Evaluation of Technical Quality and Procedural Errors of Root Canal Treatment Performed by Undergraduate and Postgraduate Dental Students: A Retrospective Radiographic Analysis

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Abstract

Aims: To assess and compare the technical radiographic quality of root canal fillings (RCF) and the occurrence of procedural errors in the endodontic treatment performed by 5th grade undergraduate and postgraduate students in the College of Dentistry/University of Baghdad- Baghdad- Iraq.

Materials and methods: Records and periapical radiographs of 216 and 143 root-filled teeth treated by 5th year undergraduate and postgraduate students, respectively during 2018-2019 were collected. Periapical radiographs of 35 (16.2%) and 15 (10.4%) teeth, respectively excluded because of inadequacy in the radiographs. A final total periapical radiographs/records of 181 and 128 root-filled teeth were used to evaluate the technical quality of the root fillings in 197 and 275 root canals treated by 5th year undergraduate and postgraduate students, respectively. Outcome variables categorized as acceptable and not acceptable quality depending on the absence/presence of overfilling, underfilling, voids in the fillings and the absence/presence of ledges, root perforation, transportation, and fractured instruments. Chi-square and 2 sample z tests were used for statistical analysis, significance level set at $\alpha=0.05$

Results: Acceptable RCF were in 49.3% and 63.3% of the canals treated by 5th year undergraduate and postgraduate students, respectively with a significant difference between them ($z=2.99$, $p<0.05$). 55.1% and 44.9% of RCF treated by undergraduate students were in anterior and premolars, respectively. 70.9%, 20.7% and 8.4% of RCF treated by postgraduate students were in molars, premolars and anterior teeth, respectively. Significantly more voids, ledges were observed in RCF performed by undergraduate compared to postgraduate students ($z=4.6$ and 2 respectively, $p<0.05$). In contrast, significantly more instrument separations were observed in RCF treated by postgraduate compared to undergraduate students ($z=2.09$, $p<0.05$). However, there was no significant difference in proportions of underfilling, overfilling, perforations, transportation between the two academic levels.

Conclusion: Overall technical quality of RCF performed by postgraduates was better than that of 5th year undergraduate students, however, improvement in preclinical and clinical training is needed.

Keywords: *root canal treatment, undergraduate, postgraduate, dental students*

Introduction

Prognosis of the root canal treatment strongly affected by the technical quality of the coronal restoration and the root canal filling in order to preserve the functionality of the root filled teeth [1]. There are several factors that affect the technical quality of root canal treatment including the density and length of the filling material from the radiographic apex as well as the occurrence of iatrogenic procedural errors that happens during different stages of root canal treatment such as ledge formation, perforations, instrument fractures and transportation [2]. Although, measuring different technical

quality variables of root canal treatment do not measure its outcome, but greater probability of successful outcome associated with good technical quality of the root canal treatments [3]. A study found that the only predicting factor fortooth survival was the technical quality of the root canal filling not the presence of pretreatment periapical pathology [4].

Density of root canal filling (i.e. presence/absence of voids in the filling materials) represent a significant variable in determining the technical quality of root canal filling. It has been reported that unfavorable treatment outcome of root canals is correlated with low dense and non-homogenous root fillings. Also, it was demonstrated that homogenous voids free root fillings are associated with lower risk of post treatment pathology [5,6]. Extent of the length of the root filling materials in the root canal similarly can be correlated with the outcome of the treatment. It has been found that distance of 0-2 mm between the root filling and the radiographic apex is associated with lower risk of post treatment disease than those underfilled (with more than 2mm distance between filling materials and the radiographic apex) [2,7,].

Canal cleaning and shaping can be compromised by incidence of procedural errors that result in inadequate filling of the root canal which risk the prognosis of the treatment [8]. There is always possibility of failure when procedural errors occur during root canal treatment of infected teeth [9]. Perforations of the root can impair the healing process as it is associated with infection of periodontal ligaments and bone [10]. On the other hand, transportation associated with leakage in the root filling and inadequate cleaning of the canal, both may result in apical pathosis persistence [11]. Also, ongoing periapical pathosis after root canal treatment can results frequently after ledge formation because it prevent complete chemomechanical debridement of the canal to the full working length [8]

Many previous epidemiological studies evaluated the technical quality of root canal treatment performed by dental students in different academic institutions with variable results [12,13,14]. However, to authors knowledge, there is no previous study investigated the technical quality and incidence of procedural errors in root canal filled teeth performed by undergraduate and postgraduate students in the College of Dentistry/ University of Baghdad. The aims of the present study are to evaluate and compare the density and length of the root canal fillings and the incidence of procedural errors (perforations, transportation, ledge formation and instrument separation) by reviewing the radiographs of root canal treatments performed by 5th year undergraduate and postgraduate students in the authors' institute.

Materials and Method

Dental record and periapical radiographs of 216 and 143 teeth received root canal treatment performed by 5th year undergraduate and postgraduate students in the year 2018-2019 in the College of Dentistry/University of Baghdad were collected for analysis of the technical quality and incidence of the procedural errors.

Three periapical radiographs for each tooth including diagnostic, working length estimation and post obturation periapical radiographs were utilized for this purpose. Post obturation PA radiographs that do not provide adequate information because of poor processing or unclear image were exclude from the analysis. Therefore, periapical radiographs and records of a total 309 (181 and 128 teeth root filled by 5th year undergraduate and postgraduate students, respectively) teeth were utilized in this study. Data analysis was based on the number of the filled canals not on the number of teeth, therefore 309 teeth yielded 473 root canal fillings. Radiographs examined with magnification lens (3X magnification) in a dark room under even illumination by two experienced endodontists. All teeth treated by the 5th year undergraduate students were instrumented with step-back technique using stainless steel hand instruments and obturated with gutta-percha and sealer (Zinc Oxide eugenol based), using a cold lateral condensation technique. Teeth treated by the postgraduate students were instrumented with either NiTi rotary instruments or hand instruments and obturated with either cold or hot techniques according to student discretion.

Root canal filling quality classified acceptable if the filling materials end within 0-2 mm from the radiographic apex and there were no voids within the filling materials and no space between the filling material and the canal wall. If the filling materials end shorter than 2 mm from the radiographic apex then the root canal filling classified as underfilled, if the filling materials end beyond the radiographic apex, the root

canal filling classified as overfilled. Both underfilled or overfilled root fillings classified as not acceptable root canal filling. [13,14]

Similarly, evaluation criteria for the procedural errors classified the root canal fillings into acceptable/ not acceptable based on the absence/presence of the followings:

1- Ledges: a ledge was identified in the radiograph if the path of the filling materials deviated from the original curvature of the canal in the working length radiograph.

2- Perforation: a perforation was identified if the filling materials was extruding through the lateral walls of the canal away from the radiographic apex.

3- Transportation: a transportation was identified if the filling materials located on the outside curve of the canal.

4- Instrument separation: an instrument separation was identified if fractured instrument piece was detected in the canal.

Statistical analysis of data performed using Statistical Package for the Social Sciences (Version 24; SPSS Inc., IBM, Chicago, Illinois, USA), descriptive statistics were used to describe the data and inferential statistics included Chi square and two samples z-test for 2 population proportions, significance level set at α=0.05

Results

Total number of acceptable root canal fillings was 272 out of 473 (57.5%) for both academic levels. Acceptable root canal fillings were found in 49.3% and 63.3% of the canals treated by 5th year undergraduate and postgraduate students, respectively with a significant difference between them (z score=2.99, $p<0.05$), as shown in Table 1.

Table 1: distribution of acceptable and not acceptable root canal fillings among 5th year undergraduate and postgraduate students.

Academic level	Acceptable RCF N (%)	Not acceptable RCF N (%)	Total N (%)
5th year undergraduates	98 (49.3) a	100 (51.7%)	198 (100%)
Postgraduates	174 (63.3) a	101 (36.7)	275 (100%)
Total N (%)	272 (57.5%)	201 (42.5%)	473 (100%)

RCF= Root canal fillings, N=number of root canal fillings, %=percentages and identical superscript represent statistical significance among relevant groups.

In root canal treatments performed by 5th year undergraduate, 133 (67.2%) and 65 (32.8%) of root canal fillings were in maxilla and mandible, respectively. Insignificantly, more acceptable root canal fillings occurred in the maxilla (50.4%) compared to the mandible (47.7%) ($p>0.05$). 55.1% and 44.9% of RCF treated by 5th year undergraduate students were in anterior and premolars teeth, respectively, as shown in Table 2. Acceptable root canal fillings were 52.3% and 46.1% in anterior and premolar teeth, respectively, with no significant difference between anterior and premolars ($z=0.8$, $p>0.05$). Procedural errors, voids, underfilling and overfilling in root canal fillings performed by undergraduate students were as follow, perforations were in 2 root canal fillings (1%), ledge was in 3 root canal fillings (1.5%), transportation was in 1 root canal fillings (0.5%), instrument separation was in zero root canal fillings (0%), voids were in 51 root canal fillings (25.7%) and underfilling was in 31 root canal fillings (15.6%) and overfilling was in 24 root canal fillings (12.1%).

Table 2: distribution of root canal fillings performed by 5th year undergraduate' students in arches according to tooth type.

Arch	Anterior	Premolars	Total n(%)
Maxilla n(%)	92 (46.5%)	41 (20.7%)	133 (67.2%)
Mandible n(%)	17 (8.6%)	48 (24.2%)	65 (32.8%)
Total n(%)	109 (55.1%)	89 (44.9%)	198 (100%)

n=number of root canal fillings.

In root canal treatments performed by postgraduate students, 53.8% and 46.2% of root canal fillings were in mandible and maxilla, respectively. Insignificantly more acceptable root canal fillings occurred in the mandible (67.6%) compared to the maxilla (58.3%) ($p>0.05$). 70.9%, 20.7% and 8.4% of root canal fillings treated by postgraduate students were in molars, premolars and anterior teeth, respectively, as shown in Table 3. Acceptable root canal fillings were 67.2%, 56.1% and 47.8% in molars, premolars, and anterior teeth, respectively, with no significant difference between molars, anterior and premolars ($z=1.8$ $z= 1.5$, $p>0.05$, respectively). Procedural errors, voids, underfilling and overfilling in root canal fillings performed by postgraduate students were as follow, perforations were in 2 root canal fillings (0.7%), there was no ledge in any root canal filling, transportation was in 1 root canal filling (0.3%), instrument separation were in 6 root canal filling (2.1%), voids were in 27 root canal fillings (9.8%) and both underfilling and overfilling were in 35 root canal fillings (12.7%) each.

Table 3: distribution of root canal fillings performed by postgraduate students in arches according to tooth type.

Arch	Anterior	Premolars	Molars	Total n(%)
Maxilla n(%)	21 (7.6%)	41 (14.9%)	65 (23.6%)	127 (46.2%)
Mandible n(%)	12 (0.7%)	16 (5.8%)	130 (47.3%)	148 (53.8%)
Total n(%)	33 (8.4%)	57 (20.7%)	195 (70.9%)	273 (100%)

n=number of root canal fillings.

Significantly more voids, ledges were observed in root canal fillings performed by 5th year undergraduate compared to that performed by postgraduate students ($z=4.6$ and 2.0 respectively, $p<0.05$). In contrast, significantly more instrument separations were observed in root canal fillings treated by postgraduate compared to 5th year undergraduate students ($z=2.09$, $p<0.05$). However, there was no significant difference in proportions of underfilling, overfilling, perforations, transportation between 5th year undergraduate and postgraduate students, as shown in Table 4.

Table 4: Distribution of acceptable and not acceptable (voids, underfilling and overfilling and procedural errors) root canal fillings among 5th year undergraduate and postgraduate students.

Academic level	Acceptable root canal fillings	Not Acceptable root canal fillings						
		Voids n(%)	Underfilled n(%)	Overfilled n(%)	Ledges n(%)	Perforations n(%)	Transportation n(%)	Instrument separation n(%)
5th year undergraduate	98	51(25.7)a	31(15.6)	24(12.1)	3(1.5)b	2(1)	1(0.05)	0(0)c
Postgraduates	174	27(9.8)a	35(12.7)	35(12.7)	0(0)b	2(0.7)	1(0.03)	6(2.1)c
Total n*	272	78	66	59	3	4	2	6

n= number of root canal fillings. numbers in parenthesis are percentages. identical superscript letters represent significant difference between relevant groups. *some of the canals show two technical problems.

Discussion

Materials used for this study consisted of dental records and periapical radiographs of teeth received root canal treatment by the 5th undergraduate and postgraduate students. In total 473 root canal fillings were selected in both jaws with no significant difference between the number of root canal treatments performed in the maxilla or in the mandible. In this sample, it was found that postgraduate students treated more root canals in molars than in any other tooth group in comparison to undergraduate students who treated only anterior and premolar.

Previous studies reported different rates of acceptable technical quality of root canal treatments performed by dental students ranging from 23%-74% Our results are within the middle range 57.5% for both academic levels. However, acceptable technical quality of root canal treatment was lower in the treatments performed by the 5th year undergraduate student compared to that performed by the postgraduate students (Table 1), this can be attributed to the greater experience accumulated in the postgraduate students and the use of advanced endodontic tools such as NiTi rotary instruments and developed obturation techniques that help in performing root canal treatments with better technical quality.

Our results show that voids of root canal fillings were numerous among treatments performed by 5th year undergraduate students compared to that performed by postgraduate students (25.7% vs 9.8%) with significant difference between both academic levels (Table 4). This can be attributed to techniques difference in instrumentation and obturation of root canals utilized by both academic levels. Undergraduate use step back and cold lateral condensation techniques for instrumentation/ obturation of root canals compared to using NiTi rotary instruments and thermal compaction by the postgraduate students. It has been reported that cold lateral condensation was associated with more voids compared to thermal compaction (Kierklo et al., 2015). Figures of voids or density problems reported by previous studies evaluated the technical quality of root canal treatment performed by dental undergraduate students were 65.1%, 15% and 7.34% in [13, 14]. Presence of voids can significantly be associated with unfavorable outcome of the treatment and post treatment disease, Denser and more homogenous filling materials associated with better outcome. [5, 6]

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Conflict of Interest: None to declare.

Ethical Clearance: All experimental protocols were approved under the College of Dentistry and all experiments were carried out in accordance with approved guidelines.

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