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Periapical Tissue Status of Endodontically Treated Teeth Restored with Fixed Coronal Restoration: A Cone-beam Computed Tomographic Study

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Abstract

Objective: The aim of this study was to use cone beam computed tomography scans from a database to assess the prevalence of periapical radiolucency found in root canal treated teeth. Additionally, to evaluate the quality of coronal restoration and root canal treatment, as well as their impact on the periapical tissue.

Material and Method: 301 root canal treated teeth were randomly selected and examined from 143 cone beam computed tomographic scans, and the teeth were categorized as healthy or diseased based on the periapical status. Other variables such as tooth type, endodontic treatment quality, presence of fixed coronal restorations and posts, type and quality of coronal restorations were investigated for their relationship with periapical status. The chi-square test was a statistical method for analyzing the relationship between sets of data.

Results: The overall prevalence of periapical radiolucency was (64.1%), whereas the maxillary molars and mandibular molars were more affected than other teeth types (75.7%), (65.9%), respectively. The length and homogeneity of the root canal filling were significantly associated with periapical status. While the teeth had both inadequate root canal treatment and coronal restoration be revealed with diseased periapical status were (91.8%).

Conclusion: This study shows that the prevalence of periapical radiolucency was relatively high. Molar teeth were most likely to be associated with periapical radiolucency. Poor homogeneity of root canal filing was the most frequent type of technical error associated with periapical radiolucency. Moreover, the results showed that inadequate root canal filling and coronal restoration were associated with an increased incidence of periapical radiolucency.

Keywords: *Periapical Radiolucency; Cone-Beam Computed Tomography; Root Canal Treated Teeth; Fixed Coronal Restoration; Adequate Coronal Restoration*

Introduction

In the past, endodontic treatment effectiveness was dependent on complete debridement, disinfection, and root canal filling (RCF), all of which were equally important. Endodontic therapy has recently been expanded to encompass wider concepts. These include a diagnostic and treatment strategy, as well as an understanding of anatomy and morphology [1]. Endodontic treatment aims to seal the apical

and coronal areas perfectly to avoid bacterial leakage [2]. However, the presence of apical periodontitis at the apex of the tooth is generally indicative of a root canal treatment failure [3,4]. This might occur as a result of incorrect root canal treatment, insufficient cleaning or faulty root canal system closure. Treatment failure has also been linked to coronal leakage. As a result, avoiding coronal leakage and maintaining an adequate seal is critical for successful endodontic treatment. Root canal treatment (RCT) is diagnosed using a combination of clinical symptoms and radiographic examination. Healing is indicated by the lack of clinical symptoms and a radiograph with an intact periodontal ligament space in the apical area, whereas the presence of apical periodontitis indicates that the disease is still active. The majority of cross-sectional studies formulated to study periapical status (PS) in root canal treated teeth (RCTT) and coronal seal correlation have been done using 2-dimensional periapical radiographs or panoramic radiographs (2D). Recent investigations, however, have demonstrated the limitations of 2D radiography, particularly in terms of determining treatment quality and detecting periapical radiolucency (PR). Because of its great sensitivity for detecting bone changes, cone-beam computed tomographic (CBCT) scanning has the potential to overcome most of the limitations of 2D radiographs [5]. A recent clinical study demonstrates 14 times rise in the periapical radiolucency rate when teeth were evaluated with CBCT scanning when compared with periapical radiographs [6]. Many studies have approved the importance of coronal leakage as a possible reason for root canal treatment failure. Malone and Donelly considered coronal restoration (CR) as it prevents canals recontamination and is assumed to be the first protective barrier for the periapical tissues after RCT [7]. Torabinejad., *et al*. agreed with the results of Swanson and Madison 1978 that root canal treatment failure can be due to the delayed final restoration placement or when the temporary filling fell partially or completely [8,9]. In 1995, research was published that concluded that the CR's adequacy is more significant than the RCF's quality [10]. They also discovered that periapical pathosis was linked to the quality of CR rather than the RCF. Similar findings were obtained by Kirkevang., *et al* [11].

On the other hand, several studies have shown that appropriate RCT is the most significant factor in preventing periapical tissue pathosis (despite the importance of CR) [12]. Furthermore, Ricucci and Bergenholtz [13] found that saliva exposure of RCF (teeth without coronal restoration) was not always linked with apical pathosis in situations where endodontic treatment was appropriate. According to one study, if a good RCT and CR are present, a greater success rate is authorized. When compared to competent endodontic therapy and ineffective CR, the latter had a much lower success rate [14]. In Poorva Khullar., *et al*. [15], both well-performed RCT and well-sealing CR are essential for the overall success of endodontic treatment. In Atakan Kalender., *et al*. [16], they found the same results in the Turkish population as they stated that a high prevalence of periapical pathology with or without endodontic treatment and poor technical standard of both root fillings and coronal restorations of root canal treated teeth.

Aim of the Study

This study aimed to investigate the periapical status in root canal treated teeth using CBCT scanning in patients attending the Collage of Dentistry at Qassim University. To determine the type of coronal restoration and the presence of fixed coronal restoration (FCR). And assess the quality of coronal restoration and root canal treatment and their effects on periapical tissue.

Material and Method

A prospective cross-sectional study based on CBCT scans. That was accepted by the ethical committee of a college of dentistry - Qassim University reference number: (ST/6084/2021). The CBCT scans were taken during the years from 2018 to 2020. The study comprised a random sample of 235 patients who were referred to the oral and maxillofacial radiology department for 3-dimensional CBCT scanning as part of their dental examination, diagnosis, and treatment planning but not for the aim of this study. The CBCT scans were taken with a GALILEOS SIRONA CBCT (Sirona Dental Systems GmbH, Bensheim, Germany) by following the manufacturer's instructions, utilizing a voltage of 98 kV, a tube current of 6 mA. Two examiners with a 3 years of experience reviewed the CBCT scans. In a low-light environment, all scans were reviewed using the (GALILEOS Viewer 1.9) software while standing 40-50 cm away from a 32-inch Dell LCD screen with a resolution of 1280-1024 pixels. All scans were examined in cross-sections, axial, coronal, and sagittal view. All root canal treated teeth

in adult healthy individuals were included in the study, while patients under the age of 18 and those undergoing orthodontic treatment were excluded. Third molars, nonrestorable root fragments, impacted teeth, and deciduous or permanent teeth with immature apices are also not excluded. In Multirooted teeth are ranked according to the root with the worst evaluation. Each tooth was assessed according to the following parameters:

- Presence/absence of periapical radiolucency according to CBCT periapical index score (PAI) proposed by Estrela., *et al*. (2008b) [17] showed in table 1. The variables E and D are added to each score if either of these conditions is detected in the CBCT analysis.
- Quality of root canal treatment through: (Length, Homogeneity, Complication/ Failure) according to index done by Venskutonis., *et al*. [18] as showed in table 1.
- The presence or absence of fixed coronal restoration was determined.
- Determine the type of coronal restoration and its quality [18] (Table 1).
- Presence of post or not.

Periapical Index Score	0 Periapical bone structures that are still intact
	1 0.5-1 mm periapical radiolucency diameter
	2 1-2 mm periapical radiolucency diameter
	3 2-4 mm periapical radiolucency diameter
	4 4-8mm periapical radiolucency diameter
	5 >8 mm periapical radiolucency diameter
	E periapical cortical bone expansion
	D periapical cortical bone destruction
Quality of root canal treatment	
L (length of the root canal filling)	L1 0-2 mm from radiographic apex
	L2 >2 mm from radiographic apex
	L3 Overfilling (extrusion of material through the apex)
	L4 Filling material visible only in pulp chamber
	L5 Filled canal of a surgically treated root
H (homogeneity of the root canal fillings)	H1 Complete obturation (homogenous appearance of the root canal filling)
	H2 Incomplete obturation (voids and porous appearance of the root canal filling)
CF (complications/failures)	CF0 No complications
	CF1 Perforation of root
	CF2 Not treated/missed root canal
	CF3 Resorption of root
	CF4 Fracture root/tooth
	CF5 Endodontically treated root with radiolucency
Coronal Restoration	
Type of coronal restoration	Temporary filling
	Amalgam filling
	Composite filling
	Crown
	Bridge abutment
Quality of coronal restoration	Good Restoration: Any permanent restoration that appeared intact radiographically.
	Poor restoration: Any permanent restoration with radiographic signs of overhangs, recurrent decay, fracture, open margins or short margin.

Table 1: *Evaluation criteria.*

In order to determine the individual assessment's reliability. After both observers assessed the periapical status, quality of a root canal treatment, presence of fixed coronal restoration, and quality of coronal restoration, the inter-reliability tests were conducted using Cohen's kappa test. If the kappa coefficient of the agreement was equal to or greater than 0.61, the observers were judged reliable for inter-reliability testing. The information was input into a Microsoft Excel sheet on the computer. The data was statistically analyzed using the SPSS Window Version 21 Package application [Chicago, IL, USA]. Data distribution was study by means of frequencies and percentages, and the chi-square test used to describe the characteristics of the study population. And to determine association between the primary variable, which was the prevalence of periapical lesions, whereas the predictive variables were the teeth type, quality of root canal treatment, the presence/absence of a fixed coronal restoration, type and quality of coronal restoration. The significance level for the analysis was set at $p \leq 0.05$.

Results

Inter-observer agreement was determined and the observers were well-calibrated, all values exceeded (0.61) for the PS (0.70), quality of RCT (0.82), presence of FCR (0.91), and type of CR (0.93).

A total of 235 CBCT scans were obtained to evaluated in this study, of which 143 CBCT scans had RCT. Third molars, nonrestorable root fragments, impacted teeth, deciduous or permanent teeth with immature apices were excluded of which (n = 301) root canal treated teeth. The study included 136 (45.2%) female and 165 (54.8%) male individual scans. The distribution of RCTT according to the teeth type consist of maxillary teeth 178 (59.1%) and mandibular teeth 123 (40.9%). The maxillary incisors were 34 (11.3%), maxillary canines 17 (5.6%), maxillary premolars 57 (18.9%) and maxillary molars 70 (23.3%). While the mandibular incisors 2 (0.7%), mandibular canines (0), mandibular premolars 42 (14%) and mandibular molar 79 (26.2%).

According to the PAI scoring system, (35.9%) (n = 108) teeth were healthy and the prevalence of periapical periodontitis was (64.1%) (n = 193). The periapical status of RCTT was classified in relation to teeth type as shows in table 2. For the periapical status (bone expansion and bone destruction) of periapical cortical bone 7 (2.3%) had a bone expansion and 294 (97.7%) with healthy bone also, and only (0.3%) had bone destruction, and 300 (99.7%) free and healthy bone.

Tooth Type		Periapical status						
		0	1	2	3	4	5	Total
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Maxilla	Incisor	13 (38.2)	6 (17.6)	5 (14.7)	6 (17.6)	4 (11.8)	0	34 (100)
	Canine	9 (52.9)	2 (11.8)	1 (5.9)	4 (23.5)	1 (5.9)	0	17 (100)
	Premolar	17 (29.8)	10 (17.5)	10 (17.5)	17 (29.8)	2 (3.5)	1 (1.8)	57 (100)
	Molar	17 (24.3)	14 (20)	10 (14.3)	18 (25.7)	11 (15.7)	0	70 (100)
	Total	56 (18.5)	32 (10.7)	26 (8.6)	45 (14.9)	18 (6)	1 (0.3)	178 (59.1)
Mandible	Incisor	2 (100)	0	0	0	0	0	2 (100)
	Premolar	23 (54.8)	10 (23.8)	5 (11.9)	2 (4.8)	2 (4.8)	0	42 (100)
	Molar	27 (34.2)	13 (16.5)	9 (11.4)	17 (21.5)	13 (16.5)	0	79 (100)
	Total	52 (17.3)	23 (7.6)	14 (4.7)	19 (6.3)	15 (5)	0	123 (40.9)

Table 2: *Periapical status prevalence in root canal treated teeth in relation to teeth type.*

The present study revealed there was a statistically significant relationship between the PS of RCTT in relation to the quality of the root canal treatment: Length, Homogeneity, Complication/Failure which was (p = 0.000) for all variables (Table 3) details the relationships. Furthermore, there was a statistically significant association between the periapical status of root canal treated teeth and the type of coronal restoration and the quality of the coronal restoration, with (p = 0.037), (p = 0.000), respectively. However, no statistically significant association was found between the periapical status of RCTT and the presence or absence of fixed coronal restorations (p = 0.089) (Table 4). Also, the presence of the post was (p = 0.183), only 16 (14.8%) of the RCTT had a post and health periapical status while

18 (9.3%) diseased periapical status with the post. 92 (85.2%). For the cases that had health periapical status without post 92 (85.2%) and the majority of the diseased periapical status cases without post 175 (90.7%). Table 5 shows the relationship between the periapical status of RCTT as related to combined quality of the CR and the quality of RCT regarding length and homogeneity. There was a statistically significant difference between these two groups (p = 0.000).

Quality of RCT	Periapical status of root canal treated teeth							
	PA0 (n = 108)	PA1 (n = 55)	PA2 (n = 40)	PA3 (n = 64)	PA4 (n = 33)	PA5 (n = 1)	Total	X^2 (p)
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
Length								61.700
L1	92 (30.6)	39 (13)	19 (6.3)	26 (8.6)	17 (5.6)	0	193 (64.1)	
L2	11 (3.7)	15 (5)	19 (6.3)	36 (12)	16 (5.3)	1 (0.3)	98 (32.6)	p = 0.000
L3	2 (0.7)	1 (0.3)	0	1 (0.3)	0	0	4 (1.3)	
L4	3 (1)	0	1 (0.3)	1 (0.3)	0	0	5 (1.7)	
L5	0	0	1 (0.3)	0	0	0	1 (0.3)	
Homogeneity								46.789
H1	92 (30.6)	29 (9.6)	19 (6.3)	28 (9.3)	13 (4.3)	0	181 (60.1)	
H2	16 (5.3)	26 (8.6)	21 (7)	36 (12)	20 (6.6)	1 (0.3)	120 (39.9)	p = 0.000
Complication/ Failure								638.252
CF0	105 (34.9)	0	0	0	0	0	105 (34.9)	
CF1	0	1 (0.3)	0	1 (0.3)	0	0	2 (0.6)	p = 0.000
CF2	3 (1)	4 (1.3)	3 (1)	5 (1.7)	11 (3.7)	0	26 (8.7)	
CF3	0	0	0	2 (0.7)	3 (1)	0	5 (1.7)	
CF4	0	0	0	0	0	0	0	
CF5	0	55 (18.3)	40 (13.3)	64 (21.3)	33 (11)	1 (0.3)	193 (64.2)	

Table 3: *Periapical status of root canal treated teeth as related to quality of the root canal treatment [Length - Homogeneity- Complication/ Failure] (n = 301).*

Present of fixed coronal restoration	Periapical status of root canal treated teeth							
	PA0 (n = 108)	PA1 (n = 55)	PA2 (n = 40)	PA3 (n = 64)	PA4 (n = 33)	PA5 (n = 1)	Total	X^2 (P)
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
Present	47 (15.6)	14 (4.7)	10 (3.3)	22 (7.3)	8 (2.7)	0	101 (33.6)	9.548
Absent	61 (20.3)	41 (13.6)	30 (10)	42 (14)	25 (8.3)	1 (0.3)	200 (66.4)	p = 0.089
Type of coronal restoration								
Temporary filling	1 (0.3)	3 (1)	2 (0.7)	3 (1)	3 (1)	0	12 (4)	
Amalgam filling	10 (3.3)	5 (1.7)	5 (1.7)	7 (2.3)	10 (3.3)	0	37 (12.3)	32.527
Composite filling	50 (16.6)	33 (11)	23 (7.6)	32 (10.6)	12 (4)	1 (0.7)	151 (50.2)	p = 0.037
Crown	30 (10)	11 (3.7)	8 (2.7)	17 (5.6)	2 (0.7)	0	68 (22.6)	
Bridge abutment	17 (5.6)	3 (1)	2 (0.7)	5 (1.7)	6 (2)	0	33 (11)	
Quality of the coronal restoration								
Good	88 (29.2)	12 (4)	15 (5)	24 (8)	14 (4.7)	0	153 (50.8)	68.480
Poor	20 (6.6)	43 (14.3)	25 (8.3)	40 (13.3)	19 (6.3)	1 (0.3)	148 (49.2)	p = 0.000

Table 4: *Periapical status of root canal treated teeth as related to present fixed coronal restoration (FCR), type and quality of the coronal restoration (CR) (n = 301).*

Quality of the coronal restoration combined with quality of the root canal treatment	Periapical status			
	Healthy	Diseased	Total	X^2 (p)
	n (%)	n (%)	n (%)	
Adequate RCT/Adequate CR	73 (70.2)	31 (29.8)	104 (100)	89.971 p = 0.000
Adequate RCT/Inadequate CR	12 (23.1)	40 (76.9)	47 (100)	
Inadequate RCT/Adequate CR	15 (31.9)	32 (68.1)	47 (100)	
Inadequate RCT/Inadequate CR	8 (8.2)	90 (91.8)	98 (100)	
Total	108 (35.9)	193 (64.1)	301 (100)	

Table 5: *Periapical status of root canal treated teeth as related to quality of the coronal restoration (CR) combined with quality of the root canal treatment (RCT) determined by the length and homogeneity of the root canal filling (n = 301).*

Discussion

The total frequency of periapical radiolucency in RCTT was (64.1%), which is greater than the reported prevalence of periapical, panoramic or CBCT scans in numerous previous studies [5,19-27].

The maxilla (40.5%) was more often impacted than the mandible (23.6%), while maxillary and mandibular molars (75.7%) and 65.9%, respectively, were more affected than other tooth types (Table 1). This was in agreement with Paes da Silva Ramos Fernandes., *et al*. [23], Van der Veken D., *et al*. [25] and Bürklein S., *et al*. [26] studies. The anatomical complexity and shape of molar teeth, accessory canals, and the existence of isthmuses and curvatures may all contribute to the increased frequency of periapical radiolucency [28,29]. The length and uniformity of the root canal filling were shown to be strongly related to periapical status in the current research as showed in figure 1.

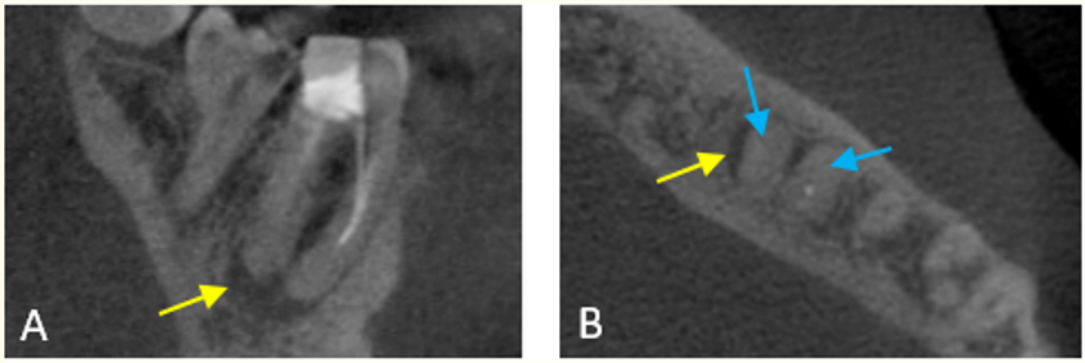

Figure 1: *Cone beam computed topography tooth #46. (A) Sagittal plane shows a radiolucency related to tooth #46 (yellow arrow). (B) axial view demonstrate root canal filling does not reach to apical area in mesiobuccal root and distal root (blue arrow).*

For all factors, teeth with root canal fillings positioned 0 - 2 mm from the root apex and a good homogeneous appearance of the RCF were evaluated free of periapical radiolucency in (30.6%) of cases, whereas teeth with short fillings exhibited periapical radiolucency in (28.9%) of cases. Furthermore, (34.9%) of teeth without complications or failure had no PR, but (7.7%) of teeth with missing canals had

PR. These findings are consistent with those of numerous previous researchs [21,30-35] that have demonstrated the benefits of conducting endodontic treatment closer to the apical foramen, which could be explained by the cleaning and shaping procedures in the entire length of the root canals ensuring adequate disinfection procedures within the entire root canal system.

When compared to all other technical mistakes, periapical radiolucency in root canal treated teeth with voids and porous appearance of the root canal filling was the most common (34.6%) and was associated with an elevated risk of PR. This is consistent with earlier research, which found that poor homogeneity was prevalent in (46.2%) [36,37]. Voids along the RCF might offer a route for bacterial proliferation to the tooth's apex [38-40]. This study's findings highlight the significance of adopting precautions during root canal obturation to achieve a high density of root canal filling.

Coronal restoration works as a barrier to reinfection of the root canal system after root canal treatment. Clinical examination and intraoral radiographs are better methods to evaluate the marginal quality of coronal restorations [41]. However, the study found some interesting data with restored teeth were evaluated with a failure rate of cases that absent of fixed coronal restoration was (46.1%). This high failure rate shows that the importance of FCR should be considered as a step to be taken after endodontic treatment [42]. A high prevalence of PR was found in teeth restored with single unit crown (12.6%) showed in table 4 and figure 2. This is in agreement with previous studies [24,27]. While the composite fillings were associated with a large prevalence of periapical radiolucency (33.6%) when compared to full crown or bridge, a fact that might be related to the polymerization shrinkage property of composite material. The dentists may need intensive training about the best techniques for placing the composite filling in the cavity and light-curing techniques [43-45]. Ray and Trope [10] and Kirkevang., *et al*. [11] found that the quality of the coronal restoration was more important for periapical health than the quality of the root canal filling. However, Tronstad., *et al*. (2000) [12], Segura-Egea., *et al*. (2004) [32] and Siqueira., *et al*. (2005) [19] found that the quality of the coronal restoration was significantly less important than the quality of the root canal filling. Hommez., *et al*. [46] found both quality of root filling and coronal restoration to be equally important. This study discovered a statistically significant difference between periapical statue and coronal restoration quality paired with root canal treatment quality (Table 5). The frequency of healthy periapical status was (70.2%) in RCTT with appropriate RCT and acceptable CR. While root canal treated teeth with insufficient RCT or CR revealed a diseased periapical state in (68.1%) and (76.9%) of cases, respectively (Table 5). Furthermore, (91.8%) of the teeth had both insufficient RCT and CR, as well as diseased periapical status. This is supported with studies that focused on the importance of good quality for both RCT and CR to increase the success and survival rate with root canal treated teeth [40,46].

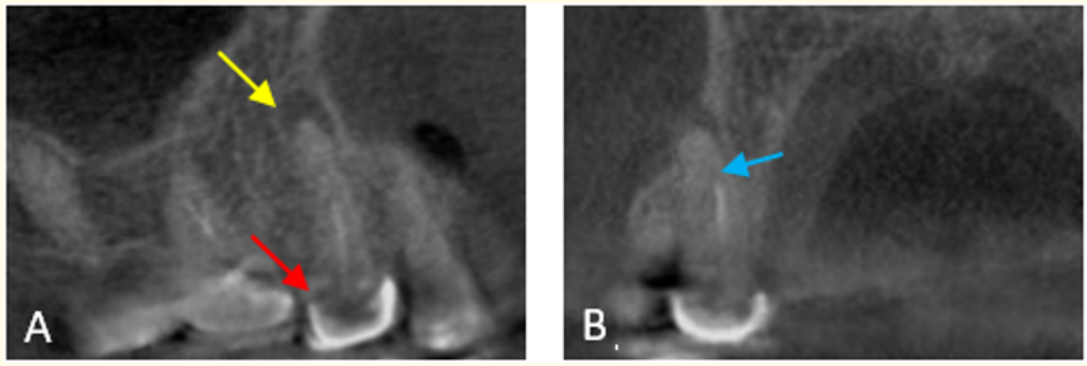

Figure 2: *Cone beam computed topography tooth #15. (A) Sagittal view, (B) Coronal view both showed tooth #15 with periapical radiolucency (yellow arrow). The tooth has short root canal filling (blue arrow), also open gap was noticed in the crown (red arrow).*

Conclusion

In conclusion, findings from this present study shows that the prevalence of periapical radiolucency was relatively high in (64.1%) of RCTT. Molar teeth were most likely to be associated with PR. Poor homogeneity of RCF was the most frequent type of technical error associated with PR. RCTT restored with the composite filling was associated with a significantly greater prevalence of PR. Moreover, the results showed that inadequate RCF and CR were associated with an increased incidence of PR. Therefore, emphasis on the quality of work and continuing education in the field of Endodontology and Prosthodontics must be provided for dentists.

Bibliography

1. Hargreaves Kenneth M. "Cohen's pathways of the pulp. Elsevier (2016).
2. Ng Y-L., *et al*. "Outcome of primary root canal treatment: systematic review of the literature–Part 2. Influence of clinical factors". *International Endodontic Journal* 41.1 (2008): 6-31.
3. Gencoglu Nimet., *et al*. "Periapical status and quality of root fillings and coronal restorations in an adult Turkish subpopulation". *European Journal of Dentistry* 4.01 (2010): 017-022.
4. Lupi-Pegurier L., *et al*. "Periapical status, prevalence and quality of endodontic treatment in an adult French population". *International Endodontic Journal* 35.8 (2002): 690-697.
5. Gomes Aline C., *et al*. "Influence of endodontic treatment and coronal restoration on status of periapical tissues: a cone-beam computed tomographic study". *Journal of Endodontics* 41.10 (2015): 1614-1618.
6. Tsai Patrick., *et al*. "Accuracy of cone-beam computed tomography and periapical radiography in detecting small periapical lesions". *Journal of Endodontics* 38.7 (2012): 965-970.
7. Malone III., *et al*. "An in vitro evaluation of coronal microleakage in obturated root canals without coronal restorations". *Journal of Endodontics* 23.1 (1997): 35-38.
8. Torabinejad Mahmoud., *et al*. "*In vitro* bacterial penetration of coronally unsealed endodontically treated teeth". *Journal of Endodontics* 16.12 (1990): 566-569.
9. Swanson Kimberly and Sandra Madison. "An evaluation of coronal microleakage in endodontically treated teeth. Part I. Time periods". *Journal of Endodontics* 13.2 (1987): 56-59.
10. Ray HA and M Trope. "Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration". *International Endodontic Journal* 28.1 (1995): 12-18.
11. Kirkevang L-L., *et al*. "Periapical status and quality of root fillings and coronal restorations in a Danish population". *International Endodontic Journal* 33.6 (2000): 509-515.
12. Tronstad L., *et al*. "Influence of coronal restorations on the periapical health of endodontically treated teeth". *Dental Traumatology* 16.5 (2000): 218-221.
13. Ricucci D and G Bergenholtz. "Bacterial status in root-filled teeth exposed to the oral environment by loss of restoration and fracture or caries–a histobacteriological study of treated cases". *International Endodontic Journal* 36.11 (2003): 787-802.
14. Ingle John I., *et al*. "Ingle's endodontics 6th edition". United States of America: BC Decker (2008): 342-345.

15. Khullar Poorva., *et al*. "A survey report on effect of root canal fillings and coronal restorations on the periapical status of endodontically treated teeth in a selected group of population". *International Journal of Clinical Pediatric Dentistry* 6.2 (2013): 89.

16. Kalender Atakan., *et al*. "Influence of the quality of endodontic treatment and coronal restorations on the prevalence of apical periodontitis in a Turkish Cypriot population". *Medical Principles and Practice* 22.2 (2013): 173-177.

17. Estrela Carlos., *et al*. "A new periapical index based on cone beam computed tomography". *Journal of Endodontics* 34.11 (2008): 1325-1331.

18. Venskutonis Tadas., *et al*. "Periapical and endodontic status scale based on periapical bone lesions and endodontic treatment quality evaluation using cone-beam computed tomography". *Journal of Endodontics* 41.2 (2015): 190-196.

19. Siqueira Jr José F., *et al*. "Periradicular status related to the quality of coronal restorations and root canal fillings in a Brazilian population". *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* 100.3 (2005): 369-374.

20. Gulsahi K., *et al*. "Frequency of root-filled teeth and prevalence of apical periodontitis in an adult Turkish population". *International Endodontic Journal* 41.1 (2008): 78-85.

21. Tavares Paula BL., *et al*. "Prevalence of apical periodontitis in root canal–treated teeth from an urban French population: influence of the quality of root canal fillings and coronal restorations". *Journal of Endodontics* 35.6 (2009): 810-813.

22. Al-Omari Mohammad A., *et al*. "Frequency and distribution of root filled teeth and apical periodontitis in a Jordanian subpopulation". *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* 111.1 (2011): e59-e65.

23. Paes da Silva Ramos Fernandes LM., *et al*. "Prevalence of apical periodontitis detected in cone beam CT images of a Brazilian subpopulation". *Dentomaxillofacial Radiology* 42.1 (2013): 80179163-80179163.

24. Dutta A., *et al*. "Prevalence of periradicular periodontitis in a S cottish subpopulation found on CBCT images". *International Endodontic Journal* 47.9 (2014): 854-863.

25. Van der Veken D., *et al*. "Prevalence of apical periodontitis and root filled teeth in a Belgian subpopulation found on CBCT images". *International Endodontic Journal* 50.4 (2017): 317-329.

26. Bürklein Sebastian., *et al*. "Quality of root canal fillings and prevalence of apical radiolucencies in a German population: a CBCT analysis". *Clinical Oral Investigations* 24.3 (2020): 1217-1227.

27. Meirinhos J., *et al*. "Prevalence of apical periodontitis and its association with previous root canal treatment, root canal filling length and type of coronal restoration–a cross-sectional study". *International Endodontic Journal* 53.4 (2020): 573-584.

28. De Pablo Óliver Valencia., *et al*. "Root anatomy and canal configuration of the permanent mandibular first molar: a systematic review". *Journal of Endodontics* 36.12 (2010): 1919-1931.

29. Silva Emmanuel João Nogueira Leal., *et al*. "Evaluation of root canal configuration of mandibular molars in a Brazilian population by using cone-beam computed tomography: an *In vivo* study". *Journal of Endodontics* 39.7 (2013): 849-852.

30. De Souza Filho., *et al*. "Influence of the enlargement of the apical foramen in periapical repair of contaminated teeth of dog". *Oral Surgery, Oral Medicine, Oral Pathology* 64.4 (1987): 480-484.

31. Buckley Michael and Larz SW Spangberg. "The prevalence and technical quality of endodontic treatment in an American subpopulation". *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* 79.1 (1995): 92-100.

32. Segura-Egea JJ., *et al*. "Periapical status and quality of root fillings and coronal restorations in an adult Spanish population". *International Endodontic Journal* 37.8 (2004): 525-530.

33. Sunay H., *et al*. "Cross-sectional evaluation of the periapical status and quality of root canal treatment in a selected population of urban Turkish adults". *International Endodontic Journal* 40.2 (2007): 139-145.

34. Georgopoulou Maria K., *et al*. "Periapical status and quality of root canal fillings and coronal restorations in a Greek population". *Quintessence International* 39.2 (2008): 85-92.

35. Da Silva Katherine., *et al*. "Cross-sectional study of endodontic treatment in an Australian population". *Australian Endodontic Journal* 35.3 (2009): 140-146.

36. Ng Y-L., *et al*. "A prospective study of the factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health". *International Endodontic Journal* 44.7 (2011): 583-609.

37. Nascimento Eduarda Helena Leandro., *et al*. "Prevalence of technical errors and periapical lesions in a sample of endodontically treated teeth: a CBCT analysis". *Clinical Oral Investigations* 22.7 (2018): 2495-2503.

38. Huybrechts Bart., *et al*. "Void detection in root fillings using intraoral analogue, intraoral digital and cone beam CT images". *International Endodontic Journal* 42.8 (2009): 675-685.

39. Chugal Nadia M., *et al*. "Endodontic infection: some biologic and treatment factors associated with outcome". *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* 96.1 (2003): 81-90.

40. Liang Yu-Hong., *et al*. "Endodontic outcome predictors identified with periapical radiographs and cone-beam computed tomography scans". *Journal of Endodontics* 37.3 (2011): 326-331.

41. Tyndall Donald A and Sonali Rathore. "Cone-beam CT diagnostic applications: caries, periodontal bone assessment, and endodontic applications". *Dental Clinics of North America* 52.4 (2008): 825-841.

42. Aquilino Steven A and Daniel J Caplan. "Relationship between crown placement and the survival of endodontically treated teeth". *The Journal of Prosthetic Dentistry* 87.3 (2002): 256-263.

43. Malhotra Neeraj and M Kundabala. "Light-curing considerations for resin-based composite materials: a review. Part I". *Compendium of Continuing Education in Dentistry - Journals* 31.7 (2010): 498-505.

44. Chandrasekhar Veeramachaneni., *et al*. "Incremental techniques in direct composite restoration". *Journal of Conservative Dentistry: JCD* 20.6 (2017): 386.

45. Bicalho AA., *et al*. "Incremental filling technique and composite material-part II: shrinkage and shrinkage stresses". *Operative Dentistry* 39.2 (2014): e83-e92.

46. Hommez GMG., *et al*. "Periapical health related to the quality of coronal restorations and root fillings". *International Endodontic Journal* 35.8 (2002): 680-689.

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