Original Article

# Assessment of apical periodontitis in relation to quality of root canal fillings and coronal restorations in a Turkish subpopulation: A retrospective cone-beam computed tomography study

Seda Falakaloglu, Ceren Aktuna Belgin[1], Latife Altınok Uygun[2], Özkan Adigüzel[3]

Department of Endodontics, Faculty of Dentistry, Afyonkarahisar Health Sciences University, Afyonkarahisar, [1]Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Hatay Mustafa Kemal University, Hatay, [2]Afyonkarahisar Oral and Dental Health Center, Afyonkarahisar, [3]Department of Endodontics, Faculty of Dentistry, Dicle University, Diyarbakir, Turkey

## Abstract

**Introduction:** This study aims to investigate the prevalence of apical periodontitis (AP) and relate the quality of root canal fillings (RCFs) and coronal restorations (CRs) with using cone-beam computed tomography (CBCT) in a Turkish subpopulation.

**Materials and Methods:** A total of 824 CBCT scans were performed at the Dicle University Faculty of Dentistry between January 2015 and December 2017. The age, sex, root canal-treated teeth of each patient, quality of RCF and CR, and CBCT periapical index (CBCTPAI) scores of teeth were calculated and recorded. Data were statistically analyzed.

**Results:** Among 333 patients, 152 (45.6%) patients were male and 181 (54.3%) were female. The mean age was 30.1 ± 5.3 years. The total number of endodontically treated teeth was 550, and 76.2% had AP. In 238 (43.3%) teeth with inadequate RCF, AP rate was 89.4%. There was a significant correlation between the density of the RCF and AP ($P < 0.00$). Inadequate restorations accounted for 177 teeth (32.2%), of which 10.1% (18) of the teeth were CBCTPAI 1. Of the 41 teeth with missing CR, 39 (95.1%) teeth showed signs of AP. A significant difference was found between CR and AP ($P = 0.00$).

**Conclusions:** The RCF quality, adequate CR, and the type of CR are related to AP.

**Keywords:** Apical periodontitis, cone-beam computed tomography, coronal restoration, quality of root filling

**Address for correspondence:** Dr. Seda Falakaloglu, Department of Endodontics, Faculty of Dentistry, Afyonkarahisar Health Sciences University, Afyonkarahisar 03030, Turkey.
E-mail: sedafalakaloglu@gmail.com

**Submission:** 29-07-19 **Revision:** 13-09-19 **Acceptance:** 10-10-19 **Web Publication:** ***

## INTRODUCTION

Post-treatment apical periodontitis (AP) is usually associated with etiological agents of root canal infection.[1] In the literature, an important factor affecting the prognosis of endodontic treatments is the quality of root canal filling (RCF).[2] Some of the studies investigating the quality of RCF are based on the obturation density and some are based on the length of the RCF.[3,4]

Access this article online

Quick Response Code:

Website: www.saudiendodj.com

DOI: 10.4103/sej.sej_114_19



**How to cite this article:** Falakaloglu S, Belgin CA, Uygun LA, Adigüzel Ö. Assessment of apical periodontitis in relation to quality of root canal fillings and coronal restorations in a Turkish subpopulation: a retrospective cone-beam computed tomography study. Saudi Endod J 2020;XX:XX-XX.

Coronal restoration (CR) quality is reported to be as important as the quality of RCF in the prognosis of endodontic treatments.[5,6] Indirect restorations on root canal-filled teeth protect the root canal against microleakage and secondary infections and also ensure that the teeth remain functional for longer periods of time.[7]

Periapical radiolucency is a common sign of AP, which is related to the perforation or erosion of the cortical bone structure.[8] Intraoral radiography, panoramic radiography and cone beam computed tomography (CBCT) can be used to for imaging this bone loss caused by AP.[9-11] In reviewing the literature on this subject, intraoral radiograph and panoramic radiograph were frequently used in studies related to AP prevalence in Turkey.[12-15] CBCT images show hard tissue changes at an early stage due to their high resolution. Furthermore, CBCT scans have a higher sensitivity to reveal missed canals and evaluate to RCF quality.[16,17] It was reported that the 3-dimentional CBCTs are more advantageous than two-dimensional radiographs in imaging AP. In addition, the size of AP, its relationship with adjacent anatomic structures, and exact location are evaluated correctly.[18-20]

Therefore, the aim of this study was to investigate the effects of CR and RCF quality on periapical changes by taking advantage of CBCTs.

## MATERIALS AND METHODS

The ethical approval acceptance was taken by the Clinical Research Ethics Committee of the Dicle University, Faculty of Dentistry (30.01.19/Protocol no: 2019/1). Interexaminer agreement was determined by Cohen's kappa (0.82).

This retrospective study was comprised of 550 root canal-treated teeth from 824 CBCT images referred to the Dicle University Faculty of Dentistry, Department of Oral and Maxillofacial Radiology between January 2015 and December 2017. All images were taken with an I-CAT Vision (Imaging Sciences International, Hatfield, PA, USA). The scanning parameters were 120 kVp, 5 mA, 8–9 s acquisition time, 0.3 mm voxel size, and 13 cm × 10 cm image area. When the images from each patient were obtained, ALARA as reasonably achievable" principle was followed, which advocates using the minimum dose of radiation required for diagnosis. CBCT images with poor image quality and having radiological artifact were excluded. Furthermore, teeth that had undergone endodontic surgery, root fractures or trauma, root perforation or root resorption altering the anatomy of the root, and having marginal bone loss of more than 4 mm were excluded.

Of the patients, 181 were female and 152 were male. All the patients had one or more teeth with a history of endodontic treatment. The ages of the participants were arranged in five groups: 18–25, 26–35, 36–45, 46–55, and ≥56 years.

Each patient's age, gender, quality of RCF and CR, and CBCT periapical index (CBCTPAI) scores of the teeth were noted. All radiographs were viewed on 15.6" laptop screen (Dell Inc., Round Rock, TX, USA). They were evaluated independently by an endodontist and a radiologist. The presence of untreated canals and AP were evaluated first on axial section images and subsequently confirmed on sagittal and panoramic section images. Diameter of periapical radiolucency and the length of endodontic treatment were measured on sagittal section; the density of RCF was evaluated on axial and sagittal section together. All measurements were made on the same laptop to rule out changes in image resolution. Image manipulation was not allowed using the development tools of the tracer solution such as magnification, contrast, and brightness.

All images were examined according to parameters.

### Periapical status

AP was assessed by the CBCTPAI[19] for each of the treated teeth and scored as follows:

- Score 1: Diameter of periapical radiolucency >0.5–1 mm (healthy)
- Score 2: Diameter of periapical radiolucency > 1–2 mm
- Score 3: Diameter of periapical radiolucency > 2–4 mm
- Score 4: Diameter of periapical radiolucency > 4–8 mm
- Score 5: Diameter of periapical radiolucency > 8 mm.

The teeth in the images were assembled into groups according to the quality of RCF and CR. The parameters used for evaluation were based on Tronstad *et al*.[5] and Kirkevang *et al*.[6] studies as follows:

### Endodontic treatment

*The length was measured in millimeters*

- Short: Shorter than 2 mm from the radiographic apex
- Adequate: 0–2 mm is the distance from the radiographic apex
- Over extended: Root-filling material was overflowed into the periapical region.

*The density of root canal filling*

- Adequate: The RCF has good adaptation with the root canal walls and uniform radiopacity
- Inadequate: The RCF has space appears laterally along the filling, nonuniform radiopacity.

*The status of coronal restoration*

- Acceptable: Acceptable restoration (with intact margins)
- Unacceptable: Unacceptable restoration (presence of caries and/or disrupted margins)
- Missing: Loss of restoration (broken or lost).

*Type of coronal restoration*

- Amalgam
- Composite
- Crown
- Post
- Post and crown.

SPSS software (version 21.0; IBM, Chicago, IL, USA) was used for statistical analyses. The Chi-square test was used with the independent variables, gender, age, quality of RCF, type of CR, and quality of CR in relation to AP. A value of $P < 0.05$ was considered as statistically significant.

## RESULTS

The total number of endodontically treated teeth was 550 from 152 (45.6%) male patients and 181 (54.3%) female patients. The mean age was 30.1 ± 5.3 years. On the basis of the CBCTPAI scoring system, 419 (76.2%) teeth had AP. A total of 131 teeth were recorded as healthy. The majority of people by age group were aged 36–45 years [Table 1]. The prevalence of AP in different age groups were 87.5% in 18–25, 72.9% in 26–35, 75.7% in 36–25, 73.7% in 46–55, and 75.8% in ≥ 56.

For the 312 (56.7%) teeth with adequate endodontic treatment, the success rate was 33.9%. However, in 238 (43.3%) teeth with inadequate endodontic treatment, the rate of AP was 89.5%. There was statistically correlation between the quality of endodontic treatment and AP ($P = 0.00$) [Table 2].

Of the 332 teeth (60.4%) found to have acceptable CR, 33.4% (111) were scored as CBCTPAI 1. Unacceptable restorations consisted of 177 teeth (32.2%), of which 10.1% (18) of the teeth were CBCTPAI 1. Of the 41 teeth with missing CR, 39 (95.1%) teeth showed signs of AP [Table 2]. This evidence demonstrates the significant difference observed when comparing treatment outcomes for teeth with acceptable and unacceptable restorations ($P = 0.00$).

For the 297 (54%) teeth with adequate length, the success rate was 33.6%. The group with short length consisted of 214 teeth (38.9%), and the success rate in this group was 12.1%. A total of 39 (7.1%) teeth had over extended length, and in this group, the AP rate was 87.1% [Table 3].

**Table 1: The distribution of apical periodontitis according to cone beam computed tomography periapical index belonging to different age groups and gender**

| | CBCTPAI | | | | | Total, *n* (%) |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| Age group | | | | | | |
| 18-25 | 6 | 4 | 11 | 16 | 11 | 48 (14.4) |
| 26-35 | 13 | 1 | 10 | 17 | 7 | 48 (14.4) |
| 36-45 | 23 | 2 | 13 | 39 | 18 | 95 (28.5) |
| 46-55 | 21 | 1 | 20 | 30 | 8 | 80 (24.0) |
| ≥56 | 15 | 3 | 12 | 18 | 14 | 62 (18.6) |
| Gender | | | | | | |
| Male | 39 | 3 | 29 | 50 | 31 | 152 (45.6) |
| Female | 39 | 8 | 37 | 70 | 27 | 181 (54.3) |

*n*: Number of CBCT scans, CBCT: Cone beam computed tomography, CBCTPAI: CBCT periapical index

**Table 2: Cone beam computed tomography periapical index of root canal treated teeth as related to the quality of the coronal restoration with the quality of the endodontic treatment**

| Quality | CBCTPAI | | | | | Total, *n* (%) |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| CR | | | | | | |
| Acceptable | 111 | 60 | 72 | 87 | 2 | 332 (60.4) |
| Unacceptable | 18 | 16 | 38 | 78 | 27 | 177 (32.2) |
| Missing | 2 | 2 | 19 | 13 | 5 | 41 (7.5) |
| Endodontic treatment | | | | | | |
| Adequate | 106 | 59 | 80 | 61 | 6 | 312 (56.7) |
| Inadequate | 25 | 19 | 49 | 117 | 28 | 238 (43.3) |

*n*: Number of teeth, CBCT: Cone beam computed tomography, CBCTPAI: CBCT periapical index ($P<0.05$), CR: Coronal restoration

A statistically correlation was observed between the length of RCF and AP ($P = 0.00$).

CR was found in 509 teeth (92.6%), and of these, amalgam restorations and crowns were the mostly used. The success rate according to type of restoration was 28% for amalgam, 21.6% for composite, 23.7% for crown, and 32.7% for post, and post and crown. There was statistically significant correlation between type of CR and AP ($P = 0.01$) [Table 4].

## DISCUSSION

In this cross-sectional study, periradicular periodontitis was detected on scans of 333 of 824 CBCT images (40.4%). The prevalence of AP in 550 endodontically treated teeth was 76.2%. This frequency was higher than previously reported cross-sectional studies in Turkish population.[12,13,21,22]

Our sample consisted of 54.3% females and 45.6% males which indicated that females are more interested in dental care than males. In the age groups, 36–45 years (28.5%) and 46–55 years (24%) had the highest number of root-filled teeth. In our study, the prevalence of AP belonging to different age groups was similar. However, Paes da Silva Ramos Fernandes *et al*.[23] found that the highest prevalence

**Table 3: Periapical status of root canal-treated teeth as related to quality of the endodontic treatment determined by the length**

| Length of RCF | CBCTPAI | | | | | Total, *n* (%) |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| Short | 26 | 33 | 50 | 84 | 21 | 214 (38.9) |
| Adequate | 100 | 40 | 70 | 77 | 10 | 297 (54) |
| Over extended | 5 | 5 | 9 | 17 | 3 | 39 (7.1) |

*n*: Number of teeth, CBCT: Cone beam computed tomography, CBCTPAI: CBCT periapical index ($P<0.05$), RCF: Root canal filling

**Table 4: Distribution of apical periodontitis in root canal-treated teeth according to the type of coronal restoration**

| Type of restoration | CBCTPAI | | | | | Total, *n* (%) |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| Amalgam | 37 | 19 | 24 | 42 | 10 | 132 (25.9) |
| Composite | 26 | 17 | 23 | 52 | 2 | 120 (23.5) |
| Crown | 48 | 35 | 48 | 56 | 15 | 202 (39.6) |
| Post | 6 | 1 | 2 | 4 | 0 | 13 (2.5) |
| Post+crown | 12 | 4 | 13 | 11 | 2 | 42 (8.2) |

*n*: Number of teeth, CBCT: Cone beam computed tomography, CBCTPAI: CBCT periapical index ($P<0.05$)

of AP was found in people aged 60–69 years (73.1%). In addition, Corbett *et al*.[24] found that in older age groups (≥56 age), the number of missing teeth was so prevalent causing reduction of the AP prevalence.

In the present study, the length and quality of RCF were found to have important statistical effects on AP. For the 238 (43.3%) teeth with inadequate endodontic treatment, the success rate was 10.5%. The group with short and over extended length of filling corresponded to 253 (46%) of the examined cases and had a success rate of 12.2%. This information is supported by data from other researchers.[17-19] It has been confirmed that inadequate root canal treatment poses a higher risk of AP occurrence.[25] However, root canal treatment is known to involve many procedures, for example, inadequate canal cleansing and shaping, use of poor aseptic techniques, complex canal anatomy, and lack of rubber dams. Therefore, it is not possible to judge the quality of treatment based on numerical data.[23] This is a limitation of our study because the biological factors and conditions of clinical treatment are unknown. This indicates a significant potential for AP to occur in the remaining poorly filled teeth.

The current study found a statistical relationship between the quality of CR in root canal-treated teeth and AP. For the 332 (60.4%) teeth with acceptable restorations, the success rate was 33.4%. Other studies support this findings.[12,14,21,22,25] The quality of the CR was important factor that impacted the post-treatment AP of endodontically treated teeth. In this study, no statistical difference was observed in teeth with both an adequate density endodontic filling/unacceptable restoration and inadequate density endodontic filling/acceptable restoration. Hommez *et al*.[26] reported that an adequate CR was as significantly important as adequate RCF for healing AP in root canal treated teeth. According to Gündüz *et al*.,[12] the quality of the RCF is a basic component for incidence of AP with or without adequate CR. However, Tronstad *et al*.[5] and Siqueira and Rôças[27] reported that the quality of the CR was significantly less important than the quality of the RCF. In the present study, root canal-treated teeth with an amalgam restoration showed less AP than crowned teeth, which other authors supported.[28,29] However, Kayahan *et al*.[15] reported the success of root canal treatment was related to adequate RCF regardless of the type of CR. From the results of the current study, it can be noticed that periapical health after endodontic treatment is associated with the technical quality of both the root fillings and restorations.

The current study was carried out using CBCT images due to the limitations of radiographic images in the assessment of AP.[18] CBCT is important to provide three-dimensional, multislice imaging information, determination of AP, and the quality and density of RCF.[30-32] When using CBCT compared with two-dimensional images, inadequate root fillings are visible as it eliminates the superposition of RCF materials. Furthermore, the buccolingual dimension on sagittal section of the root filling is only available on CBCT scans.[33] In 80% of roots, the apical foramen is up to 3.8 mm shorter than the anatomic apex and is often located on the buccal or lingual aspect of the root.[34] Therefore, many short RCF on periapical radiography were not short on CBCT. However, CBCT is more expensive and the patient receives higher overall radiation exposure.[35,36]

The main disadvantage of a cross-sectional study is that clinical symptoms and histological evaluation can be misleading when there is no evidence regarding when treatment or restoration took place and researchers are unable to determine whether lesions were healing.[12] Therefore, this is a critical limitation of this study, and CBCT scans were not specified. On the other hand, Petersson *et al*.[35] noticed that the number of healed periapical lesions was equal to the number of developing lesions after a 10-year period. Thus, cross-sectional studies can provide dependable results about outcomes of root canal treatment.[36]

## CONCLUSIONS

The RCF quality, adequate CR, and the type of CR were significantly correlated with the high (87.7%) presence of AP in endodontically treated teeth of the evaluated Turkish

subpopulation. Therefore, root canal treatments should be evaluated as a whole.

## Acknowledgment

The authors would like to thank Dr. Burcu GUCYETMEZ TOPAL for helping statistical analyzing.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

## REFERENCES

1. Arnold M, Ricucci D, Siqueira JF Jr. Infection in a complex network of apical ramifications as the cause of persistent apical periodontitis: A case report. J Endod 2013;39:1179-84.
2. Sjogren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endod 1990;16:498-504.
3. Ricucci D, Russo J, Rutberg M, Burleson JA, Spångberg LS. A prospective cohort study of endodontic treatments of 1,369 root canals: Results after 5 years. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:825-42.
4. Chen CY, Hasselgren G, Serman N, Elkind MS, Desvarieux M, Engebretson SP. Prevalence and quality of endodontic treatment in the Northern Manhattan elderly. J Endod 2007;33:230-4.
5. Tronstad L, Asbjørnsen K, Døving L, Pedersen I, Eriksen HM. Influence of coronal restorations on the periapical health of endodontically treated teeth. Endod Dent Traumatol 2000;16:218-21.
6. Kirkevang LL, Hörsted-Bindslev P, Ørstavik D, Wenzel A. Frequency and distribution of endodontically treated teeth and apical periodontitis in an urban Danish population. Int Endod J 2001;34:198-205.
7. Dias MC, Martins JN, Chen A, Quaresma SA, Luís H, Caramês J. Prognosis of indirect composite resin cuspal coverage on endodontically treated premolars and molars: An *in vivo* prospective study. J Prosthodont 2018;27:598-604.
8. Patel S, Dawood A, Mannocci F, Wilson R, Pitt Ford T. Detection of periapical bone defects in human jaws using cone beam computed tomography and intraoral radiography. Int Endod J 2009;42:507-15.
9. Alrahabi M, Younes HB. A cross-sectional study of the quality of root canal treatment in Al-Madinah Al-Munawwarah. Saudi Endod J 2016;6:31-5.
10. Chakravarthy PK, Moorthy JK. Radiographic assessment of quality of root fillings performed by undergraduate students in a Malaysian dental school. Saudi Endod J 2013;3:77-81.
11. Karabucak B, Bunes A, Chehoud C, Kohli MR, Setzer F. Prevalence of apical periodontitis in endodontically treated premolars and molars with untreated canal: A Cone-beam computed tomography study. J Endod 2016;42:538-41.
12. 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;11:20.
13. Gumru B, Tarcin B, Pekiner FN, Ozbayrak S. Retrospective radiological assessment of root canal treatment in young permanent dentition in a Turkish subpopulation. Int Endod J 2011;44:850-6.
14. Özbaş H, Aşcı S, Aydın Y. Examination of the prevalence of periapical lesions and technical quality of endodontic treatment in a Turkish subpopulation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:136-42.
15. Kayahan MB, Malkondu O, Canpolat C, Kaptan F, Bayirli G, Kazazoglu E. Periapical health related to the type of coronal restorations and quality of root canal fillings in a Turkish subpopulation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;105:e58-62.
16. Falakaloglu S, Veis A. Determining the size of the mental foramen: A cone-beam computed tomography study. Int Dent Res 2017;7:20-5.
17. Liang YH, Yuan M, Li G, Shemesh H, Wesselink PR, Wu MK. The ability of cone-beam computed tomography to detect simulated buccal and lingual recesses in root canals. Int Endod J 2012;45:724-9.
18. Lofthag-Hansen S, Huumonen S, Gröndahl K, Gröndahl HG. Limited cone-beam CT and intraoral radiography for the diagnosis of periapical pathology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103:114-9.
19. Estrela C, Bueno MR, Leles CR, Azevedo B, Azevedo JR. Accuracy of cone beam computed tomography and panoramic and periapical radiography for detection of apical periodontitis. J Endod 2008;34:273-9.
20. Tanomaru-Filho M, Lima RK, Nakazone PA, Tanomaru JM. Use of computerized tomography for diagnosis and follow-up after endodontic surgery: Clinical case report with 8 years of follow-up. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109:629-33.
21. Kalender A, Orhan K, Aksoy U, Basmaci F, Er F, Alankus A. Influence of the quality of endodontic treatment and coronal restorations on the prevalence of apical periodontitis in a Turkish Cypriot population. Med Princ Pract 2013;22:173-7.
22. Cakici EB, Yildirim E, Cakici F, Erdogan AS. Assessment of periapical health, quality of root canal filling, and coronal restoration by using cone-beam computed tomography. Niger J Clin Pract 2016;19:673-7.
23. Paes da Silva Ramos Fernandes LM, Ordinola-Zapata R, Húngaro Duarte MA, Alvares Capelozza AL. Prevalence of apical periodontitis detected in cone beam CT images of a Brazilian subpopulation. Dentomaxillofac Radiol 2013;42:80179163.
24. Corbett J, Dobbie F, Doig M. Scottish Health Survey 2009. Main Report. 1st ed., Vol. 1. Glasgow: The Scottish Government; 2010.
25. Nair PN. Pathogenesis of apical periodontitis and the causes of endodontic failures. Crit Rev Oral Biol Med 2004;15:348-81.
26. Hommez GM, Coppens CR, De Moor RJ. Periapical health related to the quality of coronal restorations and root fillings. Int Endod J 2002;35:680-9.
27. Siqueira JF Jr., Rôças IN. Clinical implications and microbiology of bacterial persistence after treatment procedures. J Endod 2008;34:1291-301.e3.
28. Buckley M, Spångberg LS. The prevalence and technical quality of endodontic treatment in an American subpopulation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;79:92-100.
29. Loftus JJ, Keating AP, McCartan BE. Periapical status and quality of endodontic treatment in an adult Irish population. Int Endod J 2005;38:81-6.
30. Aktuna Belgin C, Adiguzel O, Bud M, Colak M, Akkus Z. Mandibular buccal bone thickness in Southeastern Anatolian people: A cone-beam computed tomography study. Int Dent Res 2017;7:6-12.
31. Hassan B, Metska ME, Ozok AR, van der Stelt P, Wesselink PR. Detection of vertical root fractures in endodontically treated teeth by a cone beam computed tomography scan. J Endod 2009;35:719-22.
32. Cangul S, Adiguzel O. Cone-beam three-dimensional dental volumetric tomography in dental practice. Int Dent Res 2017;7:62-70.
33. van der Sluis LW, Wu MK, Wesselink PR. An evaluation of the quality of root fillings in mandibular incisors and maxillary and mandibular canines using different methodologies. J Dent 2005;33:683-8.
34. El Ayouti A, Weiger R, Löst C. Frequency of overinstrumentation with an acceptable radiographic working length. J Endod 2001;27:49-52.
35. Petersson K, Håkansson R, Håkansson J, Olsson B, Wennberg A. Follow-up study of endodontic status in an adult Swedish population. Endod Dent Traumatol 1991;7:221-5.
36. Hugoson A, Koch G, Göthberg C, Helkimo AN, Lundin SA, Norderyd O, *et al.* Oral health of individuals aged 3-80 years in Jönköping, Sweden during 30 years (1973-2003). II. Review of clinical and radiographic findings. Swed Dent J 2005;29:139-55.