Longitudinal study of periapical and endodontic status in a Danish population

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Abstract

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Aim To describe and discuss changes in periapical and endodontic status in a general Danish population.

Methodology In 1997, 616 randomly selected individuals had a full-mouth radiographic survey taken. In 2003, 77% of the participants attended for a new full-mouth radiographic examination. Information on endodontic treatment and periapical status was obtained. The periapical index (PAI) was used to assess apical periodontitis (AP).

Results More participants had root filling(s) and AP in 2003 than in 1997. More teeth had AP and/or root fillings in 2003. Fewer of the root-filled teeth (RFT) had AP in 2003. Less than 3% of the teeth without root fillings (NRFT) that in 1997 had no AP, developed AP and/or received a root filling. Of the NRFT which in 1997 had AP, more than 35% still had AP and no root filling in 2003. Approximately, 30% of the NRFT with AP in 1997 received a root filling. Of the teeth that received a root filling, 40% had healed, whereas 60% had not. Approximately, 25% of the NRFT that in 1997 had AP had been extracted. In 1997 there were 618 RFT, 314 of the RFT had no AP in 1997. Almost 20% of the RFT that in 1997 were periapically sound, developed AP. Of the 304 RFT with AP in 1997, approximately 30% had healed, in 60% AP persisted, and 10% were extracted.

Conclusions The present study indicates that caution must be exercised when statements on the outcome of root canal treatment are made based on the cross-sectional studies.

Keywords: apical periodontitis, endodontic, epidemiology, longitudinal.

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Introduction

In the endodontic literature results from controlled, longitudinal studies have shown success rates up to 96% in establishing periapically sound conditions after endodontic treatment (Strindberg 1956, Kerekes & Tronstad 1979, Sjögren *et al.* 1990, 1997, Ørstavik & Hörsted-Bindslev 1993, Friedman *et al.* 1995, Caliskan & Sen 1996, Ørstavik 1996). The information from such clinical studies suggests that it is possible to control and eliminate apical periodontitis (AP).

During the last decades, cross-sectional studies of the prevalence of AP have been performed in several countries. These studies reveal high frequencies of AP in the populations indicating that the treatment has not eliminated AP. On the contrary, such studies have revealed a high frequency of inadequate root fillings and of AP associated with the root-filled teeth (Petersson *et al.* 1986, Eckerbom *et al.* 1987, Eriksen *et al.* 1988, 1995, Ödesjö *et al.* 1990, Eriksen & Bjertness 1991, De Cleen *et al.* 1993, Saunders *et al.* 1997, Marques *et al.* 1998, Sidaravicius *et al.* 1999, De Moor *et al.* 2000, Kirkevang *et al.* 2000, Boucher *et al.* 2002).

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Cross-sectional studies can be used to describe disease prevalence (e.g. AP) and evaluate its association with concurrent exposure information (e.g. root fillings). Cross-sectional studies do not provide information on the timing of events, but describe exposure and disease status at the time of the investigation. It is not possible in this type of study to decide whether the exposure preceded the disease or the disease preceded the exposure (Rothman & Greenland 1998). Consequently, longitudinal observations are necessary to decide whether a periapical lesion is healing or developing.

The endodontic literature contains surprisingly few longitudinal epidemiological studies on periapical and endodontic status. A study performed by Petersson *et al.* (1991) evaluated the dynamics of AP in a general population, but only on mandibular premolars and molars. Another study has studied AP over time but on a highly selected population of patients exposed repeatedly to full-mouth radiographic examination in a specialist unit (Eckerbom *et al.* 1989). In a recently published study, the changes in prevalence and frequencies of root fillings and AP in randomly selected women during the period from 1968 to 1992 were investigated (Frisk & Hakeberg 2005).

The aim of the present study was to describe and discuss changes in periapical and endodontic status in a general adult Danish population examined in 1997 and in 2003.

Material and methods

The initial population consisted of 1199 randomly selected individuals from Aarhus County, Denmark in 1997. The year of birth ranged from 1935 to 1975. The individuals were contacted by letter and offered a full-mouth radiographic survey. Only individuals who had at least one tooth were included in the study. Written informed consent was given by 311 males and 305 females, who attended the radiographic examination. Thus, the attendance rate in 1997 study was 51%. Analysis of nonattendees was performed and has been described in a previous paper (Kirkevang *et al.* 2001).

In 2003, the 616 participants from the 1997 study were contacted again and offered a new full-mouth radiographic survey. Of these individuals, 473 gave written informed consent and attended the radiographic examination in 2003 (234 males and 239 females). Thus, the attendance rate in the 2003 study was 77%. Various reasons for not attending the second investigation were given: lack of time or interest (22), pregnancy (three), other diseases (two) and death (one).

Analysis of the nonparticipants was performed based on the information from the 1997 study (Kirkevang *et al.* 2001). The analysis revealed no differences between participants and nonparticipants concerning the gender, age distribution, smoking habits, visits to the dentist, root fillings and crowns. The group of nonparticipants included more individuals with very few fillings and more individuals with very few teeth.

The regional Committee of Ethics had approved the study design in 1997 as well as the follow-up study in 2003.

Radiographic recording

All participants underwent in 1997 and in 2003 a full-mouth radiographic survey consisting of 14 periapicals and two bitewings, one in each side. Radiographs were taken using a 'GX 1,000' X-ray unit (Gendex Corporation, Milwaukee, WI, USA), and the paralleling technique; the exposure details were: 70 kV, 10 mA, a film-focus distance of 28 cm. Film processing was automated (Dürr 1330, AC 245L; Dürr Bietigheim-Bissingen, Germany).

The radiographic procedure used in 2003 did not differ from the 1997 study except for the radiographic film used. In 1997, Kodak Ektaspeed Plus film (Eastman Kodak, Rochester, NY, USA), and in 2003 Kodak Insight film (Eastman Kodak) were used. In both studies, the fastest and most recent film on the market was chosen in order to minimize the radiation dose to the participants.

Radiographic registration methods and thresholds

One observer examined all radiographs (L-LK). All teeth were recorded according to the FDI nomenclature using the full-mouth radiographic survey. Third molars were excluded. In all teeth, the variables and thresholds listed in Table 1 were assessed. To identify teeth with AP, the periapical index (PAI) was used (Fig. 1). The index consists of five categories, each representing a step on an ordinal scale from sound periapical bone to severe AP (Ørstavik *et al.* 1986). A tooth assigned score 1 or 2 was diagnosed healthy, whereas if the scores 3, 4 or 5 were given, it was diagnosed as having AP. The observer in the current study was calibrated to the 'golden standard atlas' of PAI before evaluating the material. The Cohen's Kappa was 0.813.

Table 1 Radiographic variables and diagnostic categories

Parameters	Registrations and codes
Root filling	0 = no root filling detectable 1 = root filling material in the root canal
Revision	0 = no radiographic signs of revision of root filling 1 = radiographic signs of revision of root filling
Periapical index (PAI)[a]	1 = normal periapical structures 2 = small changes in bone structure 3 = changes in bone structure with some mineral loss 4 = periodontitis with well defined radiolucent area 5 = severe periodontitis with exacerbating features

[a]Ørstank *et al.* 1986.

Statistical methods

SPSS version 11 was used for the data management. The data were then transferred to STATA version 8, which was used for all statistical calculations. McNemar's test was used to compare the number of root-filled teeth that healed, and the number of root-filled teeth that developed AP during the observation period. The influence on the periapical status at the second examination of endodontic re-treatment in the period between the two examinations was evaluated by a logistic regression analysis. The tooth was the unit of analysis and robust standard errors were used to adjust for cluster effects caused by dependence between the teeth from the same individual. The analysis was carried out separately for the each of the two categories of periapical status at the first examination. The level of statistical significance was set to 5%.

Table 2 Prevalence of root-filled teeth and teeth with AP in the study population in 1997 and 2003

	Status 1997		Status 2003	
	n	%	*n*	%
Number of individuals	473		473	
Median number of teeth	26		26	
Individuals with AP	195	41.2	239	50.5
Individuals with root-filled teeth	250	52.8	278	58.8
Number of teeth	12 442		12 329	
Teeth with AP	379	3	468	3.7
Teeth with root filling	621	4.9	697	5.6
Teeth with root filling and AP	304	49	309	44.3

Results

In Table 2, the prevalence of root-filled teeth and the teeth with AP for the 473 participants in the follow-up study is shown.

In 2003, more of the participants had at least one tooth with a root filling or AP than in 1997 (Table 2). The median number of teeth was 26 in both 2003 and 1997. More teeth in 2003 had AP and root fillings than in 1997. However, fewer of the root-filled teeth had AP in 2003 compared with 1997 (Table 2).

For further analyses, the teeth were divided into two groups, with or without root fillings.

Teeth without root fillings

Less than 3% of the teeth without root fillings, which in 1997 were periapically sound, developed AP or received a root filling during the observation period, and less than 0.5% were extracted. Of the teeth without root fillings, which in 1997 had AP, almost 40% still

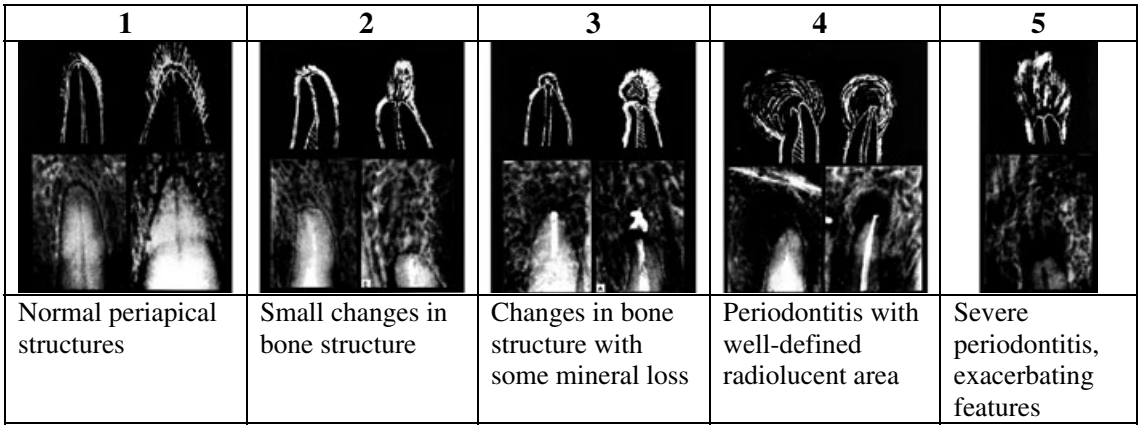

Figure 1 Visual references of the periapical index (PAI) (Ørstavik *et al.* 1986).

had AP and no endodontic treatment in 2003. Approximately, 30% of the teeth without root fillings in 1997, which had AP, received a root filling. Of the teeth that received a root filling, 40% had healed, whereas 60% had not. Approximately, 25% of the teeth without root fillings, which in 1997 had AP, were extracted during the observation period (Table 3).

Teeth with root fillings

In 1997, 618 teeth were root filled, 314 of these teeth had no AP in 1997 (Table 4). Almost 20% of the root-filled teeth, which in 1997 were periapically sound, developed AP during the observation period. Of the 304 teeth that had a root filling and AP in 1997, approximately 30% healed, in 60% AP persisted, and 10% were extracted (Table 4).

The number of root-filled teeth, which healed was significantly larger than the number of root-filled teeth that developed AP ($P = 0.02$).

Table 3 Development of AP in teeth without root fillings during the period 1997–2003

Status 1997	*n*	Status 2003	*n*[a]	%
Healthy	11 729	Healthy	11 406	97.6
		AP	130	1.1
		Root filling + healthy	44	0.4
		Root filling + AP	57	0.5
		Extraction	52	0.4
AP	75	Healthy	5	6.6
		AP	29	38.7
		Root filling + healthy	9	12
		Root filling + AP	14	18.7
		Extraction	18	24

[a]Because of the missing values caused by low quality of the radiographs, the total number of teeth are not the same in 1997 and 2003.

Table 4 Development of AP in teeth with root fillings during the period 1997–2003

Status 1997	*n*	Status 2003	*n*[a]	%
Root filling + healthy	314	Root filling + healthy	244	77.6
		Root filling + AP	61	19.8
		Extraction	8	2.6
Root filling + AP	304	Root filling + healthy	91	30.4
		Root filling + AP	177	58.1
		Extraction	35	11.6

[a]Because of the missing values caused by low quality of the radiographs, the total number of teeth are not the same in 1997 and 2003.

Table 5 Treatment of root-filled teeth during the period 1997–2003

		Status 2003					
		Healthy		AP		Extraction	
Treatment	Status 1997	*n*	%	*n*	%	*n*	%
No revision	Healthy	231	78	57	19.3	8	2.7
	AP	79	30.2	148	56.5	35	13.3
Revision	Healthy	7	63.6	4	36.4		
	AP	8	25.8	23	74.2		

Teeth receiving revision of a root filling

From 1997 to 2003, 42 of the root-filled teeth were re-treated endodontically. Irrespective of previous periapical status, re-treatment did not seem to have any effect on the healing/development of AP. No statistically significant difference of development/healing of AP was found between the teeth that received root canal re-treatment during the observation period and teeth that did not (Table 5).

Discussion

The rate of individuals in the present study, who attended the second radiographic examination after a 5-year observation period, was high, almost 80%. In the study by Petersson *et al.* (1991), the observation period was 10 years and the attendance rate 40%, and in the study by Frisk & Hakeberg (2005) with an observation period of 24 years the attendance rate was 48%. The high attendance rate in the present study provides a solid base for investigations of the periapical status in the general Danish population.

The fastest and the most recent film on the market in 1997 and 2003, respectively, was chosen in order to minimize the radiation dose to the participants. The change in film is not expected to have influenced the results as the performance of the two films has been shown not to be significantly different (Ludlow *et al.* 2001).

In the present study, the PAI was used to diagnose AP. The PAI is based on a study by Brynolf (1967) who, in order to disclose to what extent histological changes are reflected in radiographs, compared histological and radiographic appearances of periapical changes in human autopsy materials. The PAI consists of five categories, each representing a step on an ordinal scale from sound periapical bone to severe AP. One or two radiographs from Brynolf's original material represents each of the five groups, and these

radiographs were used as visual references (Fig. 1) (Ørstavik *et al.* 1986). Each tooth in the study had to be assigned to one of the five PAI-scores using visual references for the five categories within the scale. If in doubt about which score to assign to a tooth, the higher score was chosen. This rule was based on the findings that histological examination always reveals more infection than radiographic examination can detect (Brynolf 1967). In the study by Petersson *et al.* (1991), AP was diagnosed using other criteria: sound = normal or slight widening of the periodontal ligament space, and disease = periapical radiolucency, and 'if in doubt' the tooth should be diagnosed healthy. The study by Frisk & Hakeberg (2005) used panoramic radiographs for the evaluation of AP, the criteria for AP were: a widened periapical ligament space or overt radiolucency. The differences in disease criteria and radiographic method may be reflected in the number of teeth assessed to have AP in the present study compared with the two Swedish studies, which had lower frequencies of AP teeth (Petersson *et al.* 1991, Frisk & Hakeberg 2005). On the other hand, differences in disease frequencies may be real. Disease frequency is dependent on a time period for disease progress/regress; differences in disease dynamics may therefore result in differences in disease frequency. This is often referred to as length bias, which is a considerable problem in relation to cross-sectional studies.

In 2003, more individuals had AP and root-filled teeth than in 1997. Further, the total rate of teeth with AP and teeth with root fillings in 2003 had increased, coincident with a decrease in the rate of teeth that had both root fillings and AP (Table 2). This may be influenced by several factors. It may indicate that more new AP lesions emerge in individuals who did not previously have AP, or that the rate of root-filled teeth with AP that heal is higher than the rate of root-filled teeth that develop AP. It may also be that the teeth, which had received a root filling during the observation period, did not present with AP either because they never had AP, or because the root filling was successful and the healing rapid, or because the root filling was completed so recently that AP had not developed yet.

One could speculate that the raise in the fee for root canal treatment in the Danish Health Security System which came into effect from October 1999 may have influenced the quality of the treatment and with it, the success rate. Further studies are needed to elucidate this.

Teeth without root fillings

Most of the teeth with no root fillings, which were scored sound in 1997, remained sound during the observation period. This corresponds with the findings of Petersson *et al.* (1991).

Of the teeth that had AP at the first examination approximately one-third still had AP at the second examination and had not received endodontic treatment. The relationship between AP and bacterial infections in the root canal system is well established (Kakehashi *et al.* 1965, Sundqvist 1976, Möller *et al.* 1981). It is also well known that AP does not heal without intervention (Strindberg 1956, Kvist 2001, Happonen & Bergenholtz 2003). However, there can be several explanations for this observation: the patients may not have seen a dentist during the 5 years, the AP may not have been diagnosed, or the patients may have refused treatment because of lack of pain or money. Kvist *et al.* (1994) discussed endodontic decision making in relation to endodontically treated teeth and found that dentists regard 'various periapical conditions as different stages on a health continuum' and that lesion size is a major decision factor. It may be speculated that even if a lesion is diagnosed, the dentists tend to create their own cut-off point for disease irrespective of the 'Strindberg concept' of prevailing disease. Further investigations are needed to clarify and explain the findings in the present study.

In the present study as well as in the Swedish studies, teeth were found that had AP at the first examination, appeared to have healed during the observation period without endodontic intervention (Petersson *et al.* 1991). The findings could be ascribed to radiographic projection phenomena, as alterations in angulation may disguise/reveal periapical lesions (Forsberg & Halse 1994, 1997).

Approximately, 30% of the teeth with AP in 1997 had received root canal treatment in 2003 and 25% had been extracted. Of the teeth with AP in 1997, which received root canal treatment during the observation period, approximately 40% had healed and 60% still had AP in 2003. In the present study, information on time of completion of the root filling was not available, thus the healing rate may be underestimated as the root filling may have been completed so recently that healing had not yet occurred. Healing rate may also be influenced by the quality of both the coronal restoration and the quality of the root filling (Ray & Trope 1995, Sidaravicius *et al.* 1999, Kirkevang *et al.* 2000, Tronstad *et al.* 2000). This problem will be investigated in a future study.

In the Swedish study, few teeth that initially were diagnosed with AP were left untreated; however, more than 50% of the teeth that initially had AP were extracted. The healing rate for the teeth that had received endodontic treatment in the Swedish study was higher than in the present study, but the observation period was longer (Petersson *et al.* 1991).

Teeth with root fillings

In the present study, more than three quarters of the healthy root-filled teeth remained healthy during the 5 years. The same rate was found by Petersson *et al.* (1991) over a period of 10 years. In the present study, almost 20% of the root-filled teeth, which originally were diagnosed periapically healthy, developed AP during the observation period. In the Swedish study, 17% of the originally healthy root-filled teeth developed AP. Further studies are needed to disclose and evaluate possible risk factors for these teeth.

Of the root-filled teeth that in 1997 had AP, 30% healed during the observation period, 60% remained with AP and 10% were extracted. In the Swedish study, 35% of the teeth healed, 40% remained with AP, and approximately 20% were extracted.

When teeth with AP in the present study are compared with the findings in the Swedish study, it seems as if teeth with AP, teeth that may be difficult to treat, or perhaps have other dental problems, were more likely to be extracted 20 years ago than today.

This observation corresponds well with the findings of Bjørndal & Reit (2004), who found that in the adult Danish population more root fillings have been performed, especially in the 40–60-year-old individuals, and the number of tooth extractions have been more than halved from 1977 to 2003. These findings support the trend seen in most Western countries that patients tend to keep their teeth longer and fewer extractions are performed (Petersen *et al.* 2004). Reasons for this development may be a general reduction in dental disease, and/or a change in the treatment strategy amongst dentists towards more preventive and conservative treatments where extraction of teeth is the last resort (Bælum & Scheutz 1995, Mojon *et al.* 2004).

In the present study, 42 teeth received further treatment in the root canal during the observation period. Any treatment inside the root canal offers a potential risk of re-infection of the root canal system. Revision of a root filling may be performed either to treat AP or to facilitate prosthetic reconstruction. If the reason for the revision was AP, it should preferably result in improvement of the periapical status, and if the revision was performed for prosthetic reason AP should not arise. The present study found no statistical difference whether a revision had been performed or not on the presence of AP (Table 5). It should be noted however that information on time of completion of an intervention was not available in the present study.

Conclusion

During the last decades, numerous cross-sectional studies have been performed in several countries where the prevalence and frequency of AP have been assessed. Often, the studies have referred to the study by Petersson *et al.* (1991), which found that the number of root-filled teeth that developed AP and the number of root-filled teeth that healed was approximately the same and therefore 'cross-sectional studies could provide reliable information on the long-term success rate of endodontic treatment at population level' (Petersson *et al.* 1991). The present study does not support this conclusion, although the present findings are not at variance with the findings of Petersson *et al.* 1991. The present study found that more root-filled teeth with AP healed, and fewer root-filled teeth without AP developed AP lesions during the observation period. It is important to realize that, in relation to root canal treatment, time is a crucial factor when success rates in population studies are calculated. Further, it is indicated that extreme caution must be exercised when statements on success/failure of root canal treatment are made based on the cross-sectional studies. It is important to take the rate of extractions in the population, the constitution of the population and treatment dissimilarities of different populations into account as these parameters may strongly influence success/failure rates.

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