



ORIGINAL ARTICLE

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Radiographic Evaluation of Root Canal Fillings in a Selected Yemeni Population: A Retrospective Study.

Abstract: Aim: To assess the root canal filling quality performed by general dental practitioners in Yemen through radiographic evaluation. Materials and Methods: Four hundred fifty-five digital panoramic radiographs were selected from the archive of the Dental Health Center in Sana'a, Yemen. The final sample consisted of 221 patients, 685 teeth, and 977 root canals. The criteria for overall radiographic adequacy of root canal fillings were defined as the presence of adequate length, density and taper, and absence of iatrogenic errors (ledges, transportations and perforations). Chi-square test was used to determine statistical significance between different parameters. Results: This study considered only radiographic criteria for evaluation of the root canal fillings. The percentage of root canal fillings with adequate length, density and taper was 30.8%, 29.6% and 20.7%, respectively. Considering the incidence of iatrogenic errors, perforations were present in 12 root canals (1.2%), while the presence of transportations was observed in 20 root canals (2.0%). However, ledges were no detected in any root canals. Conclusion: The root canal filling quality performed by general dental practitioners in Yemen is poor.

Keywords: Quality, Endodontic, Root canal filling, Radiographic evaluation.

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INTRODUCTION.

Endodontic therapy is considered an important part of oral health care, and root canal filling is an essential step in root canal treatment¹. There is significant evidence in scientific literature that the technical quality of root canal filling has a substantial effect on the outcome of root canal treatment^{1,2}. Failed root canal filling is related to insufficient treatment, through technical error in the canal system of the tooth^{3,4}. Numerous epidemiologic studies performed in many countries found a high prevalence of poor technical quality in root canal filling associated with periapical radiolucency⁵⁻¹⁰. Therefore, the quality of root canal filling was found to have the most

critical impact on successful root canal treatment⁹.

Many criteria have been suggested to evaluate the quality of root canal filling. The majority of these criteria are based on either clinical or radiographic examination separately or on a combination of both methods. However, the radiographic method was mostly used in epidemiologic studies to assess the technical quality of root canal filling¹¹⁻¹⁴.

The European Society of Endodontology in 2006 stated that: "For radiographic evaluation of root canal fillings, the prepared root canal should be filled completely unless space is needed for a post. The prepared and filled canal should contain the original canal. No space between canal filling and canal wall should be seen. There should

be no canal space visible beyond the end-point of the root canal filling¹⁵. Likewise, the American Association of Endodontists in 2009 stated: "For radiographic evaluation of root canal fillings, the three qualities that should be observed are: length, shape and density. The length of an ideal fill should be from the canal's apical minor constriction to the canal orifice unless a post is planned. The shape of the completed case is somewhat dependent on the instrumentation technique being used. Voids should not be visible on the radiographic image"¹⁶.

Numerous studies have shown that a majority of dentists, even in developed countries, do not act in accordance with the formulated guidelines on the quality of root canal treatment¹⁷⁻¹⁹. Recently, Madfa *et al.*²⁰ found that most of the Yemeni dental practitioners still use conventional materials and techniques for filling root canal systems, and that they also do not comply with the formulated guidelines on the quality of root canal treatment. Unfortunately, most patients in Yemen receive root canal treatment from general dental practitioners due to the lack of specialists in the field of endodontics. This may affect the quality of root canal treatment.

In Yemen, no published data is available on the radiographic evaluation of root canal fillings performed by general dental practitioners. Therefore, this study aimed to assess radiographically the quality of root canal fillings carried out by general dental practitioners.

MATERIALS AND METHODS.

This study was based on a retrospective assessment of digital panoramic radiographs. The present study was approved by the Medical Ethics Committee of the Faculty of Dentistry at Thamar University, Yemen (Ethics No.: 2015/006). Digital panoramic radiographs of patients who first received treatment at the Dental Health Center in Sana'a, Yemen, taken between 2012 and 2015, were selected from the archive of this center. The database of digital panoramic radiographs from 455 patients was evaluated. The final sample consisted of 221 pa-

tients, 685 teeth, and 977 root canals.

All root canal fillings were performed by general dental practitioners using step-back technique with hand instrumentation and lateral compaction filling technique, using gutta-percha and zinc oxide eugenol sealer. The target sample was single- and multi-rooted canals treated by general dental practitioners. Of these, root canal fillings with adequate quality radiographs taken after treatment were selected for the study. Radiographic images presenting deformations as well as those who had surgical procedures like cyst enucleation or apicectomy were excluded from the study.

The quality of root canal fillings was reviewed by examining the post-treatment radiographs. A pro-forma sheet was planned to facilitate data collection and analysis. The length, density and taper of root canal fillings were assessed as shown in Table 1. Iatrogenic procedural errors, such as ledges, transportations and perforations were also taken into consideration. The relation of the adequacy of root canal length, density, taper and incidence of procedural errors to tooth position (anterior/posterior, maxilla/mandible) was also evaluated.

All radiographs were taken by the same operator using a panoramic digital radiography device (Tomography X-ray System Model Pax-Flex 3D). All radiographs were reviewed by one dental surgeon. Afterwards, all radiographs were reviewed independently by two specialists. Before the evaluation, the observers participated in calibration training, which consisted of 30 randomly selected panoramic radiographs. The inter-observer agreement was determined by calculating the kappa value (kappa=0.84). In case of disagreement, the three investigators were gathered together and a final agreement was reached.

The analysis of the data was performed using SPSS 21.0 for Windows (SPSS Inc., Chicago, IL, USA). Chi-square test was used to determine statistical significance between different parameters. The significance level was 5%.

Table 1. Criteria for evaluation used in this study.

Parameters		Criteria	Definition
Quality of root canal fillings	Length of root canal filling	Acceptable	Root filling terminating 0-2mm from the radiographic apex.
		Under -filled	Root filling terminating ≥ 2 mm from the radiographic apex.
		Over -filled	Root filling extending beyond the radiographic apex.
	Density of root canal filling	Adequate	Homogeneous root filling, good condensation, no voids visible.
		Inadequate	Non homogeneous root filling, poor condensation or voids present.
	Taper of root	Adequate	Consistent and uniform taper from the coronal to apical area with a canal filling reflection of the original shape of the canal.
Inadequate		Inconsistent taper.	
Procedural errors		Ledge	Root filling is at least 1mm shorter than the working length and deviated from the original canal shape in teeth where root canal curvature occurred.
		Transportation	The filling material is located on the outside curve of the canal at the apical third.
		Perforation	The obturation material is detected outside the canal walls.

RESULTS.

The total number of root-filled canals was 977, with the predominance of maxillary canals, 583 (59.7%). More than half of the samples, 501 (51.3%), were molars, followed by 292 (29.8%) premolars and 184 (18.9%) anterior teeth. The most commonly root-filled teeth were mandibular molars 263 (26.9%), followed by maxillary molars 238 (24.4%).

The location of root canals (maxilla/mandible, anterior/posterior) and quality of the root canal fillings are shown in Tables 2 and 3. There were no significant differences for adequacy of length between maxillary and mandibular root canals or between anterior and posterior root canals ($p > 0.05$). Besides, no dependence was established between the densities of maxillary and mandibular root canals ($p > 0.05$). However, a statistically significant difference was observed between the densities of anterior and posterior root canals ($p < 0.05$). Compared to maxillary root canals, the percentage of incidence of procedural errors was significantly greater in mandibular root canals ($p < 0.05$). However, no dependence was established between the tooth position (anterior/posterior) and canal procedural errors ($p > 0.05$). No statistically significant differences were observed between the taper of maxillary and mandibular ca-

nals or between the anterior and posterior canals ($p > 0.05$).

Table 4 shows the length and density of the root canal fillings according to tooth group. The percentage of root canal fillings with adequate length was 301 (30.8%). The highest percentage of canal fillings with adequate length was observed in maxillary anterior teeth, 53 (34.2%), followed by maxillary molars, 81 (34.0%). The overall percentage of root canal fillings with adequate density was 289 (29.6%). The best results were achieved in mandibular premolars, 34 (33.0%), followed by maxillary molars, 77 (32.4%).

Table 5 shows the taper and the incidence of procedural errors of root canal fillings according to tooth group. Considering the occurrence of iatrogenic errors, perforations were present in 12 root canals (1.2%), while the presence of transportations was observed in 20 root canals (2.0%). Ledges were not detected in any root canals. The highest percentage of the occurrence of perforations and transportations was identified in mandibular molar root canals [8 (3.0%), 5 (1.9%)], respectively. Regarding root canal taper, adequacy of taper was present in 202 root canals (20.7%). The highest percentage of root canal fillings with adequate taper was observed in mandibular premolars, 27 (26.2%), followed by maxillary molars, 51 (21.4%).

Table 2. Length and density of root fillings by canal location (maxilla/mandible, anterior /posterior).

Tooth Group	Total	Length			Density	
		Acceptable	Under -filled	Over -filled	Adequate	Inadequate
Maxillary canals	583 (59.7%)	188 (32.2%)†	384 (65.9%)	11 (1.9%)	167 (28.6%)*	416 (71.4%)
Mandibular canals	394 (40.3%)	113 (28.7%)	267 (67.8%)	14 (3.6%)	122 (31.0%)	272 (69.0%)
Total	977 (100%)	301 (30.8%)	651 (66.6%)	25 (2.6%)	289 (29.6%)	688 (70.4%)
Anterior canals	185 (18.9%)	61 (6.2%)†	119 (12.2%)	5 (.5%)	41 (4.2%)*	144 (14.7%)
Posterior canals	792 (81.1%)	240 (24.6%)	532 (54.5%)	20 (2.0%)	248 (25.4%)	544 (55.7%)
Total	977 (100%)	301 (30.8%)	651 (66.6%)	25 (2.6%)	289 (29.6%)	688 (70.4%)

†No statistically significant difference ($p > 0.05$) between adequate lengths of root canal fillings in maxillary and mandibular canals.

*No statistically significant difference ($p > 0.05$) between adequate density of root canal fillings in maxillary and mandibular canals.

†No statistically significant difference ($p > 0.05$) between adequate lengths of root canal fillings in anterior and posterior canals.

*Statistically significant difference ($p < 0.05$) between adequate density of root canal fillings in anterior and posterior canals.

Table 3. Procedural errors and taper of root fillings by canal location (maxilla/mandible, anterior /posterior).

Tooth Group	Total	Procedural errors			Taper	
		No errors	Transportation	Perforation	Adequate	Inadequate
Maxillary canals	583 (59.7%)	570(97.8%)†	8 (1.4%)	5 (.9%)	115 (19.7%)*	468 (80.3%)
Mandibular canals	394 (40.3%)	375 (95.2%)	12 (3.0%)	7 (1.8%)	87 (22.1%)	307 (77.9%)
Total	977 (100%)	945 (96.7%)	20 (2.0%)	12 (1.2%)	202 (20.7%)	775 (79.3%)
Anterior canals	185 (18.9%)	180(18.4%)†	2 (.2%)	3 (.3%)	31(3.2%)*	154(15.8%)
Posterior canals	792 (81.1%)	766(78.4%)	17 (1.7%)	9 (.9%)	171(17.5%)	621(63.6%)
Total	977 (100%)	946(96.8%)	19 (1.9%)	12 (1.2%)	202(20.7%)	775(79.3%)

†Statistically significant difference ($p < 0.05$) between incidence of procedural errors of root canal fillings in maxillary and mandibular canals.

*No statistically significant difference ($p > 0.05$) between adequate taper of root canal fillings in maxillary and mandibular canals.

†No statistically significant difference ($p > 0.05$) between incidence of procedural errors of root canal fillings in anterior and posterior canals.

*No statistically significant difference ($p > 0.05$) between adequate taper of root canal fillings in maxillary and mandibular canals.

Table 4. Length and density of root canal fillings by tooth group.

Tooth Group		Total	Length			Density	
			Adequate	Under -filled	Over -filled	Adequate	Inadequate
Maxilla	Anterior	155 (15.9%)	53 (34.2%)	97 (62.6%)	5 (3.2%)	34 (21.9%)	121 (78.1%)
	Premolar	189 (19.3%)	54 (28.6%)	133 (70.4%)	2 (1.1%)	56 (29.6%)	133 (70.4%)
	Molar	238 (24.4%)	81 (34.0%)	154 (64.7%)	3 (1.3%)	77 (32.4%)	161 (67.7%)
Mandible	Anterior	29 (3.0%)	7 (24.1%)	22 (75.9%)	0 (0.0%)	6 (20.7%)	23 (79.3%)
	Premolar	103 (10.5%)	33 (32.0%)	65 (63.1%)	5 (4.9%)	34 (33.0%)	69 (67.0%)
	Molar	263 (26.9%)	73 (27.8%)	180 (68.4%)	10 (3.8%)	82 (31.2%)	181 (68.8%)
Total		977 (100%)	301 (30.8%)	651 (66.6%)	25 (2.6%)	289 (29.6%)	688 (70.4%)

Table 5. Procedural errors and taper of root canal fillings by tooth group.

Tooth Group		Total	Procedural errors			Taper	
			No errors	Transportation	Perforation	Adequate	Inadequate
Maxilla	Anterior	155(15.9%)	150 (96.8%)	2 (1.3%)	3 (1.9%)	26 (16.8%)	129 (83.2%)
	Premolar	189 (19.3%)	186 (98.4%)	2 (1.1%)	1 (.5%)	38 (20.1%)	151 (79.9%)
	Molar	238 (24.4%)	235 (98.7%)	2 (.8%)	1 (.4%)	51 (21.4%)	187 (78.6%)
Mandible	Anterior	29 (3.0%)	29 (100%)	0 (.0%)	0 (.0%)	4 (13.8%)	25 (86.2%)
	Premolar	103 (10.5%)	96 (93.2%)	5 (4.9%)	2 (1.9%)	27 (26.2%)	76 (73.8%)
	Molar	263 (26.9%)	250 (95.1%)	8 (3.0%)	5 (1.9%)	56 (21.3%)	207 (78.7%)
Total		977 (100%)	945 (96.7%)	20 (2.0%)	12 (1.2%)	202 (20.7%)	774 (79.3%)

DISCUSSION.

The radiographic image of root canal obturation reflects the original anatomy of the root canal and reveals specific details about the filling^{21,22}, allowing the assessment of its quality. Previous studies usually used conventional panoramic radiographs²³, full-mouth periapical radiographs¹⁴ or digital panoramic radiographs²⁴ to assess the root canal fillings. In this study, only digital panoramic radiographs were used to assess the quality of root canal fillings. During recent years progress was made in developing and improving digital radiography; and with the new digital high-resolution systems the detection of radiolucency may be improved. However, there is an inherent magnification factor in the panoramic radiography technique. The inherent magnification results from the distance between the patient and the film. Furthermore, the increases of horizontal and vertical axes lead to image distortion with changes in image shape. Moreover, anatomical variations of each patient, according to their facial patterns, may result in a larger or smaller degree of distortion in images caused by the position of the jaws in the image layer of the machine²⁵. Therefore, those radiographic images presenting distortions were excluded from the present study.

A negative aspect of the present study is that the data analyzed was restricted to available information and thus may be biased⁸. Furthermore, since radiographs are two-dimensional, root canal fillings or anatomic structures are often superimposed to each other, therefore making it impossible to make a valid assessment of root canal filling quality. However, the most important advantage of this method is the large sample size¹⁴.

In epidemiological studies, researchers used different criteria for radiographic evaluation. Some considered length only⁷, while others used length and density²⁶ or, in addition to the two, they also taper into consideration²⁷. In this study, length and taper along with lateral seal with no voids in filling were evaluated. The incidence of iatrogenic errors (ledges, transportations and perforations) was also considered. Kojima *et al.*²⁸ found that success rate is dependable on length of root fillings and concluded that the root canal filling should be within 2mm of the radiographic apex. The present study showed that only 30.8% of root canal fillings had adequate length.

Among the radiographic filling aspects assessed in this study, density had the maximum ideal standard scores due

to adequate homogeneity of root canal filling, which is an important factor for long-term success of root canal treatment⁸. It is clinically relevant because poor homogeneity of the filling material may cause microleakage, which is the major cause of apical lesion¹. The present study found root canal fillings with adequate density in 29.6% of cases.

Although the taper of root canal fillings is a less frequently evaluated parameter in the literature²⁷, it was considered in the present study. Root canals with adequate taper were found in 20.7% of cases.

Procedural errors are considered an important factor for long-term survival of endodontically treated teeth. They are mainly related to insufficient instrumentation and/or obturation of the root canals²⁹. It has been revealed that highly skilled operators are less likely to make procedural errors that may ultimately compromise prognosis²⁹. In this study, there were 3.2% of procedural errors in total. Transportations occurred in 2.1% of the cases, while perforations were found in 1.2%. However, ledges were no observed in any root canals.

The current study showed that quality of root canal fillings was better in anterior root compared to posterior root canals. These findings concurred with a previous study that reported that technical quality was more frequently adequate in anterior root canals³⁰. This may be explained by the more complex anatomy of posterior teeth and more posterior location, which may make the root canal filling more difficult. The common technical difficulties of cleaning and effectively obturating posterior root canals with curved roots are well known. However, the statistical analysis found no significant difference in the quality of anterior and posterior canals in our results. These findings are consistent with those of Adebayo *et al.*¹¹. In their study, the statistical analysis showed no significant difference between the tooth position (anterior/posterior) and root canal filling adequacy, which may be due to the fact that data acquisition for anterior canals was low compared to posterior canals. This could explain why no statistically significant differences were found in this study.

The present findings are in agreement with Barrieshi-Nusair *et al.*³⁰, who reported that no significant difference was observed with respect to the quality standards between maxillary and mandibular root canal fillings. Nevertheless, the quality of root canal fillings was better in maxillary root canals when compared to mandibular root canals. A possible reason for the poor technical quality of mandib-

ular root canal fillings may be the fact that mandibular root canals have a more complex anatomy in comparison to maxillary root canals.

CONCLUSION.

Under the limitations of the current study, it can be concluded that the radiographic evaluation of root canal filling quality performed by general dental practi-

tioners was poor, which is reflected on the oral health care of the Yemeni population. Moreover, the degree of complexity observed warns of the possible challenges in obtaining ideal filling in all root canal groups. Based on the data reported in this study, there is a need to implement continuous dental education programs for general dental practitioners to update their knowledge of endodontic practice.

Evaluación radiográfica de tratamientos de endodoncia realizados en una población Yemení: Estudio retrospectivo.

Resumen: Objetivo: Evaluar a través de la evaluación radiográfica la calidad de los tratamientos de endodoncia realizados por odontólogos generales en Yemen. Materiales y Métodos: Cuatrocientos cincuenta y cinco radiografías panorámicas digitales fueron seleccionados desde el archivo del Centro de Salud Dental en Sana'a, Yemen. La muestra final fue de 221 pacientes, 685 dientes y 977 endodoncias. Los criterios de adecuación radiográfica general de los tratamientos de endodoncia se definieron como la presencia de longitud adecuada, la densidad y la forma cónica y la ausencia de errores iatrogénicos (proyecciones, transportaciones y perforaciones). Se utilizó la prueba de chi-cuadrado para determinar la

significación estadística entre los diferentes parámetros. Resultados: En este estudio se consideró sólo criterios radiológicos para la evaluación de las obturaciones del conducto radicular. El porcentaje de obturaciones del conducto radicular con la longitud adecuada, la densidad y la forma cónica fue del 30,8%, 29,6% y 20,7%, respectivamente. Teniendo en cuenta la incidencia de errores iatrogénicos, las perforaciones estaban presentes en 12 tratamientos (1,2%), mientras que se observó la presencia de transportaciones en 20 tratamientos (2,0%). Sin embargo, las proyecciones no fueron detectadas en ningún tratamiento. Conclusión: La calidad de los tratamientos de endodoncia realizados por dentistas generales de Yemen es pobre.

Palabras clave: Calidad, endodoncia, obturación del conducto, evaluación radiográfica.

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