

Radiographic Assessment of Root Canal Filling for Undergraduate, Graduate Students, and Endodontic Specialist

Dr. Abdulrhman Hatiwsh^{1*}, Dr. Abubaker Deeb²

¹BDS, Msc Endodontic, Department of Dentistry, Zawia University, Libya & Endodontic Specialist, Primary Health Care Corporation (PHCC), Qatar

²BDS, Msc Restorative, Department Of Dentistry, Alasmarya University, Libya & Restorative Specialist, Primary Health Care Corporation (PHCC), Qatar

DOI: [10.36347/sjds.2022.v09i07.002](https://doi.org/10.36347/sjds.2022.v09i07.002)

| Received: 04.07.2022 | Accepted: 16.08.2022 | Published: 18.08.2022

*Corresponding author: Dr. Abdulrhman Hatiwsh

BDS, Msc Endodontic, Department of Dentistry, Zawia University, Libya & Endodontic Specialist, Primary Health Care Corporation (PHCC), Qatar

Abstract

Original Research Article

Introduction: The aim of this study was to assess the radiographic technical quality of root canal therapy performed by three different groups of undergraduate, graduate and endodontic specialists conducted in the Jordan University of Science and Technology (JUST) Dental Teaching Center. **Method and Material:** The sample comprised of 320 subjects aged 18- 60 years old attended for endodontic treatments. Patients who had endodontic treatments were divided into three treatment groups according to their treatment providers (undergraduate students, graduate students and endodontic specialists). Periapical radiographic assessment sheet was attached to the patient's file. This part included criteria for radiographic assessment for the quality of root canal filling. The following information were recorded, tooth type, quality of radiograph, taperness, length, and density of root canal filling, level of obturation in comparison to cement-enamel junction(CEJ), presence of apical periodontitis, location and size of apical periodontitis, presence of root resorption, presence of break in lamina dura, presence of widening of PDL space, presence of condensing apical periodontitis, presence of internal resorption, presence of missed canals, Presence of ledged canals, Presence of fractured instruments, presence of furcal lesions, pulpal diagnosis and restoration after endodontic treatment. Teeth were treated using at least three, long cones paralleling technique, radiographs (preoperative, working-length and postoperative) of a high quality that showed the entire length of the root and the periapical area. Two investigators using a magnifying lens and an X-ray viewer examined the radiographs independently. The results were compared and a final consensus was agreed. In case of disagreement, a third investigator was asked to read the radiograph and a final agreement was reached. Measurement was recorded and was taken as a caliber for periapical radiographs film reading. **Results:** technical quality of root filling for Specialists had the highest proportion of optimum obturation length (89%) when compared to the graduate (62%) and undergraduate (45%) students. The same impression can be seen for obturation density and taperness of root filling, where there is significant difference between the three group of treatment providers ($P<0.001$) with the highest percent of adequate density and taperness had been found in the teeth treated by specialist and the least percent of adequate density and taperness had been found in teeth treated by undergraduate students. Presence of voids in root filling had been detected in about (50.0%) of teeth treated by undergraduate students and in (37.0%) of teeth treated by graduate students compared to (4.0%) of teeth that had been treated by specialists. The difference was statistically significant ($P<0.05$). No missed canal at all in teeth treated by specialists or graduate students when compared to undergraduate students, with a significant difference ($P<0.001$). Only a single tooth treated by specialists and two teeth treated for each graduate or undergraduate students had pledged canals, while no fractured instrument had been found in teeth treated by specialists. **Conclusion:** Data demonstrated a significantly higher technical quality of endodontic treatment provided by specialist compared to postgraduate and undergraduate students.

Keywords: radiographic technical quality, endodontic treatments, root canal treatment.

Copyright © 2022 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY-NC 4.0) which permits unrestricted use, distribution, and reproduction in any medium for non-commercial use provided the original author and source are credited.

INTRODUCTION

Root canal treatment (RCT) is an important part of comprehensive quality dental care (Chueh *et al.*, 2003). There are some cases in which the treatment is

done to the highest technical standards and yet failure results. Scientific evidence indicates that some factors may be associated with the unsatisfactory outcome of well-treated cases. These include microbial factors, comprising extraradicular and/or intraradicular

infections, and intrinsic or extrinsic non-microbial factors (Nair *et al.*, 1990; Lin *et al.*, 1992, Nair *et al.*, 1993, Sjögren 1996; Sundqvist and Figdor 1998; Lopes and Siqueira 1999; Nair *et al.*, 1999).

Methods used to determine the technical quality of endodontic treatment have been mostly based on radiographic evaluation (Buckley and Spangberg 1995, Saunders *et al.*, 1997). Helminen *et al.*, (2000) showed that success or failure of RCT is based on the technical quality of the root filling. According to the European Society of Endodontology (1994), appropriate treatment includes, in addition to root canal preparation and filling, the exposure of preoperative radiographs, determination of the proper working length, and radiological control of the quality of the filling. Several studies indicate that root fillings placed within 0–2 mm of the radiographic apex were associated with less post-treatment disease than those that were filled greater than 2 mm from the radiographic apex or those that were overfilled (Saunders *et al.*, 1997, Peak *et al.*, 2001, Boltacz-Rzepakowska and Pawlicka 2003).

MATERIALS AND METHODS

This comparative cross-sectional study was conducted for radiographic assessment root canal filling for undergraduate, graduate students, and endodontic specialist. It was conducted at the conservative dental clinics at the Dental Teaching Center of Jordan University of Science and Technology (JUST) in Irbid, Jordan during the period from March to October 2011. All adults aged 18 to 60 years attended the dental teaching center for endodontic treatments were eligible to participate in this study. The inclusion criteria include being systemically healthy, mentally and legally capable of signing the consent form. It was made clear to the participants that participation is voluntary. Only those who signed a written approved consent form were included in the study. Participants were assured of confidentiality of all information obtained and that data will be used only for scientific purposes. Adults excluded from participation in the study were those taking antibiotics and pain killers for various reasons. Adult with diabetes mellitus, blood disorders, pregnant women and patients with previous or ongoing orthodontic treatment were also excluded. The reason for exclusion to avoid misinformation's by these patients because some diseases and drugs obscures the real symptoms of patient complain.

The dental teaching center is a highly specialized dental center with 113 dental clinics of various dental specialties. It provides dental treatment to all private dental patients and JUST employees. Patients initially admitted to the initial treatment unit received full mouth examinations and initial treatment plan with the possibility of immediate emergency dental treatment. Patients were then referred to deferent specialty clinics to be treated by undergraduate dental students, a postgraduate dental students or faculty

members based on their dental condition, dental insurance and their wellness to receive dental treatment.

All participants of this study were recruited from adult patients referred to the conservative dental clinics from either the initial treatment clinic or other specialty clinic located in the dental teaching center of JUST.

A total of 340 participants agreed to participate in this study. Thirty-eight participants were excluded. Of those, 28 of these participants refused because they did not have time for follow up visit. Seven participants did not show up for unknown reasons and they did not complete endodontic treatment or answer their phone calls from the dental center. The remaining three participants had poor radiographic quality.

Periapical radiographic assessment for radiographic assessment for the quality of root canal filling. The following information were recorded, tooth type, quality of radiograph, taperness, length, and density of root canal filling, level of obturation in comparison to cement-enamel junction(CEJ), presence of apical periodontitis, location and size of apical periodontitis, presence of root resorption, presence of break in lamina dura, presence of widening of PDL space, presence of condensing apical periodontitis, presence of internal resorption, presence of missed canals, Presence of ledged canals, Presence of fractured instruments, presence of furcal lesions, pulpal diagnosis and restoration after endodontic treatment.

Radiographs taken after endodontic treatment were evaluated by two independent examiners who were blinded about information of the cases and who carried out endodontic treatment.

Two investigators using a magnifying lens and an X-ray viewer examined the radiographs independently. The results were compared and a final consensus was agreed. In case of disagreement, a third investigator was asked to read the radiograph and a final agreement was reached. Measurement was recorded and was taken as a caliber for periapical radiographs film reading.

Teeth were treated using at least three, long cones paralleling technique, radiographs (preoperative, working-length and postoperative) of a high quality that showed the entire length of the root and the periapical area.

Validity and reliability of interviews and examinations were tested. A group of 10 patients were requested to complete the final questionnaire on two different occasions separated by seven days to assess the test-retest reliability. Cronbach's alpha was acceptable (0.94).

Evaluation Criteria

The technical quality of the root fillings were evaluated, classified and recorded; root canal was the unit of assessment. The criteria for radiographic classification of the technical quality of root fillings were based on three variables; length, density and taperness. They were classified as acceptable and unacceptable as follows: Acceptable: The filling material ends 0–2 mm short of the radiographic apex with consistent filling taper or no voids visible within the material or between material and the root canal walls. Unacceptable: Under-filled: The length of filling material ends more than 2 mm from the radiographic apex. Taperness problem: No consistent taper from the orifice to the apex. Density problem: The filling material ends 0–2 mm short from the radiographic apex with visible voids within or between the material and the root canal walls. Over-filled: Materials were extruded beyond the radiographic apex.

The criteria for radiographic classification of the iatrogenic errors were based on:

- **Ledge:** A ledge was considered present if the apical extent of gutta-percha in the final radiograph deviated from the original curvature compared with the working length radiograph.
- **Perforation:** A perforation was diagnosed when extrusion of materials was detected in any area of the root (lateral wall or the foramen of the root).
- **Fractured Instrument:** They were diagnosed through observation of the final radiograph and according to the radioopacity between the filling material and fractured instrument. Data were entered into a personal computer and analyzed using the Statistical Package for Social Sciences (SPSS) software (SPSS®: Inc., Chicago, IL, USA).

Frequency distribution, and cross –tabulation were produced. Means values and standard deviations

were calculated. Ordinal data were tested with chi square (χ^2) distribution for comparison. Multiple-linear regression was performed to analyze the association between dependent (each clinical parameter) and explanatory variables to determine the risk indicators that associate with each clinical parameter.

RESULTS

A total number of (340) participant agreed to participate in this study. Thirty-eight participants (11.7%) were excluded from the study because they could not manage the follow up visit. Seven participants did not show up to complete endodontic treatment or answer their phone calls for unknown reasons and three participants were excluded because of poor radiographic quality. The remaining 302 (88.8%) participants were included in the present study and completed their treatment and questionnaire.

Table 1-1 shows distribution of socio-demographic variables of the study population. The sample consisted of 302 participants, (48.3%) of them were males and (51.7%) were females. Of the total sample, (50.7%) were below 30 years of age of whom about (44%) treated by specialists, (51%) treated by graduate students and (57%) treated by undergraduate students. About (49%) of sample were above 30 years of age, of whom (56%) treated by specialists, (49%) treated by graduate students and (43%) treated by undergraduate students. About (55.0%) of sample were unemployed, (10.6) were professionals and (34.4%) were workers. The income per person was divided into three groups ranging from lowest to highest. About (36.0%) had low income, (38.0%) had medium income and (27.0%) had high income. Most of participants reside in urban areas (99%) while the rest (1.0%) reside in rural settings.

Table 1-1: Frequency distribution of demographic variables of participants

| Variable | Category | Specialist | Graduate | Undergraduate | Total | Chi square | P value |
|------------------------------------|------------------|------------|-----------|---------------|-----------|------------|---------|
| | | N (%) | N (%) | N (%) | N (%) | | |
| Age | Less than 30 Y | 44(43.6) | 51(51.0) | 58(57.4) | 153(50.7) | 3.889 | 0.143 |
| | 30 Y and above | 57(56.4) | 49(49.0) | 43(42.6) | 149(49.3) | | |
| Gender | Male | 44(43.6) | 54(54.0) | 48(47.5) | 146(48.3) | 2.232 | 0.328 |
| | Female | 57(56.4) | 46(46) | 53(52.5) | 156(51.7) | | |
| Occupation | Unemployed | 58(57.4) | 48(48.0) | 60(59.4) | 166(55.0) | 6.196 | 0.185 |
| | Workers | 29(28.7) | 43(43.0) | 32(31.7) | 104(34.4) | | |
| | Professionals | 14(13.9) | 9(9.0) | 9(8.9) | 32(10.6) | | |
| Income per month per family member | Low (JD< 70) | 25(25.3) | 39(39.0) | 43(42.0) | 107(35.7) | 20.355 | 0.000 |
| | Medium(JD70-100) | 32(32.3) | 39(39) | 42(41.6) | 113(37.7) | | |
| | High (JD>100) | 42(42.4) | 22(22.0) | 16(15.8) | 80(26.7) | | |
| Residency | Urban | 98(32.8) | 100(33.4) | 101(33.8) | 299(99.0) | 6.030 | 0.049 |
| | Rural | 3(100) | 0(0.0) | 0(0.0) | 3(1.0) | | |

Table 1-2 shows the frequency distribution of teeth with RCT in relation to their status variables. For the upper teeth, premolars were most numerous teeth

that had endodontic treatment (22.5%) while for the lower teeth; molars were the most numerous one that had endodontic treatment (30.5%). About (33.4%) of

endodontic treatments were almost equally distributed among specialists, postgraduate students and undergraduate students. About 90% of endodontic treatments were initial treatments and only about 10% was retreatment cases. About a third of root canal treatments were for vital teeth and two-thirds were for necrotic teeth.

Radiographically, about (18%) of participants had teeth with periapical radiolucency initially. Apical radiolucency was more than three millimeters in size and located at the center of root apex in all cases with

periapical radiolucency. Only (3.3%) of participants had diagnosed with furcal lesions while only (2.3%) were diagnosed with external root resorption. Widening of periodontal space was diagnosed radiographically in about (24%) of participants while break in lamina dura had been found in only (6%) of cases. Only one case was diagnosed with internal root resorption. After completion of endodontic treatment, about (70%) of participants had teeth with final permanent restoration, (13%) had temporary restoration, (8%) had crown restoration and about (10) had post-crown.

Table 1-2: Frequency distribution of teeth with RCT in relation to their status variables

| Variable | Category | Number | Percentage |
|--|--------------------------------|--------|------------|
| Tooth type with RCT | U molars | 45 | 14.9 |
| | U premolars | 68 | 22.5 |
| | U canine | 15 | 5.0 |
| | U incisors | 24 | 7.9 |
| | L molars | 92 | 30.5 |
| | L premolar | 52 | 17.2 |
| | L canine | 1 | 0.3 |
| | L incisors | 5 | 1.7 |
| Operator performed RCT | Specialist | 101 | 33.4 |
| | Postgraduate student | 100 | 33.1 |
| | Undergraduate student | 101 | 33.4 |
| Type of treatment | Initial treatment | 272 | 90.1 |
| | Retreatment | 30 | 9.9 |
| Vitality of the pulp before treatment | Vital | 94 | 31.4 |
| | Necrotic | 205 | 68.6 |
| Presence of apical periodontitis initially | Yes | 55 | 17.5 |
| | No | 249 | 82.5 |
| Size of apical periodontitis | < 3 mm | 55 | 100 |
| | 3-5 mm | 0 | 0.0 |
| | > 5 mm | 0 | 0.0 |
| Location of apical periodontitis | At the center of the root apex | 55 | 100 |
| | Lateral to the root apex | 0 | 0.0 |
| Presence of furcal lesion | Yes | 10 | 3.3 |
| | No | 292 | 96.7 |
| Presence of external root resorption | Yes | 7 | 2.3 |
| | No | 295 | 97.7 |
| Presence of widening of periodontal space | Yes | 72 | 23.8 |
| | No | 230 | 76.2 |
| Presence of break in Lamina Dura | Yes | 17 | 5.6 |
| | No | 285 | 94.4 |
| Presence of internal root resorption | Yes | 1 | 0.3 |
| | No | 301 | 99.7 |
| Type of final restoration | Permanent restoration | 210 | 69.5 |
| | Temporary restoration | 38 | 12.6 |
| | Crown | 25 | 8.3 |
| | Post-crown | 29 | 9.6 |

Table 1-3 presents frequency distribution of teeth with root canal treatment presents in relation to parameters related to their treatment quality. Radiographically, about (66%) of root filled teeth had optimum length while about 30% had short filling and only (4%) was overextended. About (70%) of root filled teeth were well condensed and taperness of root filling was adequate in about (74%) of cases. About (73%) of

the root filling were finished at cement-enamel junction, about (13%) below the cement-enamel junction and about (15%) were filled coronal to cement-enamel junction. During endodontic treatment, only seven teeth had missed canals, five teeth were ledged, four teeth had fractured instrument and only one tooth was perforated during instrumentation. About (45%) of treated teeth were molars, (40%) were premolars and

about (15%) were incisors or canines. Data showed that there is a significant difference in obturation length between treatment providers ($P<0.001$). Specialists had the highest proportion of optimum obturation length (89%) when compared to the graduate (62%) and undergraduate (45%) students. The same impression can be seen for obturation density and taperness of root filling, where there is significant difference between the three group of treatment providers ($P<0.001$) with the highest percent of adequate density and taperness had been found in the teeth treated by specialist and the least percent of adequate density and taperness had been found in teeth treated by undergraduate students. Presence of voids in root filling had been detected in about (50.0%) of teeth treated by undergraduate students and in (37.0%) of teeth treated by graduate students compared to (4.0%) of teeth that had been

treated by specialists. The difference was statistically significant ($P<0.05$). No missed canal at all in teeth treated by specialists or graduate students when compared to undergraduate students, with a significant difference ($P<0.001$). Only a single tooth treated by specialists and two teeth treated for each graduate or undergraduate students had pledged canals, while no fractured instrument had been found in teeth treated by specialists however, two teeth with fractured instrument were identified for both graduate and undergraduate student. Only one tooth with perforated canal had been found in teeth treated by undergraduate students. About (19%) of temporary restorations were found in the teeth treated by undergraduate students, (11.0%) in teeth treated by graduate students and about (8.0%) in teeth treated by specialists with significant difference between the groups ($P<0.001$).

Table 1-3: Frequency distribution of teeth with root canal treatment presents in relation to parameters related to their treatment quality

| Variable | Category | Treatment providers | | | Total N (%) | Chi square | P value |
|----------------------------------|----------------|---------------------|-----------|---------------|-------------|------------|---------|
| | | Specialist | Graduate | Undergraduate | | | |
| | | N (%) | N (%) | N (%) | | | |
| Obturation length | Within 0-2mm | 90(89.1) | 62(62) | 47(46.5) | 199(65.9) | 49.015 | 0.000 |
| | Overextended | 5(5.0) | 5(5.0) | 3(3.0) | 13(4.3) | | |
| | Short >2mm | 6(5.9) | 33(33) | 51(50.5) | 90(29.8) | | |
| Obturation density | Adequate | 97(96.0) | 63(63.0) | 50(49.5) | 210(69.5) | 54.639 | 0.000 |
| | Not adequate | 4(4.0) | 37(37.0) | 51(50.5) | 92(30.5) | | |
| Presence of Voids | Yes | 4(4.0) | 37(37.0) | 50(49.5) | 91(30.1) | 53.106 | 0.000 |
| | No | 97(96.0) | 63(63.0) | 51(50.5) | 211(69.9) | | |
| Taperness | Adequate | 96(95.0) | 64(64.0) | 64(63.4) | 224(74.2) | 34.537 | 0.000 |
| | Not adequate | 5(5.0) | 36(36.0) | 37(36.6) | 78(25.8) | | |
| Obturation level compared to CEJ | At CEJ | 80(79.2) | 71(71.0) | 68(67.3) | 219(72.5) | 3.931 | 0.415 |
| | Below CEJ | 9(8.9) | 13(13) | 16(15.8) | 38(12.6) | | |
| | Coronal to CEJ | 12(11.9) | 16(16.0) | 17(16.8) | 45(14.9) | | |
| Presence of missed canal | Yes | 0(0.0) | 0(0.0) | 7(100) | 7(2.3) | 14.261 | 0.001 |
| | No | 101(34.2) | 100(33.9) | 94(31.9) | 295(97.7) | | |
| pledged canals | Yes | 1(20.0) | 2(40.0) | 2(40.0) | 5(1.7) | 0.413 | 0.813 |
| | No | 100(33.7) | 98(33.0) | 99(33.3) | 297(98.3) | | |
| fractured instrument | Yes | 0(0.0) | 2(2.2) | 2(2.2) | 4(1.3) | 2.037 | 0.361 |
| | No | 101(33.9) | 98(32.9) | 99(33.2) | 298(98.7) | | |
| Perforation | Yes | 0(0.0) | 0(0.0) | 1(100) | 1(3.0) | 1.997 | 0.368 |
| | No | 101(33.6) | 100(33.2) | 100(33.2) | 301(99.7) | | |
| Type of restoration | Permanent | 80(79.2) | 64(64.0) | 66(65.3) | 210(69.5) | 13.042 | 0.042 |
| | Temporary | 8(7.9) | 11(11.0) | 19(18.8) | 38(12.6) | | |
| | Crown | 4(4.0) | 13(13.0) | 8(7.9) | 25(8.3) | | |
| | Post crown | 9(8.9) | 12(12.0) | 8(7.9) | 29(9.6) | | |
| Tooth type | anterior | 12(11.9) | 9(9.0) | 8(7.9) | 29(9.6) | 10.047 | 0.123 |
| | Canine | 3(3.0) | 4(4.0) | 9(8.9) | 16(5.3) | | |
| | Premolar | 33(32.7) | 40(40.0) | 47(46.5) | 120(39.7) | | |
| | Molar | 53(52.5) | 47(47.0) | 37(36.6) | 137(45.4) | | |

DISCUSSION

The study sample was collected from JUST DTC patients because DTC is the main center in the city of Irbid that provide highly specialized dental services with 113 dental clinics of various dental specialties which include specialists, graduate and undergraduate clinics. A total of 302 participants (146

males, 156 females) with an age range of 18-60 years old were included in this study. The sample was selected on the basis of systematic random method by selection of every case attended the clinics to decrease the bias in sample selection as much as possible. The gender distribution of study population was acceptable (48.3% males, 51.7% females) which is important for

the study to represent both males and females. Almost all patients lived in urban area (city of Irbid) and only 1.0% lived in rural area, this is because the DTC of JUST is located in the heart of the city which is considered representative since the majority (78.3%) of Jordan population live in urban areas according to the department of statistics of Jordan (Population and Housing Census 2004). Patients income was associated with the selection of treatment providers, where most of the patients treated by specialist had a high income ($p < 0.05$).

Consistently, epidemiological studies have shown that the high prevalence of postoperative disease after root canal treatment is related to the poor technical quality of root fillings. These studies found a higher than expected percentage of inadequate root fillings in the range of 49–87% (Tronstad *et al.*, 2000, Dugas *et al.*, 2003, Er *et al.*, 2006). However, many of these studies were conducted in general dental clinics or hospital settings. Conversely, an outcome study (Sjogren *et al.*, 1990) conducted in better controlled environments has shown that when root fillings are of a high technical standard, the presence of disease (preoperative periapical radiolucency) appears to have a minimal influence on the outcome of root canal treatment. Additionally, the survival rate of teeth treated by endodontic specialist was shown to be significantly better than those treated by general practitioners (Alley *et al.*, 2004). It has been demonstrated that highly skilled operators are less likely to perform procedural errors that may ultimately compromise the prognosis (Ingle *et al.*, 1994).

The current study analyzed the technical standard of root fillings in the term of obturation length, taperness, density, presence of voids, and presence of missed canals accomplished either by endodontic specialist, graduate or undergraduate student using radiographic records. The present study found significant difference between specialist, graduate and undergraduate students ($p < 0.05$) where the specialist had the highest quality of root filling while undergraduate students had the lowest quality. This result is consistent with previous studies that found that root canal treatments performed by specialists were significantly better than those treated by general practitioners (Ricucci *et al.*, 2000, Alley *et al.*, 2004, Friedman, 2008). This might be explained by the fact that highly skilled operators who are less likely to perform procedural errors (Ingle *et al.* 1994). The quality of root canal treatment examined after treatment by graduates might be overestimated since most of these treatments were performed under faculty supervision. It is expected that the quality of root canal treatment performed by other graduates of dentistry programs working alone, might be lower.

Alley *et al.*, (2004) reported that endodontic specialists predominantly treat posterior teeth. This was

consistent with the findings of this study where molars account for 52.5% of teeth treated by specialist and 47% and 45% of teeth treated by graduate and undergraduate students respectively, were molars.

Relation of the root canal filling material to the radiographic apex has consistently been shown to significantly affect the outcome of conventional root canal treatment. The study conducted by Sjogren *et al.*, (1990) found that in the presence of apical periodontitis, roots filled close (0–2 mm) to the apex were associated with healing in 94% of cases, but those that were filled short and those that were overfilled had healing rates of 68% and 76%, respectively. Most studies have considered apical termination within 2 mm of the radiographic apex to be the gold standard, whereas others have adopted a standard of 3 mm (Kirkevang *et al.*, 2000, Segura-Egea *et al.*, 2004). The accuracy of measurement is deficient if non-standardized radiographs was used leading to inaccuracy due to distortion or angulations. Furthermore, the apical foramen may not be at the radiographic apex. These limitations apply to all similar studies where standardization is impractical. The analysis of all relevant radiographs allowed the examiners to score the radiograph that they thought to be most accurate with minimal parallax error. In the present study, 89% of root filled teeth by endodontic specialist was 0-2 mm from radiographic apex, while about 62% and 47% of root filled teeth by graduate and undergraduate students, respectively were obturated at 0-2 mm from radiographic apex ($p < 0.05$).

There is conflicting evidence regarding the impact of root filling density on prognosis. Studies have shown that teeth with homogenous root fillings will result in more consistent healing (Kerekes and Tronstad 1979) and survival (Stoll *et al.*, 2005). Some authors revealed no difference in the prognosis of root canal treatment (Sjogren *et al.*, 1990), whereas others found non-homogenous and inadequately compacted root fillings to have a significantly increased prevalence of apical periodontitis (Kirkevang *et al.*, 2000, Dugas *et al.*, 2003, Segura-Egea *et al.*, 2004). Our findings revealed adequate obturation density 96% for root canal treatment performed by endodontic specialist, while 63% and 50% of adequate obturation density for root canal treatment performed by graduate and undergraduate students, respectively ($p < 0.05$). Studies that have investigated density have also analyzed the lateral adaptation of the root canal filling, with void detection in the lateral aspect of the root filling considered to be inadequate (Kirkevang and Horsted-Bindslev 2002). In this study, voids in the root filling were rarely found in teeth treated by endodontic specialists (4%), while it was about (37%) in teeth treated by graduate students and about (50%) in teeth treated by undergraduate students ($p < 0.05$).

The European Society of Endodontology (2006) has suggested that the root canal filling should be tapered from crown to apex. This criterion has not been widely analyzed in the literature (Barrieshi-Nusair *et al.*, 2004, Er *et al.*, 2006). This study found that about 95% of root filled teeth had adequate taperness performed by endodontic specialists, while about 64% of root filled teeth had adequate taperness performed by either graduate or undergraduate students ($p < 0.05$).

CONCLUSION

It has been found also that endodontic specialist provide endodontic treatment more professionally than graduate or undergraduate students, where root canal fillings had the best length, density and taperness when treated by specialists compared to those treated by undergraduate students.

REFERENCES

- Alley, B. S., Kitchens, G. G., Alley, L. W., & Eleazer, P. D. (2004). A comparison of survival of teeth following endodontic treatment performed by general dentists or by specialists. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology*, 98, 115-118.
- Barrieshi-Nusair, K. M., Al-Omari, M. A., & Al-Hiyasat, A. S. (2004). Radiographic technical quality of root canal treatment performed by dental students at the dental teaching center in Jordan. *Journal of Dentistry*, 32, 301-307.
- Boltacz-Rzepakowska, E., & Pawlicka, H. (2003). Radiographic features and outcome of root canal treatment carried out in the łódź region of Poland. *International Endodontic Journal*, 36, 27-32.
- Buckley, M., & Spangberg, L. (1995). The prevalence and technical quality of endodontic treatment in an American subpopulation. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology*, 79, 92-100.
- Chueh, L. H., Chen, S. C., Lee, C. M., Hsu, Y. Y., Pai, S. F., Kuo, M. L., ... & Hsiao, C. K. (2003). Technical quality of root canal treatment in Taiwan. *International Endodontic Journal*, 36(6), 416-422.
- Dugas, N., Herenia, P., Lawrence, P., Teplitsky., & Shimon, F. (2002). Quality of life and satisfaction outcomes of endodontic treatment. *Journal of Endodontics*, 28, 819-827.
- Er, O., Sagsen, B., Maden, M., Cinar, S., & Kahraman, Y. (2006). Radiographic technical quality of root fillings performed by dental students in Turkey. *International Endodontic Journal*, 39, 867-872.
- European Society of Endodontology. (1994). Consensus report of the european society of endodontology on quality guidelines for endodontic treatment. *International Endodontic Journal*, 27, 115-24.
- Friedman, S. (2008). Expected outcome in the prevention and treatment of apical periodontitis. In: *Essential Endodontology*. Örstavik, D., Pitt, Ford, T. (editors). 2nd ed. oxford, UK: blackwellmunksgaard ltd;. p 408-469.
- Helminen, Se., Vehkalahti, M., Kerosuo, E., & Murtomaa, H. (2000). Quality evaluation of process of root canal treatments performed on young adults in finnish public oral health service. *Journal of Dentistry*, 28, 227-32.
- Ingle, J., Beveridge, E., Glick, D., & Weichman, J. (1994). Modern endodontic therapy. In: Ingle J, Bakland L eds. *Endodontics*. Baltimore: *Williams and Wilkins*, pp. 27-53.
- Kerekes, K., & Tronstad, L. (1979). Long-term results of endodontic treatment performed with a standardized technique. *Journal of Endodontics*, 5, 83-90.
- Kirkevang, L. L., Hørsted-Bindslev, P. (2002). Technical aspects of treatment in relation to treatment outcome. *Endodontic Topics*, 2, 89-102.
- Kirkevang, L. L., Örstavik, D., Hørsted-Bindslev, P., & Wenzel, A. (2000). Periapical status and quality of root fillings and coronal restorations in a Danish population. *International Endodontic Journal*, 33, 509-15.
- Lin, L. M., Skribner, J. E., & Gaengler, P. (1992). Factors associated with endodontic treatment failures. *Journal of Endodontics*, 18, 625-7.
- Lopes, H. P., & Siqueira, J. F. J. R. (1999). *Endodontia: Biologia E Técnica*. Rio De Janeiro: Medsi.
- Nair, P. N. R., Sjögren, U., Krey, G., & Sundqvist, G. (1990). Therapy resistant foreign body giant cell granuloma at the periapex of a root-filled human tooth. *Journal of Endodontics*, 16, 589-95.
- Nair, P. N. R., Sjögren, U., Figdor, D., & Sundqvist, G. (1999). Persistent periapical radiolucencies of root filled human teeth, failed endodontic treatments and periapical scars. *Oral Surgery, Oral Medicine and Oral Pathology*, 87, 617-27.
- Nair, P. N. R., Sjögren, U., Schumacher, E., & Sundqvist, G. (1993). Radicular cyst affecting a root-filled human tooth: a long-term post-treatment follow-up. *International Endodontic Journal*, 26, 225-33.
- Peak, J. D., Hayes, S. J., Bryant, S. T., & Dummer, P. M. (2001). The outcome of root canal treatment. a retrospective study within the armed forces (royal air force). *British Dental Journal*, 190, 140-4.
- Ricucci, D., Gröndahl, K., & Bergenholtz, G. (2000). Periapical status of root filled teeth exposed to the oral environment by loss of restoration or caries. *Oral Surgery, Oral Medicine, Oral Pathology, Endodontics*, 90, 354-359.
- Saunders, W. P., Saunders, E. M., Sadiq, J., & Cruickshank, E. (1997). Technical standard of root

- canal treatment in an adult scottish sub-population. *British Dental Journal*, 182, 382–6.
- Segura-Egea, J. J., Jimenez-Pinzo N, A., Poyato-Ferrera, M., Velasco- Ortega, E., & Ri'Os-Santo, J. V. (2004). Periapical status and quality of root fillings and coronal restorations in an adult Spanish population. *International Endodontic Journal*, 37, 525–30.
 - SjöGren, U., HäGglund, B., Sundqvist, G., & Wing, K. (1990). Factors affecting the long-term results of endodontic treatment. *Journal of Endodontics*, 16, 498–504.
 - Sjögren, U. (1996). Success and failure in endodontics. odontological dissertations. Umea, Sweden: Umea University.
 - Sundqvist, G., & Figdor, D. (1998). Endodontic treatment of apical periodontitis. in: orstavik d, pitt ford t. *Essential Endodontology*. oxford, uk: blackwell science ltd, 242–77.
 - Tronstad, L., Asbjørnsen, K., Døving, L., Pedersen, I., & Eriksen, H. M. (2000). Influence of coronal restorations on the periapical health of endodontically treated teeth. *Dental Traumatology*, 16(5), 218-221.