Prevalence of apical periodontitis and the quality of endodontic treatment in an adult Belarusian population

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Abstract

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Aim To estimate the prevalence of teeth with apical periodontitis (AP) and technically failed root fillings in an adult Belarusian population.

Methodology Panoramic radiographs of all 1423 patients over 15 years of age not seeking emergency dental care, and attending the Dental School of the Belarusian Medical University for the first time during the period from 1 January to 31 December 2001 were examined. The quality of root fillings was scored according to criteria of length proposed by De Moor *et al.* [*International Endodontic Journal* **33** (2000) 113] and the periapical status of all teeth (except third molars) was categorized on the basis of presence or absence of radiographic signs of AP. The data were analysed using the chi-square test and odds ratio.

Results Radiographs indicated that 8632 teeth (22% in the maxilla; 21% in the mandible) were missing leaving a total of 31 212 teeth to be assessed. Twenty per cent of the teeth had some filling material in the root canal(s). AP was found in 1141 subjects (80%) and 12% of the teeth. AP was more frequently associated with molar teeth (23%) than premolar (14%), canine (4%) and incisor teeth (6%). AP was diagnosed in 45% of root filled teeth, the remaining cases with AP had not been root filled. Statistical analysis showed that the probability of radiological detection of AP in root filled teeth was 25-fold higher than when the root canals had not been filled ($\chi^2 = 8636.04$, $P \leq 0.001$, odds ratio with 95% confidence intervals: $23.01 < 25.17 < 27.45$). Periapical radiolucencies with adequately filled root canals occurred significantly less often than with teeth in which the root canal was filled more than 2 mm from radiographic apex or when filling material was extruded through the apex.

Conclusion The prevalence of AP in all age groups in Belarus was higher than in other populations. The probability of AP increased significantly after root canal treatment and was closely correlated with the quality of the root filling.

Keywords: apical periodontitis, periapical status, quality of endodontic treatment.

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Introduction

Apical periodontitis (AP) has been reported to be a widespread disease amongst the adult populations of a number of countries in Europe, North America and Australia (De Cleen *et al.* 1993, Eriksen *et al.* 1995, Marques *et al.* 1998, Sidaravicius *et al.* 1999, Boucher *et al.* 2002, Figdor 2002, Hommez *et al.* 2002, Jiménez-Pinzón *et al.* 2004). Its prevalence varies from 27 to 70% and it increases with age. Epidemiologic investigations carried out on different populations have also shown a high prevalence of AP associated with root filled teeth (Table 1). According to these investigations, poor quality of root fillings is one of the main features associated

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Table 1 Summary of some previous studies of the prevalence of apical periodontitis and root canal fillings

Author	Country	No of teeth	% AP	% Endo	% Endo with AP	Population
Ödesjö *et al.* (1990)	Sweden	17 430	2.9	8.6	24.5	General Swedish population
Imfeld (1991)	Switzerland	2004	8.4	20.3	31.0	66-year-old Zurich citizens
De Cleen *et al.* (1993)	The Netherlands	4196	6.0	2.3	39.2	Dental school patients
Weiger *et al.* (1997)	Germany	7987	3.0	2.7	61.0	Individuals visiting a general dental surgery
Sidaravicius *et al.* (1999)	Lithuania	3892	7.2	15.0	39.4	35–44-year-old Vilnius citizens
De Moor *et al.* (2000)	Belgium	4617	6.6	6.8	40.4	Dental school patients
Kirkevang *et al.* (2001)	Norway	15 984	3.4	4.8	52.2	Randomly selected individuals
Lupi-Pegurier *et al.* (2002)	France	7561	7.3	18.9	31.5	Dental school patients

% AP, percentage of teeth with apical periodontitis; % Endo, percentage of endodontically treated teeth; % Endo with AP, percentage of endodontically treated teeth with apical periodontitis.

with the presence of AP (Friedman 1998, De Moor *et al.* 2000, Figdor 2002, Kirkevang & Wenzel 2003).

The aim of this study was to gather data on the prevalence of AP and the quality of root fillings in the Republic of Belarus. Such data have not been collected previously in this country and this information is necessary to assess the effectiveness of dental care, as well as to help with the planning and development of future dental services, including the training of dental personnel.

Material and methods

Panoramic radiographs of all 1423 patients over 15 years of age not seeking emergency dental care, and presented to the Republican Clinical Dental Polyclinic for dental treatment for the first time during the period from 1 January to 31 December 2001 were studied. All radiographs were taken by the same dental radiologist using a Sirona orthophos apparatus (Sirona Dental Systems GmbH, Bensheim, Germany) to produce digital images. The periapical status and the quality of all root fillings were assessed for all teeth, except the third molars.

Digital images were examined using Photoshop 6.0 software (Abobe Systems Inc., San Jose, CA, USA) at a ratio of 1 : 1. Panoramic radiographs were examined independently by two observers. Prior to the study, 20 panoramic radiographs not included in the survey were used to calibrate the examiners; the inter-examiner agreement was determined by calculating Cohen's κ. In case of disagreement, the two observers came to consensus. The following criteria (De Moor *et al.* 2000) were applied for periapical tissue status and quality assessment of root fillings:

- *Endodontically treated tooth* – a tooth containing a radiopaque material in the root canal and/or the pulp chamber;
- *Apical periodontitis* – more $\times$ 2 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;
- *Crown* – restoration of the coronal part of the tooth with a metal or porcelain-fused-to-metal crown;
- *Post* – presence of a radiopaque (metal) post in the root canal;
- *Satisfactory length/extension of root filling* – filling material present in the root canal within 0–2 mm of the radiographic apex;
- *Unsatisfactory length/extension of root filling* – filling material in the canals more than 2 mm from the radiographic apex, extruded beyond the apical foramen, or present only in the pulp chamber. Presence of filling material in the pulp chamber only cannot be considered as evidence of pulpotomy as in Belarus this method of treatment has never been adopted.

STATISTICA 6.0 software (StatSoft® Ltd, Bedford, UK) was used for data processing and statistical analysis. The chi-square test was used to determine if the periapical status was associated with the technical quality of root filling (the apical limit of filling), coronal status and for evaluation of differences between tooth subgroups for the parameters: number of the missing teeth, number of the teeth with AP, and number of the root filled teeth with AP. Inter-rater reliability was calculated using odds ratio. The logistic regression (multivariate approach) was used to describe the periapical status by explanatory variables (different length of root canal filling and extrusion of material through the apex).

Results

The periapical status of 31 212 teeth was assessed for 1423 patients. The distribution of patients according to age is shown in Table 2. The mean number of the teeth per patient was 21.9.

There were 6339 teeth (20%) with filling material in the root canals, indicating previous endodontic treatment. Maxillary teeth had been root filled significantly more often than mandibular teeth (25% compared with 15%; $\chi^2 = 444.32$, $P \leq 0.001$; odds ratio with 95% confidence intervals: $1.73 < 1.83 < 1.93$). The maxillary right central incisor and the maxillary left first molar were the most common root filled teeth. The least common were the mandibular central incisors.

Excluding the third molar teeth, 8632 teeth were missing (22% in the maxilla; 21% in the mandible; $\chi^2 = 2.98$, $P \leq 0.1$). Mandibular first molars were missing more often than any other teeth (59% of the mandibular left first molars; 63% of the mandibular right first molars) and the mandibular right second molars were the third most commonly missing teeth (36%). These differences were statistically significant ($\chi^2 = 140.55$, $P \leq 0.001$). The mandibular canines were the least often extracted teeth (3% of the mandibular left canines; 2% of the mandibular right canines). The number of missing teeth varied from 1

Table 2 Distribution of the patients according to age

Age group	Number of patients	Number of patients with apical periodontitis (%)
15–24	150	68 (45.3)
25–34	156	132 (84.6)
35–44	277	236 (85.2)
45–54	375	307 (81.9)
55–64	271	232 (85.6)
65+	194	166 (85.6)
Total	1423	1141 (80.2)

Table 3 Distribution of teeth with apical periodontitis according to the tooth type

	Normal periapex		Apical periodontitis		Difficult radiographic interpretation		
Tooth	*n*	%	*n*	%	*n*	%	Total
11	1155	88.8	109	8.4	37	2.8	1301
12	1053	85.5	130	10.6	49	3.9	1232
13	1212	91.8	75	5.7	33	2.5	1320
14	773	77.6	200	20.1	23	2.3	996
15	739	79.2	174	18.6	20	2.1	933
16	636	72.2	193	21.9	52	5.9	881
17	776	78.3	158	15.9	57	5.7	991
21	1186	91.0	92	7.0	25	2.0	1303
22	1105	87.1	141	11.1	22	1.7	1268
23	1232	92.0	84	6.0	27	2.0	1343
24	836	81.2	170	16.5	24	2.3	1030
25	794	81.3	156	16.1	17	2.1	967
26	699	73.9	195	20.6	51	5.4	945
27	867	84.6	110	10.7	48	4.7	1025
Maxilla	13 063		1987		485		15 535
31	1225	96.9	26	2.1	13	1.0	1264
32	1280	95.5	45	3.3	15	1.1	1340
33	1325	95.7	48	3.5	11	0.8	1384
34	1141	90.1	123	9.7	2	0.2	1266
35	948	86.7	140	12.8	5	0.5	1093
36	350	60.2	228	39.2	3	0.5	581
37	734	79.0	190	20.5	5	0.5	929
41	1234	96.9	29	2.3	10	0.8	1273
42	1275	95.6	50	3.7	9	0.7	1334
43	1342	95.9	52	3.7	5	0.4	1399
44	1164	91.2	108	8.5	4	0.3	1276
45	914	82.6	189	17.0	4	0.4	1107
46	328	61.4	204	38.2	2	0.4	534
47	644	71.8	238	26.5	15	1.7	897
Mandible	13 904		1670		103		15 677
Total	26 967		3657		588		31 212

to 28 per patient, with an average of 6.0 teeth per person.

Apical periodontitis was diagnosed in 80% of patients and 3657 teeth (12% of the teeth present) had radiographic signs of AP (Table 3), including 23% of molars, 15% of premolars, 5% of canines and 6% of incisors. AP was least frequently associated with the mandibular left central incisor tooth (2%) – as a comparison, AP of the mandibular right lateral incisor was diagnosed in 3% of patients ($\chi^2 = 4.17$, $P \leq 0.05$). The teeth with the highest prevalence of AP were the mandibular left and right first molars (39 and 38%, respectively), followed by the mandibular left second molar (27%); these figures were significantly different ($\chi^2 = 20.38$, $P \leq 0.001$). The number of teeth with AP in one patient varied widely from 1 to 14 (Table 4). AP was least often present in the age group of 15–24 years. There were no statistically significant differences in the prevalence of AP amongst the other age groups.

Apical periodontitis was diagnosed in 2867 (45%) of the 6339 root filled teeth. The remaining 790 cases of AP were associated with teeth that had not been root filled. The logistic regression analysis of root filling as an independent variable for the variable 'periapical status' demonstrated that root filling affected significantly the periapical status ($\chi^2 = 8636.04$, $P \leq 0.001$; odds ratio with 95% confidence intervals: $23.01 < 25.17 < 27.45$). Of 3058 teeth with unsatisfactory length/extension of root canal AP was diagnosed in 2057 (68%) teeth.

There were 5355 teeth (20%) with artificial crowns and 1349 of these (25.2%) had radiographic signs of AP (Table 5). AP was diagnosed more frequently in crowned teeth if they had been root filled ($\chi^2 = 909.23$, $P \leq 0.001$, odds ratio with 95% confidence intervals: $7.61 < 8.88 < 10.38$).

The correlation between the quality of root canal treatment and the periapical status was determined (Table 6). AP was associated with teeth that had adequately filled root canals seven times less often than with teeth in which the root canal was filled more than 2 mm from the radiographic apex ($\chi^2 = 1264.43$, $P \leq 0.001$, odds ratio with 95% confidence intervals: $7.61 < 8.88 < 10.38$).

The periapical status of root filled teeth was analysed using the logistic regression model. The results of this analysis are shown in Table 7. The following explanatory variables had significant influence on the periapical condition: short root filling (>2 mm from the radiological apex), extrusion of material through the apex, and presence of filling material only in the pulp chamber.

Table 4 Number of teeth with apical periodontitis (AP) in different patients

Number of teeth with AP seen on one panoramic radiograph	Number of patients (%)
1	210 (18.4)
2	260 (22.8)
3	249 (21.8)
4	179 (15.7)
5	115 (10.1)
6	56 (4.9)
7	41 (3.6)
8	22 (1.9)
9 and more	9 (0.8)
Total	1141 (100)

Discussion

Different approaches have been used to establish cohorts of patients to study the incidence of AP. In some studies patients were randomly selected within defined age groups, place of settlement (rural/urban population) or social groups (Ödesjö *et al.* 1990, Imfeld 1991, Aleksejuniene *et al.* 2000, Kirkevang *et al.* 2001, Hommez *et al.* 2002) whilst others have used patients from within large dental clinics and within a

Table 5 Correlation between periapical and coronal status

	Periapical status							
	Normal		Apical periodontitis		Indistinct		Total	
	n	%	*n*	%	*n*	%	*n*	%
Crowned teeth with root filling	1255	34.3	1110	82.3	260	74.3	2625	49.0
Crowned teeth without root filling	2401	65.7	239	17.7	90	25.7	2730	51.0
Total	3656	100	1349	100	350	100	5355	100

Table 6 Correlation between the length of root canal filling and periapical status

			Periapical status					
	Total		Normal		Apical periodontitis		Indistinct	
Length of the root filling	*n*	%	*n*	%	*n*	%	*n*	%
0–2 mm from the radiological apex	3025	47.7	2134	75.3	810	28.3	81	12.7
>2 mm from the radiological apex	1874	29.6	566	20/0	1126	39.3	182	28.5
Extrusion of material through the apex	526	8.3	86	3.0	416	14.5	24	3.8
Material only in the pulp chamber	658	10.4	47	1.7	515	17.0	96	15.0
Indistinct	256	4.0	0	0	0	0	256	40.0
Total	6339	100	2833	100	2867	100	639	100

Table 7 Regression table of the periapical condition root canal filled teeth ($n = 6339$) explained by explanatory variables

				95% CI for odds ratio	
	χ^2	Significance, *P*	Odds ratio	Lower	Upper
0–2 mm from the radiological apex	1264.43	≤0.001	0.129	0.11	0.15
Short length of the root filling (>2 mm from the radiological apex)	254.18	≤0.001	2.59	2.30	2.92
Extrusion of material through the apex	233.59	≤0.001	5.42	4.27	6.88
Presence of filling material only in the pulp chamber	428.07	≤0.001	13.03	9.62	17.66

defined time periods of examination (Hülsmann *et al.* 1991, Buckley & Spångberg 1995, Saunders *et al.* 1997, De Moor *et al.* 2000, Boucher *et al.* 2002, Lupi-Pegurier *et al.* 2002, Dugas *et al.* 2003). In this study, data on the prevalence of AP in an adult population within Belarus were obtained as a result of analysing orthopantomograms which were taken of patients attending the Republican Dental Polyclinic in the Dental School of the Belarusian Medical University. This clinic deals with the treatment of residents of Minsk (the capital city of Belarus) and provides general and specialized dental care (including surgical, orthopaedic and orthodontic treatment) as well as patients from other areas who are routinely sent to the clinic for diagnosis and treatment of their dental problems. Orthopantomograms are used as general screening radiographs for all patients attending the clinic and therefore these radiographs were available for study. Such radiographs are generally accurate and have diagnostic sensitivity reaching 86–96%, as well as providing lower patient radiation doses than a full mouth series of periapical radiographs (Ahlquist *et al.* 1986). Other investigations found that an underestimation of lesions occurred when panoramic radiography was used (Gröndahl *et al.* 1970, Eriksen & Bjertness 1991).

The data obtained from a selected population group such as the one used in this study cannot be extrapolated to the entire population of the country. However, given the large sample size and the wide range of age groups studied, it is possible to estimate the prevalence of chronic AP in patients seeking dental care in Belarus.

The median number of remaining teeth in this study was 22, which is rather lower than the mean number of teeth found in Spain (Jiménez-Pinzón *et al.* 2004), Canada (Dugas *et al.* 2003), France (Boucher *et al.* 2002), Denmark (Kirkevang *et al.* 2001) and Lithuania (Sidaravicius *et al.* 1999). In most Western countries there is a trend for patients to retain their natural teeth longer, with fewer extractions being performed, and the prevalence of denture wearers decreasing (Kirkevang *et al.* 2001). A general reason for this development might be reduction of dental disease (including AP), or a change in the treatment strategy amongst dentists in favour of preventive and conservative treatment.

Analysis of the data demonstrated that in these Belarusian dental patients, the prevalence of AP was higher than in patients from other countries. In the age group of 35–44 years, AP was diagnosed in 85% of patients compared with 27% in a Portuguese population in the age group of 30–39 years (Marques *et al.* 1998), 63% in a French adult population (Boucher *et al.* 2002), and 70% in the neighbouring Lithuanian age group of 35–44 years (Aleksejuniene *et al.* 2000). In this study, AP was diagnosed radiographically in

14% of remaining teeth whereas other studies have reported only 2.9–7.2% of teeth with the disease (Table 1).

Approximately one-fifth (20%) of the remaining teeth had undergone root canal treatment. This data can be compared with the number of root filled teeth in 66-year-old Swiss residents (Imfeld 1991) which was 20%. In younger Western European age groups the number of root filled teeth per one person ranged from 2.7 to 8.6 (Table 1). The high percentage of root filled teeth is consistent with the high prevalence of AP in the population of the Republic of Belarus. In addition, statistical analysis of the data showed that the probability of radiological detection of AP in root filled teeth was 25-fold higher than for nonroot filled teeth. However, it must be emphasized that some of the cases with AP may have been healing.

In other studies, the number of root filled teeth with AP ranged widely from 24.5 to 61% (Table 1). In this study, 45% of root filled teeth had signs of AP which is lower than in some other studies. However, these studies had marked variations primarily in the age range of the populations. In neighbouring Lithuania and Poland periapical radiolucencies associated with root filled teeth were observed less frequently in 39% (Sidaravicius *el al.* 1999) and 25% (Bołtacz-Rzepkowska & Pawlicka 2003), respectively.

In general, the high proportion of root filled teeth with AP may indirectly indicate inadequate technical quality of care – a key factor in the healing or prevention of periapical pathosis (Strindberg 1956, Sjögren *et al.* 1990). One of the objective radiographic criteria that can be applied to assess the quality of root canal treatment is the length of root filling (De Moor *et al.* 2000). According to the criteria, 48% of root filled teeth in the current study had inadequately filled root canals and this data closely correlates with the prevalence of AP in root filled teeth. The results of the present study indicate that the short length of root fillings (>2 mm from the radiological apex), extrusion of material through the apex and its presence only in the pulp chamber considerably increased the relative risk of periapical disease.

The poor prognosis after root canal treatment associated with extrusion of filling materials through the apex, or when limited just to the pulp chamber, has been in other reports (Sjögren *et al.* 1990, De Cleen *et al.* 1993, Buckley & Spångberg 1995, Saunders *et al.* 1997). There are several explanations for slow or lack of bone formation after unsatisfactory length/extension of root fillings, but is particularly associated with infection in the apical part of the root canal. Overfilling may induce a foreign body reaction at the periapex that may not be dependent on the presence or absence of infectious agents or other irritants in the root canal (Nair 2003). Overfilling is often preceded by an overinstrumentation, which may push pulp remnants and microorganisms beyond the apex (Basmadjian-Charles *et al.* 2002).

The radiographic images of treatment results are not sufficient to evaluate the technical procedures and especially disinfection of the root canal prior to filling, which is a major factor in terms of the outcome (Sjögren *et al.* 1997). A previous survey regarded that despite a high incidence of AP amongst the population of Belarus the majority of dentists did not use scientifically approved procedures in their general practice (Kabak 2004). About one half of the interviewed dentists (48%) preferred multivisit treatment but without application of a calcium hydroxide dressing. Rubber dam was used by only 3% of the interviewees. Almost all surveyed dentists (97%) left the tooth open for several days until the next appointment. Root canals were filled with gutta-percha point and sealer by 27% of the dentists, whilst the remainder of the dentists used pastes and cements. Almost one-third of the dentists (34%) did not use radiographs to follow-up the quality of treatment, the remainder used them inconsistently. Coupled with unsatisfactory length/extension of root filling the use of the methods which are below accepted practice may explain the higher prevalence of AP in root filled teeth. The results indicate the need to improve the quality of root canal treatment by general practitioners in Belarus.

The quality of the seal created by the coronal restorations is one of the factors significantly associated with failure of endodontic treatment (Sidaravicius *et al.* 1999, Tronstad *et al.* 2000, Kirkevang & Hørsted-Bindslev 2002). It has been suggested that the coronal restoration, as well as the root-filling, serve as a barrier against fluid and bacterial penetration into the periapical area. Moreover, Ray & Trope (1995) found that the technical quality of the coronal restoration was even more important for periapical health than the quality of root canal treatment. In this study, 25% of the teeth with artificial crowns had radiographic signs of AP. The relative risk of AP developing significantly increased if crowned teeth had been root filled. The true quality of a coronal restoration cannot be identified accurately on a radiograph and therefore it is impossible to identify a correlation between the quality of the

coronal restoration and the periapical status of root filled teeth in cross-sectional studies.

Conclusion

This study has indicated a higher prevalence of AP in all age groups within a population in the Republic of Belarus compared with other countries where similar studies have been conducted. The incidence of AP was higher in root filled teeth than those that had not been treated, and there was a close correlation between the quality of root filling and the prevalence of AP. Adequate root fillings judged radiographically reduced the chance of AP development.

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