

A Retrospective Radiographic Study of Coronal-Periapical Status and Root Canal Filling Quality in a Selected Adult Turkish Population

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Key Words

Coronal status · Digital panoramic radiography · Periapical index · Periapical status · Root canal filling quality

Abstract

Objective: To investigate the oral health (with regard to the periapical status, quality of root fillings and coronal restorations) in an urban adult Turkish subpopulation using digital panoramic radiographs. **Materials and Methods:** One thousand digital panoramic radiographs involving 28,000 teeth were selected from the archive of the Public Oral and Dental Health Center of Isparta. Coronal status (the type of restoration, signs of marginal leakage or decay), root filling quality (length and lateral seal) and periapical status (according to Periapical Index, PAI) were evaluated. Correlations between apical periodontitis (AP) and the quality of root fillings or coronal restorations were statistically analyzed using the χ^2 test. **Results:** Of the 28,000 teeth evaluated, 22,380 (80.0%) were sound, 4,732 (16.9%) were missing, 753 (2.6%) were filled and 135 (0.5%) were decayed. Of the 753 coronal restorations, 400 (53.1%) were radiographically acceptable. Of the 23,268 teeth, 601 (2.6%) were root filled and 247 root fillings were adequate. Ninety-five (15.8%) root-filled teeth had AP (PAI 3–5). Out of the total, the AP prevalence was 0.4% in root-filled teeth and 0.8% in teeth without root fillings. The

presence of AP was significantly correlated with inadequate coronal restorations and root canal fillings ($p = 0.000$). **Conclusion:** Tooth type, quality and type of coronal restorations, and length and homogeneity of root fillings significantly affected periapical status.

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Introduction

Increasing success rate in root canal therapy has been reported [1], which may have a significant contribution to the improvement of oral health in recent years. The outcome of root canal treatment is positively correlated with the technical quality of the root filling [2]. However, it has been suggested that the primary contributing factor to the presence or development of periapical lesions is not only the filling of the root canal but also the sealing of the coronal restoration [3].

The assessment of the periapical status in different populations is important because it may help to define the treatment needs of the population and evaluate the effects of various endodontic interventions on treatment outcomes [4]. Cross-sectional [5–9] and epidemiological [3, 10] studies using different methods and criteria have documented the prevalence of apical periodontitis (AP) in

Table 1. Radiographic evaluation parameters and scores used in the present study

Parameters	Score
Radiographic coronal status [6]	Intact restoration without signs of leakage (acceptable) Restoration with open margin (unacceptable) Restoration with recurrent decay (unacceptable)
Length of root filling [6]	Root filling terminating 0 to ≤ 2 mm from the radiographic apex (acceptable) Root filling terminating > 2 mm from the radiographic apex (unacceptable) Root filling extending beyond the radiographic apex (unacceptable)
Lateral seal of root filling [3]	Adequate in the coronal 1/2 of the root filling + adequate in the apical 1/2 of the root filling Adequate in the coronal 1/2 of the root filling + inadequate in the apical 1/2 of the root filling Inadequate in the coronal 1/2 of the root filling + adequate in the apical 1/2 of the root filling Inadequate in the coronal 1/2 of the root filling + inadequate in the apical 1/2 of the root filling
PAI [11]	Normal periapical structures Small changes in bone structure Changes in bone structure with some mineral loss Periodontitis with well-defined radiolucent area Severe periodontitis with exacerbating features

various countries. In recent years, the Periapical Index (PAI) developed by Ørstavik [11] has been the most accepted method to determine the periapical status in epidemiological studies [3, 5] and clinical trials [12, 13]. The aim of this study was to investigate the oral health (with regard to the periapical status, quality of root fillings and coronal restorations) in an urban adult Turkish subpopulation using digital panoramic radiographs.

Materials and Methods

Digital panoramic radiographs of patients ($n = 3,850$) first attending the Public Oral and Dental Health Center in Isparta, Turkey, taken between January and June 2011, were selected from the archive of this center. The Public Oral and Dental Health Center renders a primary dental health care service especially to patients with government health insurance. The complicated cases are referred to the dental faculty in Isparta and some private specialists. Digital panoramic radiographs are taken for most of the adult attendees and the treatments are performed by general dentists. This center has a huge capacity with approximately 700 attendees daily covering 85% of rural and 60% of urban areas of the population.

Odd-numbered digital panoramic radiographs were examined according to exclusion criteria and the number of the sample reduced to 1,000 for this retrospective cross-sectional study. The digital panoramic radiographs obtained from patients younger than 18 years with poor image quality, particularly in the upper and lower anterior regions, those obtained from patients having ≤ 9 remaining teeth, or those obtained from patients who were not regular residents of Isparta were excluded.

Observer Agreement for Radiographic Evaluation

All radiographs were taken by the same operator using a panoramic digital radiography device (Orthophos XG 5; Sirona, Tex., USA). Digital images were examined using Photoshop 6.0 Software (Adobe Systems Inc., San Jose, Calif., USA) at a ratio of 1:1. Three observers, 2 endodontists with clinical experience of 20 (A.D.K.) and 11 (B.U.K.) years and a postgraduate student (H.E.G.) with 3 years of clinical experience, evaluated the radiographs. Before the evaluation, the observers participated in calibration training, which consisted of 50 randomly selected panoramic radiographs. The strength of interobserver agreement was determined by calculation of kappa value ($\text{kappa} = 0.87$) [14]. In case of disagreements and difficult borderline cases a consensus decision was reached by negotiating these cases and a 'joint evaluation' (JE) was established. Intra-examiner reproducibility was evaluated by repeated scoring of the same 50 radiographs at 2 months after the first examination. The intra-observer agreement on PAI scores for the 3 observers (A.D.K., B.U.K. and H.E.G.) produced kappa values of 0.91, 0.88 and 0.84, respectively.

Radiographic Evaluation

All teeth, except third molars, were recorded using the Federation Dentaire Internationale nomenclature from the panoramic radiographs. The teeth were evaluated radiographically and recorded as decayed, missing, filled, coronal restoration or root filling, and the periapical status were scored according to the criteria listed in table 1. Multirrooted teeth were assessed considering the worst-scored root. The Decayed, Missing and Filled Teeth (DMFT) Index was calculated.

Statistical Analysis

All data were analyzed using SPSS for Windows, version 14.0 (SPSS, Chicago, Ill., USA). Pearson's χ^2 test for independence was used to analyze the data and a p value of < 0.05 was considered significant.

Table 2. Distribution of decayed, missing and filled teeth and PAI scores according to tooth type

Tooth type	Sound teeth		Decayed teeth		Missing teeth	Filled teeth ¹	
	healthy periapex (PAI 1, 2)	periapex with pathology (PAI 3-5)	healthy periapex (PAI 1, 2)	periapex with pathology (PAI 3-5)		healthy periapex (PAI 1, 2)	periapex with pathology (PAI 3-5)
Maxillary							
Anterior	5,261 (18.8)	15 (0.05)	12 (0.04)	10 (0.03)	566 (2.0)	109 (0.4)	26 (0.1)
Premolar	2,432 (8.7)	1 (0.00)	5 (0.02)	12 (0.04)	1,389 (5.0)	133 (0.4)	26 (0.1)
Molar	2,924 (10.4)	4 (0.01)	11 (0.04)	15 (0.05)	911 (3.6)	104 (0.4)	30 (0.1)
Subtotal	10,617 (37.9)	20 (0.07)	28 (0.1)	37 (0.13)	2,866 (10.2)	346 (1.2)	82 (0.3)
Mandibular							
Anterior	5,650 (20.2)	7 (0.025)	2 (0.00)	7 (0.03)	289 (1.0)	39 (0.1)	12 (0.04)
Premolar	3,396 (12.2)	4 (0.01)	9 (0.03)	9 (0.03)	477 (1.7)	84 (0.3)	20 (0.1)
Molar	2,684 (9.6)	2 (0.00)	21 (0.07)	22 (0.07)	1,100 (3.9)	108 (0.4)	62 (0.2)
Subtotal	11,730 (41.9)	13 (0.05)	32 (0.11)	38 (0.14)	1,866 (6.7)	231 (0.8)	94 (0.3)
Total	22,347 (79.9)	33 (0.12)	60 (0.21)	75 (0.27)	4,732 (16.9)	577 (2.0)	176 (0.6)

Values represent numbers with percentages in parentheses.

¹ All coronal restorations.

Table 3. Distribution of RFT and PAI scores according to tooth type

Tooth type	Distribution of teeth	Healthy periapex (PAI 1, 2)	Teeth with AP (PAI 3-5)	RFT (overall)	RFT with healthy periapex (PAI 1, 2)	RFT with AP (PAI 3-5)
Maxillary						
Anterior	5,434 (23.4)	5,381 (23.1)	53 (0.2)	105 (0.4)	93 (0.4)	12 (0.06)
Premolar	2,611 (11.2)	2,572 (11.1)	39 (0.2)	142 (0.6)	127 (0.6)	15 (0.06)
Molar	3,089 (13.3)	3,039 (13.1)	50 (0.2)	108 (0.5)	93 (0.4)	15 (0.06)
Subtotal	11,134 (47.9)	10,992 (47.3)	142 (0.6)	355 (1.5)	313 (1.4)	42 (0.2)
Mandibular						
Anterior	5,711 (24.5)	5,685 (24.4)	26 (0.1)	35 (0.2)	29 (0.1)	6 (0.03)
Premolar	3,523 (15.1)	3,490 (15.0)	33 (0.1)	88 (0.4)	76 (0.3)	12 (0.06)
Molar	2,900 (12.5)	2,814 (12.1)	86 (0.4)	123 (0.5)	88 (0.4)	35 (0.15)
Subtotal	12,134 (52.1)	11,989 (51.5)	145 (0.6)	246 (1.1)	193 (0.8)	53 (0.2)
Total	23,268 (100.0)	22,981 (98.8)	287 (1.2)	601 (2.6)	506 (2.2)	95 (0.4)

Values represent numbers with percentages in parentheses.

Results

Of the 28,000 teeth evaluated, 22,380 (80.0%) were sound, 4,732 (16.9%) missing, 753 (2.6%) filled and 135 (0.5%) decayed. The DMFT was 5.62 for this selected population.

Mandibular first molars (n = 717) were the most frequently missing teeth. The distribution of decayed, miss-

ing and filled teeth and PAI scores according to tooth type is shown in table 2.

The distribution of the assessed teeth according to tooth type is shown in table 3. A total of 22,981 (98.8%) of the teeth had healthy periapex. Of these, 506 (2.2%) were root filled. Of the 23,268 teeth, 287 (1.23%) displayed periapical disease with a PAI score of 3, 4 or 5.

Table 4. Distribution of PAI scores according to treatment type, radiographic coronal status, length and lateral seal quality of root fillings

Type of treatment	PAI scores							Total	Overall frequency %
	healthy periapex			periapex with pathosis					
	1	2	subtotal	3	4	5	subtotal		
Missing coronal restoration	33	9	42 (76.3)	9	4	0	13 (23.7)	55 (100.0)	0.2
Amalgam restoration	0	21	21 (38.9)	25	7	1	33 (61.1)	54 (100.0)	0.2
Composite restoration	0	13	13 (50)	8	4	1	13 (50)	26 (100.0)	0.1
Crown restoration	0	37	37 (51.4)	25	8	2	35 (48.6)	72 (100.0)	0.3
Root canal treatment + amalgam restoration	158	27	185 (85.3)	27	3	2	32 (14.7)	217 (100.0)	0.9
Root canal treatment + composite restoration	83	12	95 (87.2)	12	1	1	14 (12.8)	109 (100.0)	0.5
Root canal treatment + crown restoration	163	21	184 (83.6)	29	3	4	36 (16.4)	220 (100.0)	0.9
Radiographic coronal status (n = 753)									
Score 1	263	67	330 (82.5)	54	11	5	70 (17.5)	400 (100.0)	1.7 ^a
Score 2	117	58	175 (72.6)	48	14	4	66 (27.4)	241 (100.0)	1.0 ^a
Score 3	57	15	72 (64.3)	33	5	2	40 (35.7)	112 (100.0)	0.5 ^a
Length of root filling (n = 601)									
Score 1	262	24	286 (89.1)	27	4	4	35 (10.9)	321 (100.0)	1.4 ^a
Score 2	148	41	189 (78.1)	45	6	2	53 (21.9)	242 (100.0)	1.0 ^a
Score 3	27	4	31 (81.6)	5	1	1	7 (18.4)	38 (100.0)	0.1 ^a
Lateral seal of root filling (n = 601)									
Score 1	226	28	254 (90.1)	22	1	5	28 (9.9)	282 (100.0)	1.2 ^a
Score 2	66	14	80 (87.9)	10	0	1	11 (12.1)	91 (100.0)	15.1 ^a
Score 3	15	1	16 (84.2)	1	2	0	3 (15.8)	19 (100.0)	0.1 ^a
Score 4	130	26	156 (74.6)	44	8	1	53 (25.4)	209 (100.0)	0.9 ^a

Values represent numbers with percentages in parentheses, unless otherwise indicated. ^a n = 22, 380.

A total of 753 teeth were treated with one of the treatment types listed in table 4. Root canal treatment with crown restoration (220, 29.2%) was the most common type of treatment; 24 (3.2%) teeth were restored with post/core restoration. A significant correlation was found between the types of treatment and the PAI score (Pearson's $\chi^2 = 290.340$, $p = 0.000$). Periapical status was scored as PAI 1 in most of the root canal-treated teeth restored with amalgam or crowns. Most of the periapically diseased teeth (PAI of 3, 4 or 5), with or without root canal treatment, had crown restorations (table 4).

Of the 753 coronal restorations (except post restorations), 400 (53.1%) were radiographically intact without signs of leakage (acceptable; table 4), whereas 112 (14.9%) had recurrent decays (unacceptable). There was a significant correlation between the radiographic coronal status and the PAI score (Pearson's $\chi^2 = 29.597$, $p = 0.000$). The teeth with radiographically acceptable restorations displayed healthy periapical regions (PAI scores of 1 and 2; table 4).

The number of root-filled teeth (RFT) was 601 (2.6%), mostly in mandibular left first molars (7.5%); 95 RFT (0.4%) displayed periapical disease, with a PAI score of 3, 4 or 5; 321 teeth (53.4%) had acceptable root filling lengths (root filling terminating 0 to ≤ 2 mm from the radiographic apex), and 280 (46.6%) root fillings were assessed as unacceptable, considering the length (table 4). A significant correlation was determined between the length of the root fillings and the PAI score (Pearson's $\chi^2 = 32.181$, $p = 0.000$). Periapical status of teeth with root fillings terminating >2 mm from the radiographic apex was determined as diseased (PAI of 3, 4 or 5); this parameter was considered more important than extension of root fillings beyond the radiographic apex (table 4).

Of the root canal fillings, 282 (46.9%) were adequate, both in the coronal and apical halves, whereas 209 (34.8%) were inadequate, both coronally and apically (table 4). There was a significant correlation between the lateral seal of root fillings and the PAI score (Pearson's $\chi^2 =$

45.103, $p = 0.000$). The periapical status of the teeth with coronally and apically inadequate root fillings was mostly determined as periapically diseased (PAI of 3, 4 or 5; table 4). Both the length and the lateral seal were found to be acceptable in 247 teeth (41.1%), and only 9.31% of these had periapical disease. This was significantly less than the RFT with poor quality (Pearson's $\chi^2 = 31.819$, $p = 0.000$).

Discussion

When dental caries experience was categorized into four groups based on the DMFT score [15], the DMFT (5.6) of this population belongs to the fourth 'severe' category. High DMFT seemed to be related to the higher missing teeth number than that of the decayed and filled ones. The AP prevalence (1.2%) of this selected population was lower than that of the selected populations of the other studies from different countries [3, 5–10, 16]. The frequency of RFT in this study was 2.5%, and within 2.0–18.9% in the other studies [3, 5–10, 16]. However, the frequency of AP in RFT was lower (15.8%) than that in the previous studies (18.2–67.9%) [3, 5–10, 16]. This low AP prevalence could be due to the frequent extraction of teeth with periapical disease and even with pulpitis due to the small number of specialists in endodontics in this region of Turkey. Thus, it is difficult to interpret such epidemiological studies because the number and reasons for the extractions are usually not reported.

In the present study, similar to previous reports, the most frequently missing teeth were mandibular first molars [17, 18]. This selected population exhibited the highest AP frequency in mandibular molars. At the same time, the most frequent RFT were the mandibular molars. Molars are the first erupted, most commonly threatened and most commonly treated teeth. Moreover, they have the most complex root canal anatomy [9]. Molars are reported to have higher AP frequency than anterior teeth in various studies [5, 8].

The technical quality of the coronal restoration and endodontic treatment should have a seal of good quality to prevent periapical disease [3, 19–21]. Despite the limitations of radiographic evaluation of coronal leakage, our results obtained from this selected population support the necessity of good seal whether in coronal or apical segments, consistent with other studies [3, 6]. The 51.1% frequency of radiographically acceptable coronal restorations of this study was lower than the previously reported

73.5–75% [2, 16]. Regarding the type of coronal restoration, the present study demonstrated that the most decisive risk factor for developing AP was the presence of crowns, which is in agreement with other studies [5, 19]. Apart from the inadequate marginal adaptation or recurrent decay, various iatrogenic factors during the prosthetic procedures, such as excessive preparation and mechanical, thermal, chemical and occlusal trauma, can explain this outcome.

In this study, the quality of the root fillings has been evaluated in terms of length and homogeneity of root fillings adopting the criteria from Hommeze et al. [6] and Kirkevang et al. [3]. The apical limit of obturation of the root canal has been a topic for discussion among endodontists for decades, but there is an agreement in the literature that the length of the root filling is a crucial factor for the success of endodontic treatment [6, 7, 16]. In clinical practice, the limits of instrumentation and obturation are accepted to be between 0.5 and 2 mm from the radiographic apex, even though the position of the apical foramen has been found to be between 0.2 and 3.8 mm from the radiographic apex [20].

Teeth with adequate lengths of root fillings had 10.9% AP in this selected population, whereas other European populations had 10–46% [22, 23]. Teeth with short root fillings had 49–90.8% AP [7, 9] and long ones had 55–75% [7, 12, 22]. In the present study, the frequency of short treatments (40.3%) was significantly higher than long ones (6.3%), which led to significantly more AP (21.9%). According to our clinical experience and the findings of other studies, overfilling usually results in endodontic infections due to overinstrumentation, through infected dentin chips being propelled into the periradicular tissues or due to lack of an apical seal leading to apical percolation [7]. In contrast, in short fillings, a root canal may not have been cleaned in the apical segment and not sealed appropriately, leaving enough space for growth of residual microorganisms.

There is still some disagreement about the effects of the homogeneity of the root filling on the periapical status [3, 6, 23]. Radiographic evaluation methods usually do not allow determining the true relation between the root dentine and filling material. First and foremost, three-dimensional evaluation is not possible with radiographs. The present study reported that 53.1% of the root fillings had detectable adaptation failures and, of these, 53.21% had AP. Similar results have been reported in previous studies having root fillings with voids of between 30 and 60%, and, approximately 58–70% of these had AP [3, 12, 22]. The incomplete diagnostic val-

ue of radiographs still remains a limitation of the present and other studies. However, further studies utilizing more sensitive techniques, such as cone beam computed tomography, have the potential to assess the true periapical status.

Conclusions

The data from this selected population recorded the highest AP frequency in mandibular molars. Tooth type had a significant impact on the periapical status. The radiographic quality and type of coronal restorations also had a significant impact on the periapical status, as did the length and homogeneity of the root fillings.

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