Frequency and distribution of root-filled teeth and apical periodontitis in an adult population of Barcelona, Spain

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Aim: To determine the prevalence of apical periodontitis (AP) and the frequency of root canal treatment in a sample of Spanish adults. Design: A descriptive cross-sectional study. Setting: Barcelona, Spain. Participants: A total of 397 adult subjects, 49% males and 51% females. Methods: Digital panoramic radiographs were used. Periapical status was scored according to the periapical index. Results were analysed statistically using the chi-squared test and logistic regression. Results: Radiographic signs of AP in one or more teeth were found in 135 patients (34%). The prevalence of AP was significantly higher in males (42.3%) than females (26.1%) [odds ratio (OR) = 2.1; 95% confidence interval (95% CI) = 1.4–3.2; P = 0.0007]. At least one root-filled tooth (RFT) was found in 233 patients (59%). Twenty-six per cent of subjects with RFT had at least one RFT with AP. The prevalence of AP increased with age (P < 0.05). Patients with RFT showed a higher prevalence of AP (42%) relative to patients without RFT (23%) (OR = 2.4; 95% CI = 1.5–3.7; P = 0.00013). Adjusting for age, gender and teeth number, endodontic status remained significantly associated with periapical status (OR = 2.3; 95% CI = 1.4–3.6; P = 0.0005). Conclusions: Both the prevalence of AP and the frequency of root canal treatment are high among Spanish adults. AP affects more frequently RFT relative to untreated teeth. Patients with one or more RFT have a greater likelihood of having AP than patients without RFT.

Key words: Apical periodontitis, endodontic treatment, root canal treatment

Endodontic and periapical status are important parameters that can predict tooth survival and the future need for dental treatment¹. Endodontic epidemiology aims to determine the distribution and prevalence of apical periodontitis (AP) and its determinants in different populations evaluated by the presence/absence of AP².

Several epidemiological studies have reported that 23.8–83.7% of adults have AP³–⁵, which raises an important public health problem in many countries concerning the medical, economic and ethical repercussions⁶–⁷. Furthermore, prevalence rates of AP as high as 52.2%¹, 58.1%⁸, 60.0%⁹ and 61.0%¹⁰ have been reported to be associated with root-filled teeth (RFT). In Spain, the only published epidemiological study to date¹¹ reported a prevalence of AP of 61% and of RFT with AP of 64.5% in an adult sample. These data have been suggested to reflect the realistic outcome of endodontic treatment in the general population¹²,¹³.

The purpose of the present study was to determine the prevalence of AP and the frequency of root canal treatment in a sample of Spanish adults, analysing the association between radiographic periapical status and previous root canal treatment.

METHODS

The sample consisted of 397 subjects, 194 males (48.9%) and 203 females (51.1%), attending for routine dental treatment (not emergency care) at the University of Barcelona, Faculty of Dentistry, between the years 2009 and 2011. The criteria for inclusion in the study were that the patients should be attending for the first time. Patients younger than 18 years were excluded. The Ethics Committee of the Dental Faculty approved the study and all patients gave written informed consent. The research was conducted in full accordance with the World Medical Association Declaration of Helsinki.

Radiographic examination

Periapical and endodontic status were diagnosed on the basis of the examination of digital panoramic
Radiographic evaluation

All teeth, excluding third molars, were recorded. Teeth were categorised as RFT if they had been filled with a radiopaque material 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 having identifiable periapical lesions; (iii) number and location of RFT; (iv) number and location of RFT having identifiable periapical lesions; (v) severe periodontitis with exacerbating inflammation. PAI > 2 is considered to be a sign of AP. The periapical status of all teeth and the frequency of RFT were determined. The worst score of all roots was taken to represent the PAI score for multirooted teeth.

Observers

Three observers with extensive clinical experience in endodontics examined the radiographs. Before evaluation, the observers participated in a calibration course for the PAI system, which consisted of 100 radiographic images of teeth (gold standard atlas), some root-filled and some not, kindly provided by Dr Ørstavik. 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 with the gold standard atlas and Cohen’s kappa was calculated (0.81–0.85).

The inter-observer and intra-observer reproducibility was determined. The intra-observer 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, each observer was recalibrated in the PAI system by scoring of the 100 standard images. The intra-observer agreement test on the PAI scores of the 50 patients produced a Cohen’s kappa in the range 0.82–0.89. Cohen’s kappa for inter-observer variability was in the range 0.82–0.89. The consensus radiographic standard was the simultaneous interpretation by the three examiners of all radiographs for each subject.

Statistical analysis

Raw data were entered into Excel® (Microsoft Corporation, Redmond, WA, USA). All analyses were performed in an SPSS environment (Version 12.0; SPSS, Inc., Chicago, IL, USA). Chi-squared test and logistic regression analysis were used to determine the significance of the results. The significance level was set at \( P < 0.05 \).

RESULTS

The average patient age was 52.0 ± 15.7 years. The distribution of patients by age, gender and number of teeth is illustrated in Table 1. The average number of teeth per patient was 23.6 ± 5.8 (median, 25). No significant differences between males and females were found with regard to the number of teeth (\( P > 0.05 \)). However, the number of teeth decreased significantly with age (\( P < 0.01 \)).

AP in one or more teeth was found in 135 patients (34.0% prevalence), and 233 patients (58.7% prevalence) had at least one RFT (Table 2). Among subjects with RFT, 60 (25.8%) had AP affecting at least one RFT. The prevalence of AP was significantly higher in males (42.3%) than in females (26.1%) (odds ratio...
(OR) = 2.1; 95% confidence interval (95% CI) = 1.4–3.2; \( P = 0.0007 \). No significant differences between males and females were found for RFT and RFT with AP \(( P > 0.05)\).

The total number of teeth examined was 9390, 259 (2.8%) of which had AP (PAI).\(^{3}\) \(( P = 0.00009)\), as well as more RFT \(( OR = 1.3; 95\% CI = 1.1–1.5; \ P = 0.006)\). There was no correlation between sex and number of RFT with AP \(( P > 0.05)\), but gender correlated significantly with the number of untreated teeth with AP \(( OR = 1.9; 95\% CI = 1.3–2.7; \ P = 0.001)\). The prevalence of AP in RFT was significantly higher (23.8%) than that in untreated teeth \((1.3\%); \ P = 0.0000000)\).

The distribution of patients by age according to their periapical and endodontic status was analysed \((Figure 1\)\). The overall prevalence of AP increased with age, reaching a maximum at 60–69 years (56.0%). After 30 years, the prevalence of endodontic treatment exceeded 50% and the percentage of RFT with AP was practically constant (22–29%) in all age groups \(( P > 0.05)\).

The percentage of teeth with AP increased slowly throughout life, peaking in the group older than 70 years (4.4%) \((Figure 2\)\). The proportion of RFT increased with age, reaching a maximum in the group aged 70 years or above (9.4%). The highest percentages of RFT with AP (26%) and untreated teeth with AP (2.9%) were found in the 60–69-year age group.

The correlation between periapical and endodontic status was analysed \((Table 4\)\). Patients with one or more RFT showed a higher prevalence of AP (41.6%) relative to patients without RFT (23.2%) \(( OR = 2.4; 95\% CI = 1.5–3.7; \ P = 0.00013)\). Multivariate logistic regression analysis was run with age, gender (0, female; 1, male), and number of RFT with AP as predictors. The results showed that the prevalence of AP in RFT was significantly higher (23.8%) than that in untreated teeth \((1.3\%); \ P = 0.0000000)\).

### Table 3 Distribution of teeth with apical periodontitis (AP), root-filled teeth (RFT), root-filled teeth with AP (RFT-AP) and untreated teeth with AP (UT-AP) by gender

<table>
<thead>
<tr>
<th></th>
<th>Females</th>
<th>Males</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of teeth</td>
<td>4970</td>
<td>4420</td>
<td>9390</td>
</tr>
<tr>
<td>AP (%)</td>
<td>106 (2.1)</td>
<td>153 (3.5)</td>
<td>259 (2.8)</td>
</tr>
<tr>
<td>RFT (%)</td>
<td>287 (5.8)</td>
<td>317 (7.2)</td>
<td>604 (6.4)</td>
</tr>
<tr>
<td>RFT-AP (%)</td>
<td>62 (21.6)</td>
<td>82 (25.9)</td>
<td>144 (23.8)</td>
</tr>
<tr>
<td>UT-AP (%)</td>
<td>44 (0.9)</td>
<td>71 (1.7)</td>
<td>115 (1.3)</td>
</tr>
</tbody>
</table>

\( \text{OR females} 1.0 \quad \text{OR males} 1.6^{**} \quad \text{RFT-AP of all RFTs. OR, odds ratio.} \)

\( ^{*} P > 0.05; ^{**} P < 0.01. \)

\( ^{3}\text{RFT-AP versus UT-AP: } P < 0.01. \)

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\( \gamma^{2} \text{ test } = 13.804; P = 0.00013. \)

Odds ratio (OR) for patients with RFT = 2.4 (95% confidence interval, 1.5–3.7).
Table 5 Multivariate logistic regression analysis of the influence of the explanatory variables age, gender, teeth number and endodontic status (0, patients without root-filled teeth; 1, patients with one or more root-filled teeth) on the dependent variable ‘periapical status’ [0, apical periodontitis (AP) absent; 1, patients with one or more teeth with AP]

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>B</th>
<th>P</th>
<th>Odds ratio</th>
<th>95% CI, inferior limit</th>
<th>95% CI, superior limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.0318</td>
<td>0.0007</td>
<td>1.0323</td>
<td>1.0135</td>
<td>1.0515</td>
</tr>
<tr>
<td>Gender</td>
<td>0.6769</td>
<td>0.0028</td>
<td>1.9678</td>
<td>1.2615</td>
<td>3.0694</td>
</tr>
<tr>
<td>No. of teeth</td>
<td>0.0136</td>
<td>0.5753</td>
<td>1.0137</td>
<td>0.9666</td>
<td>1.0631</td>
</tr>
<tr>
<td>Endodontic status</td>
<td>0.8187</td>
<td>0.0005</td>
<td>2.2675</td>
<td>1.4264</td>
<td>3.6046</td>
</tr>
</tbody>
</table>

CI, confidence interval. 
Overall model fit: $\chi^2 = 41.1064; \text{df} = 4; \text{P} = 0.0000$.

1, male), teeth number and endodontic status (0, no RFT; 1, one or more RFT) as explanatory variables and periapical status dichotomised (0, AP absent; 1, AP present) as the dependent variable (Table 5). Adjusting for age, gender and teeth number, the endodontic status remained significantly associated with periapical status (OR = 2.3; 95% CI = 1.4–3.6; $\text{P} = 0.0005$).

**DISCUSSION**

The study population consisted of patients treated at the Barcelona University Faculty of Dentistry, and does not represent a random sample of the adult Catalanian population. The extrapolation of the results to the general population must be performed with caution. However, the recruitment of subjects was the same as that used by others, 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 the dental school in Barcelona 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 Barcelona, Catalonia and Spain.

The sample size of the present study (397 patients) is high compared with that of other studies on endodontic epidemiology, and with the study by Jiménez-Pinzón et al. (180 patients). The sample incorporated similar proportions of males (49%) and females (51%). In other epidemiological studies, the samples consisted of more women than men, including the earlier study of Jiménez-Pinzón et al. on periapical and endodontic status in Spain, whose sample included 64% women and 37% men. This may constitute a recruitment bias or reflect certain sociological aspects of the studied population.

The age distribution of the sample was balanced. In contrast, other studies on the epidemiology of AP have analysed population samples in which younger individuals (18–39 years) have made up the majority of the samples.

In the present study, panoramic radiography and PAI were used to score periapical status. Other previous investigations on periapical status have used panoramic radiographs over the two types of radiograph. However, it has been suggested that periapical radiographs are more accurate than panoramic radiographs in the assessment of periapical pathology. An underestimation of periapical lesions has been reported when panoramic radiography is used to assess the periapical status, but the difference from periapical radiography is not statistically significant. The fact that all teeth can be seen on one panoramic radiograph, the relatively low exposure to ionising radiation, the convenience of panoramic radiographs and the speed with which they can be obtained are advantageous when compared with full-mouth periapical radiographs. Nevertheless, cone beam computed tomography, an extra-oral imaging system which produces three-dimensional scans of the maxillofacial skeleton, is useful in overcoming the limitations of conventional radiography for the detection of AP. A recent study has suggested that cone beam computed tomography is 100% successful in identifying periapical lesions, compared with a 25% success rate for intraoral radiographs, concluding that routine radiography (panoramic or periapical) seriously underestimates the prevalence of AP by a factor of four.

The PAI score has been widely used in the literature to assess the periapical status, and therefore the results of this study can be more appropriately compared with these reports. The intra-observer (Cohen’s kappa = 0.86–0.93) and inter-observer (Cohen’s kappa = 0.82–0.89) reproducibility were acceptable. As noted previously, PAI is mainly used with a cut-off at two, according to the work of Ørstavik et al. The choice of the cut-off at two for PAI is debatable and a cut-off at unity for the evaluation of periapical health might be more appropriate.

The mean number of teeth per person in this study was 23.6, in agreement with a previous report on the prevalence of AP in a sample of the Spanish population.
The results of the present study showed that 34% of patients have at least one tooth with AP (PAI ≥ 3). This prevalence of AP is in agreement with that found in other investigations that have used panoramic radiographs to assess the periapical status, such as studies carried out in Portugal (26%)23, Ireland (33%)46 and the Netherlands (45%)18. However, in these three studies, as well as in the present one, the possibility of an underestimation of periapical lesions exists30. Moreover, workers who have used periapical radiographs to assess the periapical status have found a higher prevalence of AP, such as studies carried out in Lithuania (70%)9, Spain (61%)13, Greece (86%)9 and Japan (70%)27. Such findings from related studies should be compared with caution because of the variations in sampling procedure, age and gender of the participants, type of radiograph examined and criteria for the diagnosis of periapical disease.

The number of teeth with AP (PAI ≥ 3) was 259, representing 2.8% of the total. Other studies have found similar results, ranging from 1.5% to 4.2%1,10,13,23,25,39. However, this value is lower than the percentages reported by De Moor et al.20 (6.6%), Boucher et al.21 (7.4%), Lupi-Pegurier et al.22 (7.3%), Allard & Palmqvist37 (9.8%) and Georgopoulou et al.9 (13.6%). The range is large, probably as a result of the variation among populations examined and the radiological technique used to assess the periapical status.

The results of this study showed that AP was more likely to be detected in males (42%) than in females (26%) (OR = 2.1; P < 0.01), but there was no significant difference by gender in the number of RFT with AP. Other studies have not found differences by gender with regard to the prevalence of AP5,13,21, although Genc et al.48 found a higher prevalence of RFT with AP in males, suggesting that it could reflect the greater interest of women in receiving dental care and in attending for check-ups. Segura-Egea et al.42 found an increased prevalence of AP in smokers compared with nonsmokers. Thus, the higher prevalence of AP in males could be explained by the higher frequency of smoking in males relative to females in the Catalan population.

Of the 397 subjects having a total of 9390 natural teeth, 233 (59%) had at least one RFT, a lower percentage than reported by Imfeld49 in Switzerland (78%) and Sidaravicius et al.3 in Lithuania (84%) but similar to that reported in a Greek population (66%)9. The higher percentage of patients with RFT in the present study compared with the previous finding of Jiménez-Pinzón et al.11 in Spain (41%) can be explained by the fact that the sample population analysed in Andalusia was younger (mean age, 37 ± 16 years) than that in the present investigation (mean age, 52 ± 16 years). Nevertheless, a lowest level of dental health care could also explain the smaller percentage (2.0%) of patients having RFT in the Andalusian population11, three times lower than that found in the present study (6.4%). However, other studies have also found a lower prevalence of RFT, in the range 1.3–4.8%1,4,7,10,18,23,25,39.

However, the total percentage of RFT found in the present study (6.4%) was low compared with the results of other studies3,21,22,28,49–51, which were in the range 8.6–26.0%. This phenomenon can be explained by the fact that, first, the survey population was not representative of the whole country. Second, the differences in healthcare services in the various countries could account for these discrepancies. 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 RFT2–30, as reported in the present study.

The present study showed that 604 teeth had undergone root canal treatment and that a periapical lesion was found in 144 of these (23.8%). This result is comparable with the values reported in previous studies carried out in Norway30 (18–25.6%), Turkey4 (18.2%), Portugal25 (21.7%), the Netherlands26 (24.1%), Sweden28 (24.5%), Ireland46 (25%), Sweden47 (27%) and France21,22 (29.7–31.5%). However, this percentage is low compared with the results of Sidaravicuis et al.3 in Lithuania (35%), Tsuneishi et al.27 in Japan (40%), Kabak & Abbott52 in Belarus (45%), Dugas et al.23 in Canada (45.4%), Kirkevang et al.4 in Denmark (52.2%), Sunay et al.31 in Turkey (53.5%), Touré et al.7 in Senegal (56.1%), Saunders et al.8 in the UK (58.1%), Georgopoulou et al.9 in Greece (60%), Weiger et al.10 in Germany (61%) and Al-Omari et al.5 in Jordan (87%). This high prevalence of AP associated with RFT is of concern, as the prognosis for teeth presenting with periapical disease is poor7. In follow-up studies, it has been demonstrated that up to 50% of teeth exhibiting AP will be extracted36,53.

Interestingly, the percentage of RFT with AP found in the present study (23.8%) was lower than that found in another study carried out in Spain (64.5%)13. In Turkey, two investigations performed in different regions of the country also reported dissimilar percentages of RFT with AP4,31. 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 they are healing. Some of the radioluencies associated with RFT, and identified as AP in this study, may have represented healing lesions, particularly if the time elapsed since treatment was <2 years23. However, the negative predictive value of radiographs with regard to AP is 0.6754, and therefore the prevalence of AP reported in the present study could
also be an underestimation of the real situation. Thus, because of the cross-sectional design of this survey, some of the observed periapical radiolucencies may represent persistent AP, whereas others may be incompletely healed lesions after root canal treatment.

CONCLUSIONS

Both the prevalence of AP and the frequency of root canal treatment are high among Spanish adults. AP affects more frequently RFT relative to untreated teeth. Patients with one or more RFT have a greater likelihood of AP than patients without RFT.

Acknowledgement

None.

Conflict of interest

The authors declare that they have no conflict of interest.

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