Influence of the Quality of Root Canal Treatment and Crown Restoration on the Prevalence of Apical Periodontitis

Original Article

Mahdieh Dehghani[1], Sahar Ghanea[2], Mehdi Tabrizizadeh[3], Sahar Hajizadeh[4]

[1]Assistant Professor, Department of Oromaxilofacial Radiology, Faculty of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.
[2] Oral and Maxillofacial Resident, Department of Oromaxilofacial radiology, Faculty of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.
[3] AssociateProfessor, Department of Endodentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.
[4] Dentist, Faculty of dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

Received: May 14, 2015
Accepted: Jul 29, 2015

Corresponding Author:
Sahar hajizadeh
Address:
Department of Maxillofacial Radiology, Faculty of Dentistry ,Shahid Sadoughi University of Medical Sciences, Yazd, Iran
Telephone:09133545623
Email: mdehghanit@yahoo.com
Fax:03526222921

Abstract

Introdouction:

The high prevalence of apical periodontitis (AP) of endodontic origin raises an important public health problem. Root canal treatment (RCT) and crown restoration (CR) have an effect on its prevalence. This cross-sectional study was performed to assess the effect of RCT and CR on the prevalence of AP.

Materials and methods:

Two observers assessed 608 teeth with RCT belonging to patients who were referred to the radiology ward of the dental school at the Shahid Sadoughi University of Medical Sciences, Yazd, Iran, in 2011–2012 in the form of 152 panoramic radiographs. The quality of RCT, including length/density of root restoration, and crown restoration and the prevalence of AP were recorded from patients' medical files. Data were analyzed by chi-square test, one-way ANOVA, and logistic regression model using SPSS (ver. 19).

Results:

The frequency of AP in teeth with RCT was 50.5%. Appropriate CR and RCT was observed in 348 (57.2%) and 168 (30.6%) of teeth, respectively. Furthermore, 36.8% of teeth with appropriate and 68.8% with inappropriate crown restoration showed AP, and the difference was significant ($p < 0.001$). Prevalence of AP was significantly lower in teeth with acceptable RCT than in those with unacceptable RCT ($p < 0.001$). Teeth with unacceptable RCT/CR showed AP 6 times more frequently than teeth with acceptable RCT/CR.

Conclusion:

The findings showed that a considerable number of teeth in Yazd had RCT/CR with unacceptable results and that the quality of both RCT and CR may affect the prevalence of AP. Therefore, considerable efforts are required to improve endodontic and restorative treatment standards.

Key words:

•Root Canal Therapy •Tooth Crown •Periapical Periodontitis •Radiology

Introduction

Apical periodontitis (AP) is a multi-factorial disease mostly caused by bacteria.[1] The disease results from the reaction of periapical tissue to mild irritations, such as pulp necrosis or inappropriate root canal treatment (RCT).[2] RCT is done to prevent AP and to create an appropriate condition for apex healing [3-5], although some RCTs may not be successful because of technical errors or difficulty in applying cleaning devices to the root canal.[6, 7] The prevalence of AP in teeth with RCT is about 24.5%–65.8% [5, 7-9]; however, its prevalence in teeth without RCT is about 4–9%.[9-12]

Panoramic radiography has been used in some studies because of its high validity and low patient exposure.[13-17] Various indices are used for radiographic assessment of the quality of root canal and crown restorations and the condition of teeth apices.[18-20] The periapical index (PAI) is one of the indices used as a reference for the assessment of AP.[20]Some studies have assessed the role of coronal sealing on apex healing.[9, 11, 16] Penetration of saliva from the crown to the interior of the tooth that has received RCT creates a damp environment that is suitable for the growth of bacteria.[8, 21, 22]

Considering the importance of crown and root canal treatment and its association with AP, this study was designed to assess the prevalence of AP and its association with the quality of root and crown restorations in patients referred to the oromaxillofacial radiology ward of dental schools.

Materials and Methods

A total of 608 teeth with RCT in 152 digital panoramic radiographs, obtained in 2011–2012, were randomly selected. The subjects, who were referred to the dental school for the first time, were included in the study and those younger than 18 years old, possessing lesser than 10 teeth, and having had an RCT in the last year were excluded from the study. Additional exclusion criteria were systemic disease, pulp stone, teeth with post and core, and extreme premolar overlap in the radiography. Anterior teeth were not included in our study because of vertebra column superimposition in panoramic view on the anterior site. Differentiation between scar and apical periodontitis was obtained from the patients' history. The study was approved by the ethics committee of the Shahid Sadoughi University of Medical Sciences (ethical code 138846). Radiographs were obtained by a digital device (Proline XC, Planmeca, Helsinki, Finland) under the following exposure parameters: exposure: 66–70 KVP, intensity: 8–10 mA, and duration: 10–12 s). Images were observed on a computer by Romexis 2.9.2 Planmeca software. The monitor size was 17 inches with 1024-pixel resolution. The contrast and brightness of the monitor was set by the observers, who were an oromaxillofacial radiologist and an endodontist. For consistency, 30 panoramic radiographs were reviewed and reported upon by both observers separately. Then, all radiographs were interpreted by the shared opinion of both observers. Teeth in which the root or pulp chamber were radiopaque were considered as being RCT. Length and density of root treatment, the overall quality of root treatment according to length/density, the quality of crown restoration, presence of AP, and its score (Table 1) were also assessed. The periapical situation of teeth was scored with the PAI index and the teeth were divided into 5 groups [25]. A score of 3 or higher was considered to be AP. Because this study was conducted according to the radiographic findings, leakage was not assessed.

Data were analyzed with SPSS using the chi-square test, Fisher's exact test, and logistic regression model. Level of significance was set at $p < 0.05$.

Results

This study was conducted on 3936 teeth from 152 subjects. 608 teeth (15.41%) had RCT. Table 2 shows the frequency distribution of subjects in different age groups. RCT teeth with AP were less frequent in males (30.2% vs. 69.7%). The oral hygiene of the selected population and the number of remaining and lost teeth are shown. Table 3 shows the frequency of RCT teeth and RCT teeth with AP. Table 4 shows the condition of the tooth restorations in terms of length and density. We found a significant association between the frequency of AP and length/density of canal in RCT teeth ($p < 0.001$) (Table 5).

Table 6 shows the multiple logistic regression analysis for the effect of two independent var-

iables (i.e., appropriate length and density) on periapical condition. Teeth that had acceptable RCT with adequate length/density were tested against any other combination of unacceptable RCTs (Table 5). Both length and density were found to be adequate in 186 teeth; 29.6% of these teeth had AP that was significantly lesser than any other combination of parameters ($p < 0.001$). In cases of unacceptable RCT, AP was present in 59.7% of teeth. Furthermore, the association between quality of CR and AP is presented in Table 5. Apical periodontitis was significantly less present in properly treated teeth, compared with teeth that had been treated improperly ($p < 0.001$).

The parameters for the combined quality of CR and RCT are also shown in Table 5. Both of these variables were adequate in only 19.9% of the teeth studied, and approximately one-sixth of these teeth (19%) had AP. When tested against other combinations of the quality parameters, RCT/CR was significantly less than acceptable ($p < 0.001$). Table 7 shows the multiple logistic regression analysis for the effect of two independent variables (RCT and CR quality) on periapical condition. The odds of AP/normal periodontal status in cases with both unacceptable RCT and CR was more than 6 times greater compared with cases with acceptable RCT/CR.

Table 1. Radiographic variables and diagnostic categories

Parameters	Registration and codes
Apical periodontitis[20]	1 = Absence (Normal periapical structures (score 1); or small changes in bone structure (score 2)
	2 = Presence (Changes in bone structure with some mineral loss (score 3); apical periodontitis with a well-defined radiolucent area (score 4); or extensive/severe periodontitis with exacerbating features (score 5)
Length of root filling[10]	1 = Adequate (<2 mm from, or flush with, the radiographic apex)
	2 = Inadequate (>2 mm from the radiographic apex or overextended)
Density of root filling[24]	1 = Adequate (Uniform density and adaptation of the filling to the root canal walls)
	2 = Inadequate (visible canal space laterally along the filling; voids within the filling mass; or identifiable untreated canal)
Coronal restorations[21]	1 = Adequate (radiographically intact restoration with no signs of leakage)
	2 = Inadequate (radiographic sings of overhangs, open margins/ recurrent decay, or no coronal restoration)

[a] if a multirooted tooth presented with different periapical statuses at different roots, the root canal with the most severe periapical condition was categorized.

[b] In cases of multirooted teeth, not all root canal fillings of such teeth were assessed separately; only the canal with the worst technical obturation quality was evaluated.

Table 2. Frequency distribution of remaining and lost teeth in different age groups

			Percent						
	Age group	Number	5	10	25	50	75	90	95
Remaining teeth	≥20	3	28.0	28.0	28.0	28.0	28.0	28.0	28.0
	21–30	50	23.0	26.0	27.0	28.0	28.0	28.0	28.0
	31–40	60	21.0	24.0	26.0	28.0	28.0	28.0	28.0
	41–50	22	16.3	18.3	20.75	24.0	25.0	28.0	28.0
	51–60	15	17.0	17.0	18.0	24.0	25.0	27.4	28.0
	<60	2	21.0	21.0	21.0	24.5	28.0	28.0	28.0
Lost teeth	≥20	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21–30	50	0.0	0.0	0.0	0.0	1.0	2.0	5.0
	31–40	60	0.0	0.0	0.0	0.0	2.0	4.0	6.9
	41–50	22	0.0	0.0	3.0	4.0	7.25	9.7	11.7
	51–60	15	0.0	0.6	3.0	4.0	10.0	11.0	11.0
	<60	2	0.0	0.0	0.0	3.5	7.0	7.0	7.0

Table 3. Frequency distribution of treated teeth and treated teeth with AP regarding gender and type of tooth

	Tooth type	Treated teeth			Treated teeth with AP		
		Total (%)	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)
Maxilla	Molar	43.9	36.8	63.2	48.0	39.1	60.9
	Premolar	56.1	29.2	70.8	52.0	22.5	77.5
	Total	100.0	32.6	67.4	100	61.6	138.4
Mandible	Molar	60.6	34.4	65.5	69.9	27.1	72.9
	Premolar	39.4	35.5	64.5	30.1	36.9	63.1
	Total	100	34.5	65.5	100	60.0	136.0

Table 4. Frequency distribution of the study variables

Variable	Situation	Number	Percent
Length of restoration	Appropriate	361	59.4
	Inappropriate	247	40.6
Density of restoration	Appropriate	247	40.6
	Inappropriate	361	59.4
Quality of RCT	Acceptable	186	30.6
	Unacceptable	422	69.4
AP	Presence	307	50.5
	Lack	301	49.5
AP score	3	214	35.2
	4	89	14.6
	5	4	7.0
Quality of CT	Appropriate	348	57.2
	Inappropriate	260	42.8

Table 5. Frequency distribution of AP in RCT teeth regarding the quality of RCT and CT

Parameter	Total		Apical periodontitis		p-value
	Number	Percent	Number	Percent	
RCT teeth	608	100	307	50.5	-
Sufficient length/density of restoration (acceptable)	186	30.6	55	29.6	<0.001
Sufficient length/insufficient density of restoration (unacceptable)	175	28.8	96	55.9	<0.001
Insufficient length/sufficient density of restoration (unacceptable)	61	10.0	32	52.4	<0.001
Insufficient length/insufficient density of restoration (unacceptable)	186	30.6	124	66.7	<0.001
Unacceptable RCT	422	69.4	252	59.7	-
Acceptable CR	348	57.2	128	36.8	<0.005
Unacceptable CR	260	42.8	179	68.8	<0.005
Acceptable RCT/acceptable CR	121	19.9	23	19.0	<0.001
Acceptable RCT/unacceptable CR	227	37.3	105	46.2	<0.001
Unacceptable RCT/acceptable CR	65	10.7	32	49.2	<0.001
Unacceptable RCT/unacceptable CR	195	32.1	147	70.4	<0.001

Table 6. Multiple logistic regression for evaluation of the effect of two independent variables (length and density of restoration) on the dependent variable (AP)

	B	SE	Wald	df	Sig	Exp	95% CI for OR (odds ratio)	
							Minimum	Maximum
Length of restoration	0.659	0.177	13.853	1	0.00	19.33	1.366	2.734
Density of restoration	0.899	0.177	25.800	1	0.00	2.458	1.737	3.478
Constant	0.776	0.143	29.474	1	0.16	-	-	-

Table 7. Multiple logistic regression for evaluation of the effect of two independent variables (quality of RCT and CR) on the dependent variable (AP)

	B	SE	Wald	df	Sig	Exp	95% CI for OR (odds ratio)	
							Minimum	Maximum
Quality of RCT	1.312	0.181	52.744	1	0.00	3.713	2.606	5.290
Quality of CR	1.233	0.198	38.758	1	0.00	3.433	2.328	5.062
Constant	−3.3945	0.447	77.812	1	0.00	-	-	-

Discussion

The main objective of RCT is prevention or treatment of AP lesions. According to studies in controlled situations, the success rate of RCT is more than 90%, but some cross-sectional studies on human populations have shown a success rate of 35%–60% for this treatment [23, 25]. RCT and post-treatment factors (e.g., length and density of root restoration and quality of crown restoration) are the main factors in the success rate of RCT (presence or lack of AP).[26]

In this study, panoramic radiography was used to assess the condition of AP and the quality of root canal or crown treatments. Length and density of restoration were used as the indices of acceptable root treatment, although panoramic radiography underestimates the real frequency of AP; however, because of a high correlation between intra-oral and panoramic radiographies and overestimation of panoramic radiography in comparison to intra-oral radiography [27-29], it seems that recording the prevalence of periodontitis using panoramic radiography is a satisfactory method [26]. Because of the study limitations, canal length was classified as acceptable and unacceptable.

The direct association between the quality of RCT and the prevalence of AP has been seen in previous studies as well.[2, 26] Asgary et al. found AP in 29.1% of RCT teeth, consistent with the results of the current study [26]; however, in Kakehashi's study, the prevalence of AP in teeth with acceptable RCT was 16.5%, which is probably because of the higher quality of treatment in this study.[2]

When we assessed the quality of root restorations according to the length and density separately, it was determined that the length and density of restorations were appropriate in 59.4% and 40.6% of cases, respectively. Thus, it was shown that both factors play an important role in the quality of RCT and the prevalence of AP. Asgary et al. [26], Deamkashan et al. [23], and Kirkevang et al. [8] found similar results.

In the current study, teeth that received RCT in the last year were included; since the majority of healing takes place in the first six months after treatment, size of AP is affected by the treatment procedure. In this study, prevalence of AP in all teeth was 50.5%, but this measure in different studies ranged from 20% to 65%.[28-31] This difference is probably because of the patient's level of oral health and the skill of the dentists.

In the current study, 69.7% of AP cases were given a score of 3, which agrees with the findings of Asgary et al. [26] With increasing score, the size of lesion and its effect on the surrounding tissue will increase. The size of lesion may also affect the decision for treatment [32], but the size does not affect the patient's improvement. Large lesions only need a longer time to be cured [33]. The

frequency of all RCT teeth and treated teeth with acceptable RCT quality in the present study was 15.4% and 30.6%, respectively, while the same measures were 3.5% and 42.3% in the study conducted by Asgary et al. [26], which may show that the index of oral and tooth health in Yazd is lower than the Iranian average. Nonetheless, other studies have shown a frequency of 8.6 to 26% for RCT.[34-40]

The current study emphasized the importance of the quality of root and crown treatments on the prevalence of AP. The results showed that AP occurred in 29.6% of teeth with acceptable RCT, 59.7% of teeth with unacceptable RCT, 41.82% of teeth with appropriate restoration length, and 35% of teeth with appropriate restoration density. In similar studies in European countries, it was demonstrated that AP occurred in 10%–46% of teeth with appropriate restoration length.[27, 28] For instance, in a study in Denmark [19], 44.3% and 26.92% of teeth with appropriate restoration density exhibited AP. Therefore, it can be concluded that both length and density of restoration affect the quality of treatment and the prevalence of AP.

This study showed that, in spite of appropriate RCT quality, AP occurred in 46.2% of cases. Therefore, the quality of RCT is not the only factor that affects AP; appropriate crown restoration can also serve as a barrier to the penetration of liquids and bacteria from the oral cavity to the root space.[8]In the present study, crown restoration was acceptable in 57.2% of RCT teeth, which was similar to the results of Asgary et al. [26] It seems that the prevalence of AP in cases with unacceptable RCT and acceptable CR is almost similar to cases with acceptable RCT and unacceptable CR, consistent with the results of Sidaravicius et al. [39]; but, in a study by Roy and Trop, CR was more important than RCT. [41] Considering the prevalence of 15.4% for RCT and 50.5% for AP in RCT teeth in the study population, combined with the emphasis of this and similar studies on the effect of RCT and CR on the prevalence of AP, attention should be paid to all stages of the treatment of a tooth with pulp disease.

Conclusion

The findings of this study confirmed the results of past studies about the effect of the quality of RCT and CR on the occurrence of AP. Therefore, in order to cure teeth with pulp disease, all stages of treatment should be performed with caution. It is recommended that additional studies be conducted to clinically assess crown sealing conditions using both intra-oral and panoramic radiography.

Acknowledgement

This study was performed with the collaboration of the oromaxillofacial ward of the dental school at the Shahid Sadoughi University of Medical Sciences, Yazd, Iran. The authors declare that they do not have any competing interests.

Refrences

1.Siqueira JF Jr, Rôças IN. Bacterial pathogenesis and mediators in apical periodontitis. Braz Dent J 2007; 18(4):267-80.
2.Kakehashi S, Stanley H, Fitzgerald R. The effects of surgical exposures of dental pulps in germ-free and conventional laboratory rats. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1965; 20(3):340-9.
3.Kirkevang LL, Væth M, Hörsted-Bindslev P, et al. Risk factors for developing apical periodontitis in a general population. Int Endod J 2007; 40(4):290-9.
4.Al-Omari MA, Hazaa A, Haddad F. Frequency and distribution of root filled teeth and apical periodontitis in a Jordanian subpopulation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011; 111(1):e59-e65.
5.Kabak Y, Abbott P. Prevalence of apical periodontitis and the quality of endodontic treatment in an adult Belarusian population. Int Endod J 2005; 38(4):238-45.
6.Abbott PV. The periapical space--A dynamic interface. Aust Endod J 2002; 28(3):96-107.
7.Nair P. Pathogenesis of apical periodontitis and the causes of endodontic failures. Crit Rev Oral Biol Med 2004; 15(6):348-81.
8.Kirkevang LL, Ørstavik D, Hörsted-Bindslev P, Wenzel A. Periapical status and quality of root fillings and coronal restorations in a Danish population. Int Endod J 2000; 33(6):509-15.
9.Marques M, Moreira B, Eriksen H. Prevalence of apical periodontitis and results of endodontic treatment in an adult, Portuguese population. Int Endod J 1998; 31(3):161-5.
10.De Moor R, Hommez G, De Boever J, et al. Periapical health related to the quality of root canal treatment in a Belgian population. Int Endod J 2000; 33(2):113-20.

11.Buckley M, Spangberg LS. The prevalence and technical quality of endodontic treatment in an American subpopulation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995; 79(1):92-100.
12.Tsuneishi M, Yamamoto T, Yamanaka R, et al. Radiographic evaluation of periapical status and prevalence of endodontic treatment in an adult Japanese population. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005; 100(5):631-5.
13.Matijević J, Čižmeković Dadić T, Prpić Mehičić G, et al. Prevalence of apical periodontitis and quality of root canal fillings in population of Zagreb, Croatia: a crosssectional study. Croat Med J 2011; 52(6):679-87.
14.Kamberi B, Hoxha V, Stavileci M, et al. Prevalence of apical periodontitis and endodontic treatment in a Kosovar adult population. BMC Oral Health 2011; 11(1):32.
15.Kalender A, Orhan K, Aksoy U, et al. Influence of the quality of endodontic treatment and coronal restorations on the prevalence of apical periodontitis in a Turkish Cypriot population. Med Princ Pract 2012; 22(2):173-7.
16.Ahlqwist M, Halling A, Hollender L. Rotational panoramic radiography in epidemiological studies of dental health. Comparison between panoramic radiographs and intraoral full mouth surveys. Swed Dent J 1986; 10(1-2):73-84.
17.Molander B, Ahlqwist M, Gröndahl H, Hollender L. Comparison of panoramic and intraoral radiography for the diagnosis of caries and periapical pathology. Dentomaxillofac Radiol 1993; 22(1):28-32.
18.Hessari H, Vehkalahti MM, Eghbal MJ, Murtomaa HT. Oral health among 35- to 44-year-old Iranians. Med Princ Pract 2007; 16(4):280-5.
19.Gündüz K, Avsever H, Orhan K, Demirkaya K. Cross-sectional evaluation of the periapical status as related to quality of root canal fillings and coronal restorations in a rural adult male population of Turkey. BMC Oral Health 2011; 11(1):11-20.
20.Ørstavik D, Kerekes K, Eriksen HM. The periapical index: A scoring system for radiographic assessment of apical periodontitis. Endod Dent Traumatol 1986; 2(1):20-34.
21.Siqueira JF, Rôças IN, Alves FR, Campos LC. Periradicular status related to the quality of coronal restorations and root canal fillings in a Brazilian population. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005; 100(3):369-74.
22.Tronstad L, Asbjørnsen K, Døving L, et al. Influence of coronal restorations on the periapical health of endodontically treated teeth. Endod Dent Traumatol 2000; 16(5):218-21.
23.Kashan SAD, Abu-bakr NH, Ibrahim YE. Pilot study on relation of the periapical status and quality of endodontic treatment in an adult Sudanese population. Arch Orofac Sci 2011; 6(1):3-8.
24.Segura Egea J, Jiménez Pinzón A, Poyato Ferrera M, et al. Periapical status and quality of root fillings and coronal restorations in an adult Spanish population. Int Endod J 2004; 37(8):525-30.
25.Asgary S, Shadman B, Ghalamkarpour Z, et al. Periapical status and quality of root canal fillings and coronal restorations in Iranian population. Iran Endod J 2010; 5(2):74-82.
26.Cleen MD, Schuurs A, Wesselink P, Wu MK. Periapical status and prevalence of endodontic treatment in an adult Dutch population. Int Endod J 1993; 26(2):112-9.
27.Eriksen H, Berset G, Hansen B, Bjertness E. Changes in endodontic status 1973–1993 among 35□year□olds in Oslo, Norway. Int Endod J 1995; 28(3):129-32.
28.Muhammed AH, Manson-Hing L. A comparison of panoramic and intraoral radiographic surveys in evaluating a dental clinic population. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1982; 54(1):108-17.
29.Estrela C, Leles CR, Hollanda ACB, et al. Prevalence and risk factors of apical periodontitis in endodontically treated teeth in a selected population of Brazilian adults. Braz Dent J 2008; 19(1):34-9.
30.Allard U, Palmqvist S. A radiographic survey of periapical conditions in elderly people in a Swedish county population. Endod Dent Traumatol 1986; 2(3):103-8.
31.Reit C, Gröndahl H. Management of periapical lesions in endodontically treated teeth. A study on clinical decision making. Swed Dent J 1983; 8(1):1-7.
32.Ng Y, Mann V, Rahbaran S, et al. Outcome of primary root canal treatment: systematic review of the literature–Part 2. Influence of clinical factors. Int Endod J 2008; 41(1):6-31.
33.Boucher Y, Matossian L, Rilliard F, Machtou P. Radiographic evaluation of the prevalence and technical quality of root canal treatment in a French subpopulation. Int Endod J 2002; 35(3):229-38.
34.Ödesjö B, Helldén L, Salonen L, Langeland K. Prevalence of previous endodontic treatment, technical standard and occurrence of periapical lesions in a randomly selected adult, general population. Endod Dent Traumatol 1990; 6(6):265-72.
35.Imfeld TN. Prevalence and quality of endodontic treatment in an elderly urban population of Switzerland. J Endod 1991; 17(12):604-7.
36.Lupi Pegurier L, Bertrand MF, Muller□Bolla M, et al. Periapical status, prevalence and quality of endodontic treatment in an adult French population. Int Endod J 2002; 35(8):690-7.
37.Petersson K, Pamenius M, Eliasson A, et al. 20-year follow-up of patients receiving high-cost dental care within the Swedish Dental Insurance System: 1977–1978 to 1998–2000. Swed Dent J 2006; 30(2):77.
38.Sidaravicius B, Aleksejuniene J, Eriksen H. Endodontic treatment and prevalence of apical periodontitis in an adult population of Vilnius, Lithuania. Endod Dent Traumatol 1999; 15(5):210-5.
39.Soikkonen K. Endodontically treated teeth and periapical findings in the elderly. Int Endod J 1995; 28(4):200-2003.
40.Ray H, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. Int Endod J 1995; 28(1):12-8.