Madinah (68.9%)^{12, 14} but was higher than those from Dar Alalem (36.6%), Al Farabi (32.6%), and KSU (23%) in Riyadh City^{13, 17, 15}. In terms of the percentages of acceptable cases in foreign studies, our findings were similar to those in Sharjah, UAE (78%) and Turkey (79%)^{18, 30} but were higher than those in Malaysia (61.35%), Palestine (58%), India (68.4%), Libya (48.6%), and Jordan (53.9%)^{19, 21, 23, 27}. This result was achieved because all of the cases in the current study were prepared by using apical locator sensors and a rotary system during RCFs. The findings showed that the services provided by the Arar Dental Center were within the standards of care from ET guidelines. The adequate school training of GDPs might be another factor affecting such a high number of acceptable RCFs. The mean age of the patient reported to the center was 33.98 years, which totally agreed with those described in other studies^{16, 28-29}. Most of the patients were 25–39 years old. This finding can be attributed to the high prevalence of dental caries at this age. Beyond this age, however, the prevalence decreases. In our study, the percentage of the males (53.7%) was higher than that of the females (46.3%), and this proportion (Table 2) was different from that in previous studies^{28, 29}, which showed that the number of females is higher than that of males. This result might be due to the pure social reasons of females in KSA in terms of transport.

In the current study, the quality of RCFs was evaluated using three parameters, namely, length, density, and tapering of obturated canals. The length of RCFs is considered acceptable if it extends to the apex of the teeth, leaving 0.5 mm from the apex^{8, 24}. The qualities of the length of the RCF were around (43.3%) in the maxilla and (44.6%) in the posterior teeth, this high number due to the difficulty in the acceptability and limitation of mouth opening in either arch or in the posterior region.

The total adequate filling lengths ranged between (43.3% - 79.8%), which were near to the percentages (62%, 65%, and 61.5%) in previous studies^{12, 20, 27}. The quality of the length of RCFs was significantly higher in the mandibular teeth (70.7%) than in the maxillary teeth (43.3%). Likewise, the quality of the length of RCFs in the anterior canal (79.8%) was higher than that in the posterior canals (44.6%) ($P < 0.000$). This result was consistent with previous findings^{22, 27}, which concluded that maxillary anterior canals (47.1%) significantly differ from maxillary posterior canals (5.9%) ($P < 0.01$), and significantly vary in the canal position. These results also agreed with previous findings^{17, 22}, which showed (40%) (47.1%) of their cases in the maxillary anterior teeth and significant differences in all length parameters¹⁷. Conversely, our results differed from those in another study²⁰, which demonstrated that maxillary and mandibular teeth significantly vary in terms of acceptable RCFs.

Underfilling occurs when RCO is shorter than the radiographic apex by $d \geq 2$ mm (8, 14). In the current study, the RCO underfillings were the most frequent procedural error in the maxilla (41.1%) and the posterior teeth (41.6%) and in the cases performed by GDPs (43.6%). This error might have resulted from X-ray inaccuracies in the master cone position and attributed to the half number of cases performed by GDPs (92/211; 43.6%) because of their lack of experience. This observation also agreed with those in previous studies^{14, 21, 27}, which revealed (49.4%, 38.6%, and 34.5%) of underfillings RCFs, respectively. The percentage of RCO underfillings was less than that in a previous study²⁴, which revealed 74.2%, possibly because of differences in technology, materials, and equipment used. By contrast, other studies have shown that the

majority of the used materials are old and outdated (25,26). The current findings indicated an excellent percentage of successful RCFs performed by GDPs (46.4%), and such performance was almost similar to those obtained in previous studies (48.6% and 42.3%)^{23, 29}.

Overfilling is determined when RCO materials are extruded beyond the apex^{8, 14}. The present findings revealed overfilled cases in (10%–18.8%) of the treated canals, and these values were consistent with those in other studies^{21, 18, 14}, which showed that undergraduate students had 14.6%, 14%, and 24.1% overfilled cases under strict instructions and direct staff supervision²⁷(Table 3).

Errors on RCF density are identified when visible voids within an RCO mass can be detected in periapical radiographs^{8, 13, 20, 24}. In our study, the density was acceptable in most cases (75.8%) by GDPs, and it reached 100% among canals obturate by consultants. This result indicated that only few cases with voids within the RCFs were noted. It also consistent with (23.6%, 12.6%, 24.2%, 29%) canals with voids observed in other studies^{14, 18, 20, 23}, respectively. Our findings were not consistent with the percentages (50%–65%) of canals with voids in their finished cases^{16, 21, 22, 24}. This difference might be related to the obturation techniques and materials used. Table 3 shows that the arches ($P < 0.000$) did not significantly differ, but the canal positions within the arch significantly varied in the presence of canal voids ($P < 0.05$). These findings agreed with previous observations^{17, 21}.

An RCF taper is defined as uniform and consistent tapers extending from the coronal area to the apical area and resembling the original shape of a canal^{8, 13}. The percentage of acceptable canals is over 80% of all the finished cases, and this proportion is consistent with that reported in a previous research (85%; 18) and almost similar to that in another study (70%; 23). Few poor taper cases were found in our study. Conversely, previous studies showed high taper cases of (56%; 22 and 83.4%; 24) probably because undergraduate students performed the procedures²², and (96.3%) of the cases were apical periodontitis²⁴.

Almost all of the parameters used in our study showed highly significant differences ($P < 0.000$), but they varied from those described in a previous study¹⁵, which concluded significant

differences in RCF length ($P = 0.134$), density ($P = 0.081$), and tapering ($P = 0.590$). This discrepancy was observed probably because our cases were performed by practitioners with different levels of experiences, whereas those of that study were carried out by students at different levels. In the current study, a significant difference was noted among practitioners with various levels of experiences in the different parameters ($P = 0.000$) probably because of the number of canals performed by consultants, specialists, and GDPs (18.4%, 25.5%, and 56.1%), respectively and by the equipment used during RCOs.

It is clearly reveals that endodontic consultants and specialists performed excellent RCTs, whereas GDPs reached an acceptable number and felt satisfied with their routine RCTs (43.6%). In a survey conducted in Riyadh, KSA; 77.2% of the GDPs are satisfied with their routine RCFs²⁷. GDPs still need to improve the quality of RCFs, particularly underfilled length.

This study has several limitations, such as working length registration, canal preparation, and obturation techniques, which were not investigated and might affect the final outcome of our results. The number of visits for RCFs was also not accounted because this parameter might directly affect the length, density, and tapering of RCOs.

CONCLUSIONS

Within the limitations of this retrospective study, the technical quality of RCFs performed at Arar Dental Center was acceptable in 63% of all of the cases. These RCFs significantly varied in terms of length, density, and tapering in different areas of dental arches, different canal locations, and different level of practitioner experience. The quality of RCFs in terms of length was acceptable in the majority of the cases carried out by consultants and specialists and in less than half (46.4%) of the cases performed by GDPs. The underfilling rate by GDPs was higher than those by specialists and consultants, but the overfilled RCFs of the former were fewer than those of the latter. The densities of RCFs in almost all of the cases were acceptable, but poor qualities were found in 24.2% of the cases done by GDPs. The tapering of RCFs decreased to 22.3% in the same group.

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