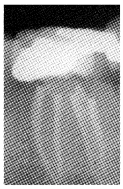
doi:10.1111/j.1365-2591.2007.01324.x



CLINICAL ARTICLE

Frequency of root-filled teeth and prevalence of apical periodontitis in an adult Turkish population

K. Gulsahi[1], A. Gulsahi[2], M. Ungor[1] & Y. Genc[3]

[1]Department of Endodontics, Faculty of Dentistry, Baskent University, Ankara; [2]Department of Oral Diagnosis and Radiology, Faculty of Dentistry, Baskent University, Ankara; and [3]Department of Biostatistics, Faculty of Medicine, Ankara University, Ankara, Turkey

Abstract

Gulsahi K, Gulsahi A, Ungor M, Genc Y. Frequency of root-filled teeth and prevalence of apical periodontitis in an adult Turkish population. *International Endodontic Journal*, **41**, 78–85, 2008.

Aim To report the frequency and distribution of root-filled teeth as well as the prevalence of apical periodontitis in an adult population in Turkey.

Summary Digital panoramic radiographs of 1000 patients who were examined at the Baskent University Faculty of Dentistry between December 2004 and May 2005 were evaluated. Patients ageing <15 years and those with less than nine remaining teeth were excluded. The coronal and periapical status of all the teeth with the exception of third molars was examined according to the criteria proposed by De Moor *et al.* (2000). Statistical analysis was performed with the Rao and Scott adjusted chi-square test for the comparison of clustered binary data. In all, 24 433 teeth were examined. A total of 346 teeth (1.4%) had radiographic signs of apical periodontitis, and 812 were root filled (3.3%). Of the 812 root-filled teeth, 148 (18.2%) had apical periodontitis. Of the 23 621 nonroot-filled teeth, 198 (0.8%) had apical periodontitis. The number of root-filled teeth in male subjects was significantly less than that in female subjects ($P < 0.001$), but the presence of apical periodontitis in male subjects was significantly higher than that in female subjects ($P < 0.05$).

Key learning points

- The prevalence of apical periodontitis and the frequency of root-filled teeth with apical periodontitis were lower than in comparable populations in other countries.
- The number of root-filled teeth was comparable to that found in other epidemiologic studies.

Keywords: apical periodontitis, epidemiology, radiographic evaluation, root canal treatment.

Received 4 December 2006; accepted 2 July 2007

Correspondence: Kamran Gulsahi, Department of Endodontics, Baskent University, Faculty of Dentistry, 11. sokak, No: 26, 06490 Bahcelievler, Ankara, Turkey (Tel.: 0090312 2151336-107; fax: 0090312 2152962; e-mails: kgulsahi@yahoo.com, kgulsahi@baskent.edu.tr).

Introduction

Apical periodontitis has been reported to be a widespread disease in adult population (Hommez *et al.* 2002, Kabak & Abbott 2005). Several epidemiologic studies have reported that 24.5–61% of adults have apical periodontitis (Marques *et al.* 1998, De Moor *et al.* 2000, Georgopoulou *et al.* 2005, Kabak & Abbott 2005, Loftus *et al.* 2005). It has also been reported that both the presence of root-filled teeth along with the quality of the root filling and coronal restoration are associated with a higher prevalence of apical periodontitis (Hommez *et al.* 2002, Kirkevang & Wenzel 2003).

The pulp and periapical status can be used to predict tooth survival and the need for future dental treatment (Kirkevang *et al.* 2001, Jimenez-Pinzon *et al.* 2004). In Turkey, only one epidemiologic study of periapical and pulp status appears to have been published (Sunay *et al.* 2007). The aim of the present study was to evaluate the frequency of root-filled teeth and the prevalence of apical periodontitis in an adult Turkish subpopulation.

Materials and methods

This epidemiologic study included all the patients who were examined at the Baskent University Faculty of Dentistry between December 2004 and May 2005. Patients ageing <15 years and those with less than nine remaining teeth were excluded. Thus, 502 patients were excluded: 320 were under 15 years of age and 182 had less than nine remaining teeth. Teeth that had root resections or hemisection were also excluded as well teeth that could not be properly evaluated because of the superimposition of anatomic structures on radiographic images. Multirooted teeth were scored according to the root with the most severe periapical status; this resulted in 1000 panoramic radiographs to be examined. All panoramic radiographs were taken by the same radiographer, who used a digital panoramic unit (PM 2002 EC Proline DIMAX2; Planmeca, Helsinki, Finland). Two examiners (an oral radiologist and an endodontist) evaluated the radiographs. Before the study, 20 panoramic radiographs not included in the survey were used to calibrate the two examiners. Missing or unrestored teeth, restorations, crowns, root-filled teeth and apical periodontitis were identified. The following terms (De Moor *et al.* 2000) were used to categorize the cases:

1. Root-filled tooth: A tooth with a radiopaque material in the root canals.

2. Apical periodontitis: more than double widening of the periodontal ligament space on the lateral aspect of a tooth or the presence of a radiolucent area connected with the apical part of the root in the periapical region.

3. Filling: restoration with what appeared to be a plastic restorative material of the coronal part of the tooth.

4. Crown: restoration with a metal or porcelain-fused-to-metal crown of the coronal part of the tooth.

5. Unrestored tooth: intact tooth with no radiographic signs of caries or restoration.

6. Caries: radiographically detectable radiolucent lesion within the crown of the tooth (with and without restoration).

Data on the age and gender of subjects, the tooth type, and the frequency of radiographically visible periapical pathosis were examined. Inter-examiner reproducibility was determined by calculating the kappa values for the detection of periapical radiolucency. For apical periodontitis, kappa values were >0.9, indicating a high degree of interobserver agreement. In case of disagreement, the two observers came to consensus. The adjusted chi-square test was used to compare clustered binary data (Rao & Scott 1992).

Results

The age of the subjects ranged from 16 to 80 years (mean age, 41.4 ± 15.8 years). The distribution of patients by age group and the presence of apical periodontitis are shown in Table 1. In the population studied, 60.7% were female and 39.3% were male. The periapical status of 322 teeth was impossible to determine because of radiographic factors. Teeth categorized as not assessable were excluded from further analysis. Therefore, in the present study, 24 433 teeth and their associated periradicular regions were examined. The mean number of teeth per patient was 24.4 ± 4.1. Table 2 provides an overview of the distribution of missing, unrestored, restored, crowned and root-filled teeth according to tooth type. If the third molar teeth are excluded, 3567 teeth were missing (55% in the maxilla and 45% in the mandible). Mandibular first molars were missing more often than any other teeth, and mandibular canines were the teeth least often missing. In total, 3308 teeth (13.5%) had been restored with coronal plastic material or amalgam, and 1964 teeth (8.0%) had been restored with a crown. Unrestored teeth included 18 121 intact teeth and 1040 teeth with carious lesions.

Root fillings were present in 812 teeth (3.3% of all teeth examined). Significantly more root-filled teeth were in the maxilla (62.3%) compared with the mandible (37.7%)

Table 1 Distribution of AP in age groups

Patient age (years)	No. patients	No. patients with AP	Patients with AP (%)	95% CI
16–25	233	41	17.6	12.7–22.5
26–35	174	37	21.3	15.2–27.4
36–45	132	34	25.8	18.3–33.3
46–55	260	69	26.5	21.1–31.9
56–65	142	40	28.2	20.8–35.6
>65	59	17	28.8	17.2–40.4
Total	1000	238	23.8	21.2–26.4

AP, apical periodontitis; CI, confidence interval.

Table 2 Distribution of missing teeth, unrestored teeth, restorations, crowns, and root-filled teeth according to tooth type

	All teeth studied					Nonroot-filled teeth				Root-filled teeth		
		NRT				NRT						
Tooth type	M	I	Ca	F	Cr	I	Ca	F	Cr	Ca	F	Cr
Maxilla												
Incisors	199	3037	123	333	308	3037	120	291	246	3	42	62
Canines	116	1544	49	97	194	1544	43	70	162	6	27	32
Pre-molars	768	2082	239	513	398	2082	230	419	295	9	94	103
Molars	888	1724	216	876	296	1724	210	788	262	6	88	34
Subtotal	1971	8387	627	1819	1196	8387	603	1568	965	24	251	231
Mandible												
Incisors	130	3752	35	35	48	3752	35	34	43	0	1	5
Canines	13	1808	43	52	84	1808	40	43	77	3	9	7
Pre-molars	380	2741	159	362	358	2741	144	300	297	15	62	61
Molars	1073	1433	176	1040	278	1433	166	958	227	10	82	51
Subtotal	1596	9734	413	1489	768	9734	385	1335	644	28	154	124
Total	3567	18121	1040	3308	1964	18121	988	2903	1609	52	405	355

M, missing; NRT, nonrestored teeth; I, intact; Ca, caries; F, filling; Cr, crown.

Table 3 Frequency of apical periodontitis by tooth type

	All teeth studied			Nonroot-filled teeth			Root-filled teeth		
		Apical periodontitis			Apical periodontitis			Apical periodontitis	
Tooth type	Total no.	*n*	%	Total no.	*n*	%	Total no.	*n*	%
Maxilla									
Incisors	3801	26	0.7	3694	14	0.4	107	12	11.2
Canines	1884	15	0.8	1819	8	0.4	65	7	10.8
Pre-molars	3232	44	1.4	3026	22	0.7	206	22	10.7
Molars	3112	80	2.6	2984	47	1.6	128	33	25.8
Subtotal	12029	165	1.4	11523	91	0.8	506	74	14.6
Mandible									
Incisors	3870	12	0.3	3864	12	0.3	6	0	0
Canines	1987	10	0.5	1968	8	0.4	19	2	10.5
Pre-molars	3617	45	1.2	3482	24	0.7	138	21	15.2
Molars	2927	114	3.9	2784	63	2.3	143	51	35.7
Subtotal	12404	181	1.5	12098	107	0.9	306	74	24.2
Total	24433	346	1.4	23621	198	0.8	812	148	18.2

($P < 0.001$). The right maxillary second pre-molars were root filled more than any other tooth, followed by the right mandibular first molars, and the right maxillary first pre-molars. The right mandibular lateral incisors and the left mandibular central and lateral incisors were root filled least often.

The periapical condition of the teeth is shown in Table 3. Apical periodontitis was detected in 346 of the 24 433 teeth studied, that is, in 1.4% of all teeth. Of the 23 621 nonroot-filled teeth, 198 (0.8%) had apical periodontitis. Of the 812 root-filled teeth, 148 (18.2%) had apical periodontitis. In the root-filled teeth, lesions were observed most often in the mandibular molars (35.7%) and maxillary molars (25.8%). The percentage of apical periodontitis of all teeth was 1.4% in the maxilla and 1.5% in the mandible. No difference in the presence of apical periodontitis of all teeth in the maxilla and mandible was observed ($P > 0.05$). Of the 14 819 teeth assessed in 607 female subjects; 555 (3.75%) had been root filled, and 186 (1.26%) teeth with apical periodontitis were detected. Of the 9614 teeth assessed in 393 male subjects; 257 (2.67%) had been root filled, and 160 (1.66%) teeth had apical periodontitis. The number of root-filled teeth in male subjects was significantly less than that in female subjects ($P < 0.001$). However, the presence of apical periodontitis in male subjects was significantly higher than that in female subjects ($P < 0.05$).

Discussion

The study population consisted of patients treated at the Baskent University Faculty of Dentistry and does not represent a random sample of the adult Turkish population. However, the data derived from the study provide useful information for the assessment of trends regarding the prevalence of apical periodontitis, as well as general dental condition of the population.

The interpretation of radiographs (periapical, panoramic, or a combination of panoramic and periapical) is the only method that can be used to evaluate periapical health in an epidemiologic study. In the present study, data on the prevalence of apical periodontitis in an adult population in Turkey were obtained from the analysis of digital panoramic radiographs. Some investigators have suggested that a full-mouth series of periapical

radiographs instead of panoramic radiographs should be evaluated, because the sensitivity of the latter is considered to be less than that of periapical radiographs in the detection of periapical lesions (especially in the anterior region) (Allard & Palmqvist 1986, Bergstrom *et al.* 1987, Eckerbom *et al.* 1989, Petersson *et al.* 1989, Odesjo *et al.* 1990, Rohlin *et al.* 1991, Buckley & Spangberg 1995, Weiger *et al.* 1997, Kirkevang *et al.* 2001, Boucher *et al.* 2002, Georgopoulou *et al.* 2005). In addition, when panoramic radiography was used, an underestimation of lesions occurred (Grondahl *et al.* 1970, Eriksen & Bjertness 1991). However, other studies concluded that the use of panoramic radiography in epidemiologic studies of dental health was acceptable and the difference between periapical and panoramic radiographs for detection of apical periodontitis was not statistically significant (Muhammed *et al.* 1982, Ahlqwist *et al.* 1986). The fact that all teeth can be seen on one panoramic radiograph, the relatively low exposure to ionizing radiation, the convenience of panoramic radiographs, and the speed with which they can be obtained are advantageous when compared with full-mouth periapical radiographs (De Moor *et al.* 2000, Lupi-Pegurier *et al.* 2002, Kabak & Abbott 2005, Loftus *et al.* 2005). The underestimation of scoring periapical lesions on panoramic radiographs of good quality is thus low, and the validity of evaluating the periapical condition on panoramic radiography is reliable. This is also confirmed by evaluations of the specificity for detecting apical periodontitis on panoramic radiographs (Molander *et al.* 1995a,b). In this study, to minimize bias, only radiographs of high quality were included, and before starting the evaluation, the two examiners were calibrated. However, there is a possibility that some information on apical periodontitis was not recorded based on panoramic radiographs only. Digital panoramic radiographs are used in the clinic as general screening for all patients and they were available for use.

The study sample consisted of more women (60.7%) than men (39.3%), which may reflect the greater interest of women within Turkey in receiving dental care and attending for check-ups. Similar epidemiologic studies have also shown a female subject predominance; however, those studies reported that gender did not correlate with the number of root-filled teeth or the presence of apical periodontitis (Boucher *et al.* 2002, Jimenez-Pinzon *et al.* 2004, Georgopoulou *et al.* 2005). In this study, there were significantly fewer root-filled teeth in men than in women ($P < 0.001$), but the presence of apical periodontitis in men was significantly higher than that in women ($P < 0.05$).

The mean number of remaining teeth per patient in this study was 24.4 ± 4.1, which is similar to that in other recent reports (Jimenez-Pinzon *et al.* 2004, Georgopoulou *et al.* 2005, Kabak & Abbott 2005). However, in the present sample, the large numbers of remaining teeth may be because of a selection bias. Individuals with less than nine remaining teeth were excluded from the study, because they often had periodontal disease and it was impossible to determine the role played by the endodontic treatment in the occurrence of a radiographic periapical lesion (De Cleen *et al.* 1993, Lupi-Pegurier *et al.* 2002, Jimenez-Pinzon *et al.* 2004). However, the exclusion of these patients may have resulted in a large numbers of remaining teeth in the included population.

In the present study, the presence of periapical lesions in all teeth was 1.4%. That finding is comparable to (Kirkevang *et al.* 2001, 3.4%; Jimenez-Pinzon *et al.* 2004, 4.2%) or less than the results of similar studies (De Moor *et al.* 2000, 6.6%; Boucher *et al.* 2002, 7.4%; Lupi-Pegurier *et al.* 2002, 7.3%; Georgopoulou *et al.* 2005, 13.6%). However, such findings from related studies should be compared with caution because of the variations in sampling procedures and varieties of participants, the type of radiograph examined and the criteria for diagnosing dental disease, etc. In this study, discrepancies may have been caused by methodological differences or by the extraction of the teeth with apical periodontitis. Moreover, it might be that the indication for root canal treatment was based on treating teeth with vital pulps and not teeth with

periapical lesions; these latter teeth may have been extracted. Thus, the results might vary from those in another population in Turkey.

The results revealed that 3.3% of the teeth had been root filled, a finding comparable to that in other studies (De Cleen *et al.* 1993, Buckley & Spangberg 1995, De Moor *et al.* 2000, Kirkevang *et al.* 2001, Jimenez-Pinzon *et al.* 2004, Loftus *et al.* 2005, Sunay *et al.* 2007) but lower than that in other investigations (Boucher *et al.* 2002, Lupi-Pegurier *et al.* 2002, Kabak & Abbott 2005). In the present study, there were significantly more root-filled teeth in the maxilla (62.3%) than in the mandible (37.7%) ($P < 0.001$), and more premolars and molars than anterior teeth were root filled. These findings support those from other studies (Kirkevang *et al.* 2001, Georgopoulou *et al.* 2005, Kabak & Abbott 2005).

The number of root-filled teeth with apical periodontitis in reported studies ranges widely from 24.5% to 61% (Kabak & Abbott 2005). In this study, 18.2% of root-filled teeth had apical periodontitis, which is lower than that reported in the many countries: Spain, 64.5% (Jimenez-Pinzon *et al.* 2004); Greece, 60.0% (Georgopoulou *et al.* 2005); Norway, 52.2% (Kirkevang *et al.* 2001); Belarus, 45% (Kabak & Abbott 2005); Japan, 40% (Tsuneishi *et al.* 2005); Lithuania, 39% (Sidaravicius *et al.* 1999); France, 31.5% (Lupi-Pegurier *et al.* 2002); the United States, 31.3% (Buckley & Spangberg 1995); and Ireland, 25% (Loftus *et al.* 2005). Interestingly, the result was also lower than in other regions of Turkey (53.5%, Sunay *et al.* 2007). However, it should be noted that periapical pathosis is not always detected radiographically. Furthermore, from the periapical lesions seen on a radiograph it is not possible to determine whether or not it is healing. The results of Green *et al.* (1997) revealed that periapical radiolucency indicated an inflammatory process, whereas the absence of periapical radiolucency usually, but not always, indicated the treated tooth periapex to be free of inflammation. This contrasts with the often-cited study (Seltzer 1999) that reported inflammation with absence of radiographic indicators. Similarly, Barthel *et al.* (2004) reported that the negative predictive value of radiographs about the apical periodontitis was 0.67. Therefore, the prevalence of apical periodontitis in this study must be an underestimation of the real situation.

Conclusions

The results of this study indicated a low prevalence of apical periodontitis (1.4% of all teeth) in an adult Turkish subpopulation. The presence of root-filled teeth was 3.3% of all teeth examined and the proportion of root-filled teeth with apical periodontitis was 18.2%.

Disclaimer

Whilst this article has been subjected to Editorial review, the opinions expressed, unless specifically indicated, are those of the author. The views expressed do not necessarily represent best practice, or the views of the IEJ Editorial Board, or of its affiliated Specialist Societies.

References

Ahlqwist M, Halling A, Hollender L (1986) Rotational panoramic radiography in epidemiological studies of dental health. Comparison between panoramic radiographs and intraoral full mouth surveys. *Swedish Dental Journal* **10**, 73–84.

Allard U, Palmqvist S (1986) A radiographic survey of periapical conditions in elderly people in a Swedish county population. *Endodontics and Dental Traumatology* **2**, 103–8.

Barthel CR, Zimmer S, Trope M (2004) Relationship of radiologic and histologic signs of inflammation in human root-filled teeth. *Journal of Endodontics* **30**, 75–9.

Bergstrom J, Eliasson S, Ahlberg KF (1987) Periapical status in subjects with regular dental care habits. *Community Dentistry and Oral Epidemiology* **15**, 236–9.

Boucher Y, Matossian L, Rilliard F, Machtou P (2002) Radiographic evaluation of the prevalence and technical quality of root canal treatment in a French subpopulation. *International Endodontic Journal* **35**, 229–38.

Buckley M, Spangberg LS (1995) The prevalence and technical quality of endodontic treatment in an American subpopulation. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics* **79**, 92–100.

De Cleen MJ, Schuurs AH, Wesselink PR, Wu MK (1993) Periapical status and prevalence of endodontic treatment in an adult Dutch population. *International Endodontic Journal* **26**, 112–9.

De Moor RJ, Hommez GM, De Boever JG, Delme KI, Martens GE (2000) Periapical health related to the quality of root canal treatment in a Belgian population. *International Endodontic Journal* **33**, 113–20.

Eckerbom M, Andersson JE, Magnusson T (1989) A longitudinal study of changes in frequency and technical standard of endodontic treatment in a Swedish population. *Endodontics and Dental Traumatology* **5**, 27–31.

Eriksen HM, Bjertness E (1991) Prevalence of apical periodontitis and results of endodontic treatment in middle-aged adults in Norway. *Endodontics and Dental Traumatology* **7**, 1–4.

Georgopoulou MK, Spanaki-Voreadi AP, Pantazis N, Kontakiotis EG (2005) Frequency and distribution of root filled teeth and apical periodontitis in a Greek population. *International Endodontic Journal* **38**, 105–11.

Green TL, Walton RE, Taylor JK, Merrell P (1997) Radiographic and histologic periapical findings of root canal treated teeth in cadaver. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics* **83**, 707–11.

Grondahl HG, Jonsson E, Lindahl B (1970) Diagnosis of periapical osteolytic process with orthopantomography and intraoral full mouth radiography-a comparison. *Swedish Dental Journal* **63**, 679–86.

Hommez GM, Coppens CR, De Moor RJ (2002) Periapical health related to the quality of coronal restorations and root fillings. *International Endodontic Journal* **35**, 680–9.

Jimenez-Pinzon A, Segura-Egea JJ, Poyato-Ferrera M, Velasco-Ortega E, Rios-Santos JV (2004) Prevalence of apical periodontitis and frequency of root-filled teeth in an adult Spanish population. *International Endodontic Journal* **37**, 167–73.

Kabak Y, Abbott PV (2005) Prevalence of apical periodontitis and the quality of endodontic treatment in an adult Belarusian population. *International Endodontic Journal* **38**, 238–45.

Kirkevang LL, Wenzel A (2003) Risk indicators for apical periodontitis. *Community Dentistry and Oral Epidemiology* **31**, 59–67.

Kirkevang LL, Horsted-Bindslev P, Ørstavik D, Wenzel A (2001) Frequency and distribution of endodontically treated teeth and apical periodontitis in an urban Danish population. *International Endodontic Journal* **34**, 198–205.

Loftus JJ, Keating AP, McCartan BE (2005) Periapical status and quality of endodontic treatment in an adult Irish population. *International Endodontic Journal* **38**, 81–6.

Lupi-Pegurier L, Bertrand MF, Muller-Bolla M, Rocca JP, Bolla M (2002) Periapical status, prevalence and quality of endodontic treatment in an adult French population. *International Endodontic Journal* **35**, 690–7.

Marques MD, Moreira B, Eriksen HM (1998) Prevalence of apical periodontitis and results of endodontic treatment in an adult, Portuguese population. *International Endodontic Journal* **31**, 161–5.

Molander B, Ahlqwist M, Grondahl HG (1995a) Image quality in panoramic radiography. *Dentomaxillofacial Radiology* **24**, 17–22.

Molander B, Ahlqwist M, Grondahl HG (1995b) Panoramic and restrictive intraoral radiography in comprehensive oral radiographic diagnosis. *European Journal of Oral Science* **103**, 191–8.

Muhammed AH, Manson-Hing LR, Ala B (1982) A comparison of panoramic and intraoral radiographic surveys in evaluating a dental clinic population. *Oral Surgery, Oral Medicine and Oral Pathology* **54**, 108–17.

Odesjo B, Hellden L, Salonen L, Langeland K (1990) Prevalence of previous endodontic treatment, technical standard and occurrence of periapical lesions in a randomly selected adult, general population. *Endodontics and Dental Traumatology* **6**, 265–72.

Petersson K, Lewin B, Hakansson J, Olsson B, Wennberg A (1989) Endodontic status and suggested treatment in a population requiring substantial dental care. *Endodontics and Dental Traumatology* **5**, 153–8.

Rao JN, Scott AJ (1992) A simple method for the analysis of clustered binary data. *Biometrics* **48**, 577–85.

Rohlin M, Kullendorff B, Ahlqwist M, Stenstrom B (1991) Observer performance in the assessment of periapical pathology: a comparison of panoramic with periapical radiography. *Dentomaxillofacial Radiology* **20**, 127–31.

Seltzer S (1999) Long-term radiographic and histological observations of endodontically treated teeth. *Journal of Endodontics* **25**, 818–22.

Sidaravicius B, Aleksejuniene J, Eriksen HM (1999) Endodontic treatment and prevalence of apical periodontitis in an adult population of Vilnius, Lithuania. *Endodontics and Dental Traumatology* **15**, 210–5.

Sunay H, Tanalp J, Dikbas I, Bayirli G (2007) 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**, 139–45.

Tsuneishi M, Yamamoto T, Yamanaka R *et al.* (2005) Radiographic evaluation of periapical status and prevalence of endodontic treatment in an adult Japanese population. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics* **100**, 631–5.

Weiger R, Hitzler S, Hermle G, Lost C (1997) Periapical status, quality of root canal fillings and estimated endodontic treatment needs in an urban German population. *Endodontics and DentalTraumatology* **13**, 69–74.