Prevalence of apical periodontitis and frequency of root-filled teeth in an adult Spanish population

A. Jiménez-Pinzón, J. J. Segura-Egea, M. Poyato-Ferrera, E. Velasco-Ortega & J. V. Ríos-Santos

Department of Stomatology, School of Dentistry, University of Seville, Seville, Spain

Abstract

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Aim To estimate the prevalence of teeth with apical periodontitis (AP) and root-filled teeth in an adult Spanish population.

Methodology A total of 180 subjects, aged 37.1 ± 15.7 years, presenting as new patients to the Faculty of Dentistry, Seville, Spain, were examined. All participants underwent a full-mouth radiographic survey (14 periapical radiographs). The frequency of root canal treatment and the periapical status of all teeth, using the periapical index (PAI) score, were assessed. An intraobserver agreement test on PAI scores produced a Cohen's kappa of 0.77 (substantial agreement). Results were analysed statistically using the Chi-square test.

Results Apical periodontitis in one or several teeth was found in 110 subjects (61.1% prevalence), and 73 (40.6% prevalence) had at least one root-filled tooth. Among subjects with root-filled teeth, 48 (65.8%) had AP affecting at least one root-filled tooth. A total of 4453 teeth were examined, of these 186 (4.2%) had AP. The total number of root-filled teeth was 93 (2.1%), of which 60 (64.5%) had AP. Among non-root filled teeth, only 2.9% had AP. The prevalence of AP in connection with molar teeth was higher (5.5%) than for premolar (4.5%) and anterior teeth (3.2%; $P < 0.01$). More premolar and molar teeth were root-filled (2.8 and 2.7%, respectively) than anterior teeth (1.3%; $P < 0.01$). The prevalence of AP increased with age.

Conclusions The prevalence of AP in root-filled and untreated teeth, and the frequency of root-filled teeth were comparable to those reported in previous similar studies carried out in European countries. The prevalence of root-filled teeth with AP was found to be higher compared to that demonstrated in other epidemiological studies.

Keywords: apical periodontitis, endodontics, epidemiology, radiology.

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Introduction

Apical periodontitis (AP) is primarily a sequela to dental caries caused by infection of the root canal system. Several epidemiological investigations have reported the prevalence of AP to range from 1.4% (Eriksen *et al.* 1988) to 8.0% (Imfeld 1991), using the tooth as a unit. However, when individuals are used as the unit, the prevalence can be as high as 70% (Sidaravicius *et al.* 1999). In several Scandinavian studies, the prevalence ranged from 30 to 60%, and it increased with age (Eriksen *et al.* 1988, Ödesjö *et al.* 1990, Eriksen 1991).

Paradoxically, studies carried out on various population groups have shown that root-filled teeth have a greater prevalence of AP than non-treated teeth. Most of these data have been reported from Scandinavia (Eckerbom *et al.* 1991, Eriksen & Bjertness 1991, Petersson 1993, Eriksen *et al.* 1995, Soikkonen 1995, Eriksen 1998, Kirkevang *et al.* 2000, 2001, Eriksen *et al.* 2002), where the prevalence of AP in root-filled teeth ranged from 16 to 52.2%. Epidemiological information from other countries has also shown a high prevalence of AP in root-filled teeth (Imfeld 1991, De Cleen *et al.* 1993, Buckley &

Correspondence: Dr Juan J. Segura-Egea, Cueva de Menga n° 1, portal 3, piso 6°-C, 41020 Seville, Spain (e-mail: segurajj@wanadoo.es).

Spangberg 1995, Saunders *et al.* 1997, Weiger *et al.* 1997, Marques *et al.* 1998, Sidaravicius *et al.* 1999, De Moor *et al.* 2000, Boucher *et al.* 2002, Dugas *et al.* 2003).

Endodontic and periapical status are important parameters that can predict tooth survival and the future need for dental treatment (Kirkevang *et al.* 2001). However, studies on the prevalence of AP have not yet been performed in Spain. Moreover, the frequency and the periapical status of root-filled teeth in the Spanish population have never been investigated. This study aimed to estimate the prevalence of teeth with AP and root-filled teeth in an adult Spanish population.

Materials and methods

Patient selection

The sample consisted of 180 subjects – 66 males (36.7%) and 114 females (63.3%) – presenting consecutively as new patients seeking routine dental care (not emergency care) at the Faculty of Dentistry, University of Seville, between the years 2002 and 2003. The criteria for inclusion in the study were that the patients should be attending for the first time. Patients younger than 18 years and patients having less than 7 remaining teeth were excluded. The scientific committee of the Dental Faculty approved the study, and all the patients gave written informed consent.

Radiographic examination

All participants underwent a full-mouth radiographic survey consisting of 14 periapical radiographs. All radiographs were taken by two experienced radiographers using a trophy CCX X-ray unit (Trophy Radiologie – 94300; Vincennes, France) using the long cone paralleling technique – setting of 70 kV, 10 mA, a film-focus distance of 28 cm and Ultra Speed film (Eastman Kodak, Rochester, NY, USA). Films were processed manually by two experienced dental assistants.

Radiographic evaluation

From the full-mouth radiographic survey, all teeth, excluding third molars, were recorded according to the FDI nomenclature. Teeth were categorized as root-filled teeth if they had been filled with a radiopaque material in the pulp chamber and/or in the root canal(s). The following information was recorded on a structured form for each subject: (i) number of teeth present; (ii) number and location of teeth without root fillings (untreated teeth) having identifiable periodontal lesions and (iii) number and location of root-filled teeth.

The periapical status was assessed using the periapical index (PAI) score (Ørstavik *et al.* 1986). Each of the roots was categorized as: 1, normal periapical structure; 2, small changes in bone structure; 3, changes in bone structure with some mineral loss; 4, periodontitis with well-defined radiolucent area; and 5, severe periodontitis with exacerbating features. Each category used in the PAI represents a step on an ordinal scale of registration of periapical infection. The worst score of all roots was taken to represent the PAI score for multirooted teeth.

Observer

One observer with 6 years of clinical experience in endodontics examined the radiographs. The method of viewing the radiographs was standardized; films were examined in a darkened room using an illuminated viewer box with magnification (3.5×) while mounted in a cardboard slit to block off ambient light emanating from the viewer. Before evaluation, the observer participated in a calibration course for the PAI system, which consisted of 100 radiographic images of teeth (kindly provided by Dr Ørstavik) – some root-filled and some not. Each tooth was assigned to one of the five PAI scores, using visual references (also provided by Dr Ørstavik) for the five categories within the scale. After scoring the teeth, the results were compared to a 'gold standard atlas', and Cohen's kappa was calculated (0.61).

Intraobserver reproducibility was evaluated by the repeat scoring of 50 patients 2 months after the first examination. These patients were randomly selected. Before the second evaluation of the radiographs, the observer was re-calibrated in the PAI system by scoring the 100 standard images. The intraobserver agreement test on PAI scores on the 50 patients produced a Cohen's kappa of 0.77.

Statistical analysis

A score greater than 2 (PAI $>$ 2) was considered to be a sign of periapical pathology (Ørstavik *et al.* 1986). Thus, a PAI score of 3, 4 or 5 defined AP, including periapical cysts and periapical granulomas (Kirkevang *et al.* 2001). The frequency of root-filled teeth was calculated, and the periapical status on all teeth and on the treated teeth was assessed.

Raw data were entered into Excel® (Microsoft Corporation, Redmond, WA, USA). The Chi-square test was used to determine the significance of differences by

Table 1 Age distribution of the patient sample ($n = 180$)

Age group	Number	Percentage of total
18–29	76	42.2
30–39	42	23.3
40–49	26	14.4
50–59	10	5.6
>60	26	14.4
Total	180	100

sex, age and tooth groups for the parameters number of teeth with AP, number of root-filled teeth and number of root-filled teeth with AP.

Results

The average patient age was 37.1 ± 15.7 years. The age distribution is illustrated in Table 1. Of the 180 subjects, only 29% had all their natural teeth (excluding third molars) and 12% had less than 20 teeth. The average number of teeth per patient was 24.7 ± 4.1 (median = 26). No significant differences between males and females were found for number of teeth.

AP affecting one or more tooth (range 1–6) was found in 110 subjects (61% prevalence), and 73 (41% prevalence) had at least one root-filled tooth (range 1–3). Among subjects with root-filled teeth, 48 (66%) had AP affecting at least one treated tooth. No significant differences between males and females were found for presence of AP ($P = 0.83$), root-filled teeth ($P = 0.13$) and root-filled teeth with AP ($P = 0.77$).

The total number of teeth examined was 4453; of these 186 (4%) had AP (PAI ≥ 3). The number of root-filled teeth was 93 (2%), of which 60 (65%) had AP. All root-filled teeth had been filled with a radiopaque material in the root canal(s). Among non-treated teeth, 3% had AP. When considering the association between root filling and AP, the OR obtained for root-filled teeth versus untreated teeth was high (OR = 61.1; $P < 0.0001$).

There were no statistically significant differences between males and females for number of teeth with AP, number of root-filled teeth and number of root-filled teeth with AP (Table 2).

The prevalence of AP (Table 3) in connection with molar teeth was higher (6%) than for premolars (5%) and anterior teeth (3%; $P < 0.01$). Probability of AP in connection with molar teeth was almost two times that in connection with anterior teeth (OR = 1.77). More premolar and molar teeth were root-filled (3%) than anterior teeth (1%; $P < 0.01$).

The prevalence of AP increased with age (Table 4). The first three age groups (18–49 years old) had a similar prevalence of AP (4.0%); however, the prevalence in the older groups (>50 years old) was higher (6%; OR = 1.42; $P = 0.05$). The percentage of root-filled teeth (1.9–2.5%) was similar at all the ages ($P > 0.05$). The frequency of root-filled teeth with AP did not vary

Table 2 Distribution of AP, root-filled teeth and root-filled teeth with AP by gender

	Number of teeth	AP (%)	Root-filled teeth (%)	Root-filled teeth with AP (%)
Females	2819	123 (4.4)	65 (2.3%)	43 (66.2)
Males	1634	63 (3.9)	28 (1.7%)	17 (60.7)
Total	4453	186 (4.2)	93 (2.1)	60 (64.5)
OR females	–	1.0	1.0	1.0
OR males	–	0.88*	0.74*	0.79*

*$P > 0.05$.

Table 3 Distribution of AP, root-filled teeth and root-filled teeth with AP by tooth type

	Number of teeth	AP (%)	Root-filled teeth (%)	Root-filled teeth with AP (%)
Anterior	2004	64 (3.2)	26 (1.3)	18 (69.2)
Premolar	1291	58 (4.5)	36 (2.8)	21 (58.3)
Molar	1158	64 (5.5)	31 (2.7)	21 (67.7)
Total	4453	186 (4.2)	93 (2.1)	60 (64.5)
OR anterior	–	1.0	1.0	1.0
OR premolar	–	1.43**	2.20***	0.62*
OR molar	–	1.77***	2.11***	0.93*

*$P > 0.05$; **$P < 0.05$; ***$P < 0.01$.

Table 4 Distribution of AP, root-filled teeth and root-filled teeth with AP by age

	Number of teeth	AP (%)	Root-filled teeth (%)	Root-filled teeth with AP (%)
18–29	2036	79 (3.9)	39 (1.9)	25 (64.1)
30–39	1054	43 (4.1)	25 (2.4)	20 (80.0)
40–49	633	24 (3.8)	13 (2.0)	5 (38.5)
50–59	203	11 (5.4)	5 (2.5)	3 (60.0)
60+	527	29 (5.5)	11 (2.1)	7 (64.6)
Total	4453	186 (4.2)	93 (2.1)	60 (64.5)
OR 18–49	–	1.0	1.0	1.0
OR > 50	–	1.42**	1.06*	1.02*

*$P > 0.05$; **$P < 0.05$.

Table 5 Periapical index scores in teeth with AP according to the endodontic status, tooth groups and age groups

	PAI 3 (%)	PAI 4 (%)	PAI 5 (%)	Total
Endodontic status				
Untreated	81 (64.3)	32 (25.4)	13 (10.3)	126
Root-filled	31 (51.6)	16 (26.7)	13 (21.7)	60
Total	112 (60.2)	48 (25.8)	26 (14.0)	186
Tooth group				
Anterior	36 (56.2)	17 (26.6)	11 (17.2)	64
Premolar	34 (58.6)	15 (25.9)	9 (15.5)	58
Molar	42 (65.6)	16 (25.0)	6 (9.4)	64
Total	112 (60.2)	48 (25.8)	26 (14.0)	186
Age group				
18–29	44 (55.7)	23 (29.1)	12 (15.2)	79
30–39	25 (58.1)	13 (30.3)	5 (11.6)	43
40–49	16 (66.7)	6 (25.0)	2 (8.3)	24
50–59	6 (54.5)	1 (9.1)	4 (36.4)	11
60+	21 (72.4)	5 (17.2)	3 (10.4)	29
Total	112 (60.2)	48 (25.8)	26 (14.0)	186

significantly with age ($P > 0.05$), but the 40–49-year age group had the lowest incidence (OR = 0.28; $P = 0.034$).

The analysis of the distribution of PAI scores in teeth with AP (PAI 3–5) according to endodontic status (Table 5) revealed that a PAI score of 5 was statistically more frequent in root-filled teeth (OR = 2.40; $P = 0.037$). On the contrary, no significant differences ($P = 0.12$) were found between PAI scores in males and females. Anterior and premolar teeth had a PAI score of 5 more frequently than molars (OR = 1.90; $P = 0.19$). PAI score of 3 was more frequent in the older age group (OR = 1.90; $P = 0.14$).

Discussion

The subjects included in this study were adult patients attending the dental service of the Faculty of Dentistry, Seville (Spain) for the first time. The recruitment of subjects was the same as those used by other studies (De Cleen *et al.* 1993, Buckley & Spangberg 1995, Saunders *et al.* 1997, Weiger *et al.* 1997, De Moor *et al.* 2000, Boucher *et al.* 2002, Lupi-Pegurier *et al.* 2002, Dugas *et al.* 2003). Clearly, the sample does not represent a random sample of the Spanish population, and extrapolation of the results to the general population must be carried out with caution. However, the cohort reflected the characteristics of a general population and there was no skewed recruitment from a socio-economic perspective. Moreover, general dental care at dental schools in Spain does not attract lower fees when compared with dental care in private practice. Thus, the results of this study may provide useful data to assess trends concerning the prevalence of AP and endodontic treatment in Spain. No survey on the endodontic needs or the periapical health of a Spanish population has been published at the time of writing this report.

Patients with 7 or fewer remaining teeth were excluded 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).

The sample consisted of more women (63.3%) than men (36.7%), which may constitute a recruitment bias or reflect some sociologic aspects of the Spanish population. Other studies with the same method of recruitment also found a similar gender proportion (Boucher *et al.* 2002). However, epidemiological studies reported that gender had no effect on the presence of AP or the frequency of endodontic treatment.

The age distribution clearly showed that younger individuals (18–39 years) made up the majority of the sample (Table 1). Other investigators have reported a similar skewed distribution (Eckerbom *et al.* 1987, Ödesjö *et al.* 1990, De Cleen *et al.* 1993, Weiger *et al.* 1997, De Moor *et al.* 2000) that could be explained because younger patients probably seek dental treatment more frequently than older ones.

Periapical radiography was used in the present study because not only the presence, but also the degree of AP was assessed. Previous studies have also used periapical radiographs (Petersson *et al.* 1989, Ödesjö *et al.* 1990, Imfeld 1991, Buckley & Spangberg 1995, Saunders *et al.* 1997, Kirkevang *et al.* 2001, Boucher *et al.* 2002). Moreover, the PAI used for scoring periapical status was first described for periapical radiographs (Ørstavik *et al.* 1986). However, other epidemiological studies have used panoramic radiographs (De Cleen *et al.* 1993, Marques *et al.* 1998, De Moor *et al.* 2000, Lupi-Pegurier *et al.* 2002), or a combination of panoramic and periapical radiographs (Eriksen & Bjertness 1991, Weiger *et al.* 1997, Eriksen 1998, Sidaravicius *et al.* 1999, Dugas *et al.* 2003). An underestimation of lesions occurred when panoramic radiography was used (Eriksen & Bjertness 1991), although the difference was not statistically significant (Muhammed & Manson-Hing 1982).

Criteria for AP vary among studies (Ödesjö *et al.* 1990, Buckley & Spangberg 1995, Saunders *et al.* 1997, De Moor *et al.* 2000, Lupi-Pegurier *et al.* 2002). In this study, the PAI was used to assess the periapical status. In recent years, most of the studies on the prevalence of AP have used this index scoring to assess periapical status (Table 6), so the results of this study can be more appropriately compared with them. The reproducibility of the observer (Cohen's kappa = 0.77) was acceptable, probably because of prior calibration.

The current investigation provides data that could be compared to those obtained from several other studies. The mean number of teeth in this study was 24.7, which is in agreement with other cross-sectional studies performed on adult European populations, such as Norway (Eriksen & Bjertness 1991), Great Britain (Saunders *et al.* 1997), Germany (Weiger *et al.* 1997) and Portugal (Marques *et al.* 1998), but slightly lower than the mean number of teeth found in Lithuania (Sidaravicius *et al.* 1999), Denmark (Kirkevang *et al.* 2001), France (Boucher *et al.* 2002) and Canada (Dugas *et al.* 2003). However, these studies had marked variations in the age range of the populations. Some of the previous cross-sectional studies have been compromised by the relatively high prevalence of missing teeth in the studied populations (Ödesjö *et al.* 1990, Imfeld 1991, Soikkonen 1995, De Moor *et al.* 2000).

The prevalence of subjects with at least one tooth with a PAI score of 3, 4 or 5 was 61%, which is in agreement with data reported by Eriksen (1998) and Figdor (2002). This prevalence is lower than that found by Sidaravicius *et al.* (1999) in Lithuania (70%), but higher than those reported in Portugal (Marques *et al.* 1998) and the Netherlands (De Cleen *et al.* 1993). Of the 180 subjects having a total of 4453 natural teeth, 73 (41%) had at least one root-filled tooth, a lower percentage compared to those communicated by Imfeld (1991) in Switzerland (78%) and Sidaravicius *et al.* (1999) in Lithuania (84%).

Table 6 Previous studies on AP using the PAI

Author	Year	No. of individuals	No. of teeth	Mean no. of teeth	Teeth with PAI $\geq$ 3 (%)	Endodontic teeth	Endodontic teeth with PAI $\geq$ 3 (%)	Population age (years)	Country
Eriksen *et al.*	1988	141	3197	22.7	1.4	3.4	34.0	35	Norway
Eriksen & Bjertness	1991	119	2940	24.7	3.5	6.0	36.6	50	Norway
Eriksen *et al.*	1995	118	3282	27.8	0.6	1.3	38.1	35	Norway
Marques *et al.*	1998	179	4446	24.8	2.0	1.5	21.7	30–39	Portugal
Sidaravicius *et al.*	1999	147	3892	26.5	7.2	15.0	39.4	35–44	Lithuania
Kirkevang *et al.*	2001	614	15984	26.0	3.4	4.8	52.2	23–63	Denmark
Boucher *et al.*	2002	208	5373	25.8	7.4	19.1	29.7	18–75	France
Dugas *et al.*	2003	610	16148	26.5	3.1	2.4	45.4	25–40	Canada
Present study	2003	180	4453	24.7	4.2	2.1	64.5	18–67	Spain

Moreover, 66% of subjects with root-filled teeth had AP affecting at least one treated tooth. These figures indicated that AP is prevalent in this Spanish population and that the endodontic treatment did not control the disease.

In this study, the number of teeth with AP (PAI $\geq$ 3) was 186, representing 4.2% of the total (4453). The score 5 was more frequent in endodontically treated teeth (OR = 2.40; $P = 0.037$). On the contrary, Kirkevang *et al.* (2001) found that score 3 was the one more frequently given in connection with endodontically treated teeth. The frequency of teeth with AP in other studies varies from 0.6% (Eriksen *et al.* 1995) to 9.8% (Allard & Palmqvist 1986). The range is large, probably because of the variation among populations examined.

The total percentage of root-filled teeth was 2.1%, which is low compared to the results of other studies (Petersson *et al.* 1989, Ödesjö *et al.* 1990, Imfeld 1991, Soikkonen 1995, Sidaravicius *et al.* 1999, Boucher *et al.* 2002, Lupi-Pegurier *et al.* 2002) that ranged between 8.6 and 26.0%. This phenomenon can be explained by the fact that first, the survey population was not representative of the whole country; secondly, the differences in health care services in the various countries could account for these discrepancies and lastly, the variations in age stratification of the patient samples in the various studies are likely to contribute to these differences. Older patients usually have more root-filled teeth (Eriksen 1991, Eriksen *et al.* 2002). In contrast, other studies found the prevalence of root-filled teeth to range between 1.3 and 4.8%, similar to that found in this study (De Cleen *et al.* 1993, Eriksen 1995, Weiger *et al.* 1997, Marques *et al.* 1998, Kirkevang *et al.* 2001, Dugas *et al.* 2003).

Although all epidemiological surveys have shown a significantly higher frequency of periapical lesions in root-filled teeth, in this study, 64.5% of the total number of root-filled teeth had AP. Moreover, of the total number of teeth with AP, 32.3% were root-filled. Sidaravicius *et al.* (1999) and Kirkevang *et al.* (2001) found 39.4 and 52.2%, respectively, of root-filled teeth in connection with AP; this represented 82 and 75.1% of periapical lesions in connection with root-filled teeth. The rate of root-filled teeth with AP in this study (64.5%) was higher, but not statistically higher than those reported in other investigations (Saunders *et al.* 1997, Weiger *et al.* 1997, Kirkevang *et al.* 2001, Dugas *et al.* 2003), where the range was 45.4–61.0%. On the contrary, only 2.9% of untreated teeth had AP in this study. These results provide evidence indicating that endodontic treatment is strongly associated with the presence of AP (OR = 61.1; $P < 0.0001$), which is in agreement with Kirkevang *et al.* (2000).

Some of the radiolucencies associated with root-filled teeth and identified as AP in this study (PAI 4 or 5) may have represented healing lesions, particularly if the time elapsed since treatment was less than 2 years (Dugas *et al.* 2003). This is a recognized limitation of cross-sectional studies. However, the high percentage of root-filled teeth in connection with periapical lesions in this study (64.5%) might not only be because of the patient cohort examined, but also because of inappropriate techniques applied by some Spanish dentists. Furthermore, inferior technical quality of root canal treatment is reported to be associated with endodontic failure (Eriksen 1991).

Conclusions

The prevalence of AP in root-filled and untreated teeth, and the frequency of root-filled teeth were comparable to those reported in previous studies carried out in European countries. The prevalence of root-filled teeth with AP was found to be high compared to that demonstrated in other epidemiological studies.

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