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A 20-year follow-up study of endodontic variables and apical status in a Swedish population

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Abstract

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Aim To re-examine a population after 20 years and evaluate changes in prevalence of endodontic treatment and apical periodontitis, as well as the technical quality of root fillings.

Methodology One hundred and fifteen out of an original 200 patients living in the northern part of Sweden were re-examined with a full mouth radiographic survey after 20 years. Frequencies of root canal treated teeth, apical periodontitis and quality parameters of root fillings were registered.

Results The frequency of root canal treated teeth increased significantly ($P < 0.05$) from 13.9% at the first investigation to 17.7% after 20 years. There was also a statistically significant increase ($P < 0.05$) in teeth with apical periodontitis from 3.3% to 6.8%. Apical periodontitis both in connection with root canal treated teeth and teeth without endodontic treatment, had increased during the follow-up period. Even though the quality of the root fillings had improved, there was no corresponding improvement of the apical status in teeth with root fillings.

Conclusions There is still a great need for endodontic treatment in the Swedish population, and no improvement in apical health was found during this 20-year follow up.

Keywords: apical periodontitis, endodontics, epidemiology, long-term, quality.

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Introduction

In different parts of the world, studies regarding the frequencies and technical quality of the endodontic treatment have been conducted (Eckerbom *et al.* 1987, De Cleen *et al.* 1993, Buckley & Spångberg 1995, Saunders *et al.* 1997, De Moor *et al.* 2000, Kirkevang *et al.* 2001a, Lupi-Pegurier *et al.* 2002, Jiménez-Pinźon *et al.* 2004, Georgopoulou *et al.* 2005, Loftus *et al.* 2005, Ridell *et al.* 2006). Amongst other things, it has been shown that the number of root canal treated teeth, as well as the number of teeth with apical periodontitis, increases with age (Eriksen *et al.* 2002, Georgopoulou *et al.* 2005, Hugoson *et al.* 2005). Other studies have been made on specific age groups (Eriksen *et al.* 1995, Marques *et al.* 1998, Sidaravicius *et al.* 1999, Ridell *et al.* 2006). Some studies have been longitudinal (Eckerbom *et al.* 1989, Petersson 1993, Eriksen *et al.* 1995, Kirkevang *et al.* 2001b), but studies on the same population over time are rare (Eckerbom *et al.* 1989, Petersson 1993). Most of these studies have also shown high association with disease and poor quality of root fillings made in general dental practice, whilst patients root canal treated at dental schools have shown a great association with health rates and better quality of root fillings (Kerekes & Tronstad 1979).

It has also been shown that a majority of apical periodontitis is found in connection with root canal treated teeth, and that the quality of the root canal

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treatment is of importance for the prognosis that such lesions shall heal. Longitudinal studies have also shown that a minor improvement of the quality of the root filling has occurred over time (Eckerbom *et al.* 1989, Eriksen *et al.* 1995, Kirkevang *et al.* 2001b). And, except for Kirkevang *et al.* (2001b), these studies also showed an improvement of the apical health over time.

The aim of this study was to undertake a radiographic follow up of a population, previously described in detail (Eckerbom *et al.* 1987, 1989), 20 years after the last examination to find out if there were any changes of the endodontic parameters the number of root canal treated teeth, prevalence of apical periodontitis, as well as the quality of the root fillings.

Material and methods

The original material consisted of 200 patients examined with a full mouth radiographic survey on two occasions, 1975–1976 and 1980–1982, respectively (Eckerbom *et al.* 1987, 1989). Twenty years later, 18 subjects were deceased. In another 28 cases, the subjects could not be traced. The remaining 154 subjects were approached by a letter and offered a radiographic re-examination. Twenty-three subjects refused to participate or rejected the offer due to poor health. Three subjects did not answer despite two reminder letters, and another 13 subjects had moved to other parts of the country. Thus, a total of 115 subjects (57.5%), 62 men and 53 women, accepted the offer of a re-examination that was conducted during the time period of 2000–2002. They were all examined by a full mouth radiographic survey performed at the Department of Maxillofacial Radiology at the Sunderby Hospital, Luleå, Sweden. The standard series of radiographs for a fully dentate patient consisted of 14 periapical films and four bite-wings using a paralleling technique. The radiographs (Insight Film, Eastman-Kodak, Rochester, NY, USA) were exposed at 60 kV with a Sirona Heliodent DS (Sirona Dental Systems GmbH, Bensheim, Germany). The films were processed under standardized conditions in an automatic developer (Dürr XR24, Dürr, Bietigheim-Bissingen, Germany) according to the manufacturer's recommendations. Analysing conditions and criteria for positive recordings were the same as used and described before (Eckerbom *et al.* 1986). The parameters registered were the total number of teeth and roots, the number of teeth and roots that had received nonsurgical root canal treatment (henceforth called root canal treated teeth and roots), and apical presence of periodontitis. Endodontic variables such as the length of the root filling, proper or improper seal, and visible or nonvisible lumen apical of the root filling were also registered (Table 1). The radiographs were analysed by two experienced and calibrated observers, one an endodontist and the other a radiologist who each examined half of the material (Eckerbom *et al.* 1986). Finally, the two examiners evaluated all the radiographs together and a consensus was reached in each single case where they were of different opinions (Molven *et al.* 2002).

The results from the 20-year follow up were compared with the findings made at the examinations performed during 1980–1982 (henceforth called *first examination*). Nonparametric permutation tests according to Fisher and Pitman were used. A P-value of <0.05 was considered statistically significant.

Table 1 Criteria for the recording of endodontic information in radiographs

Variable	Criteria
Root canal treated teeth	Teeth with radiopaque material in pulp chamber and/or in one or more root canals
Root-filled roots	Roots with radiopaque material in root canal
Pulpotomized roots	Roots in teeth with radiopaque material in pulp chamber and/or orifice of root canal
Periradicular radiolucency	Radiolucent area in connection with root. Slight widening of periodontal ligament space with intact lamina dura or uncertain cases were registered as normal
Length of root filling	Categories: root filling ending more than 2 mm from radiographic apex, 2 mm or <2 mm from apex, flush with apex, or overfilling. In roots with more than one canal, the shortest root filling was registered
Seal of root canal	Seal adequate when radiopaque material in root canal is homogenous and no space is seen between material and walls of canal
Unfilled lumen apical of root filling	No radiopaque material in 1 mm or more of root canal space visible apical of root-filling material

Age group (years)	Number of patients			Mean number (and range) of remaining teeth	
	Men	Women	Total	First examination	20 years later
20–29	11	10	21	27.5 (21–32)	24.8 (19–31)
30–39	24	20	44	25.6 (16–32)	22.7 (7–32)
40–49	23	16	39	22.7 (9–29)	19.6 (7–27)
50–59	3	4	7	21.7 (16–28)	19.9 (15–27)
≥60	1	3	4	20.5 (18–24)	13.7 (2–23)
Total	62	53	115	23.6 (9–32)	20.1 (2–32)

Table 2 The number of teeth in the different age groups on two occasions with an interval of 20 years

Results

A total of 2825 teeth were registered at the first examination and 2461 at the second in the 115 patients. The number and sex distribution in the different age groups, as well as mean and range, at the first and second examination is presented in Table 2.

Only 26 subjects (22.6%) had lost no teeth during the 20-year follow-up period, and 21 subjects (18.3%) had lost more than five teeth (range: 6–21, Table 3). A total of 364 teeth (12.9%) was lost during the 20-year period. The percentage distribution of remaining teeth at the first and second examination is illustrated in Fig. 1. No sex differences were found.

Table 3 Number of teeth lost in 115 individuals during a period of 20 years

Number of teeth lost	Number of patients (%)
0	26 (22.6)
1	30 (26.1)
2	14 (12.2)
3	9 (7.8)
4	7 (6.1)
5	8 (7.0)
>5	21 (18.3)

Three hundred and ninety-three teeth were root canal treated at the first examination (13.9%, mean: 3.4/subject, range: 0–11). The corresponding figure

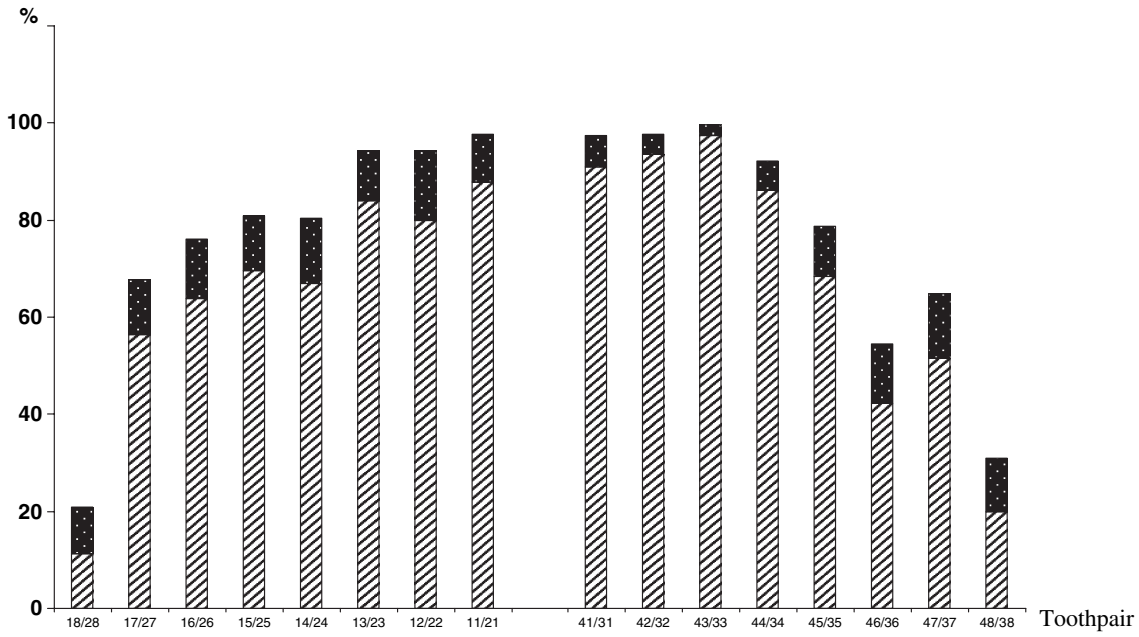

Figure 1 Percentage distribution of remaining teeth in 115 patients expressed as percentage of a 32-tooth dentition on two occasions with an interval of 20 years. The filled part of the bars represents the teeth that were extracted between the two examinations. The left and right sides are pooled together.

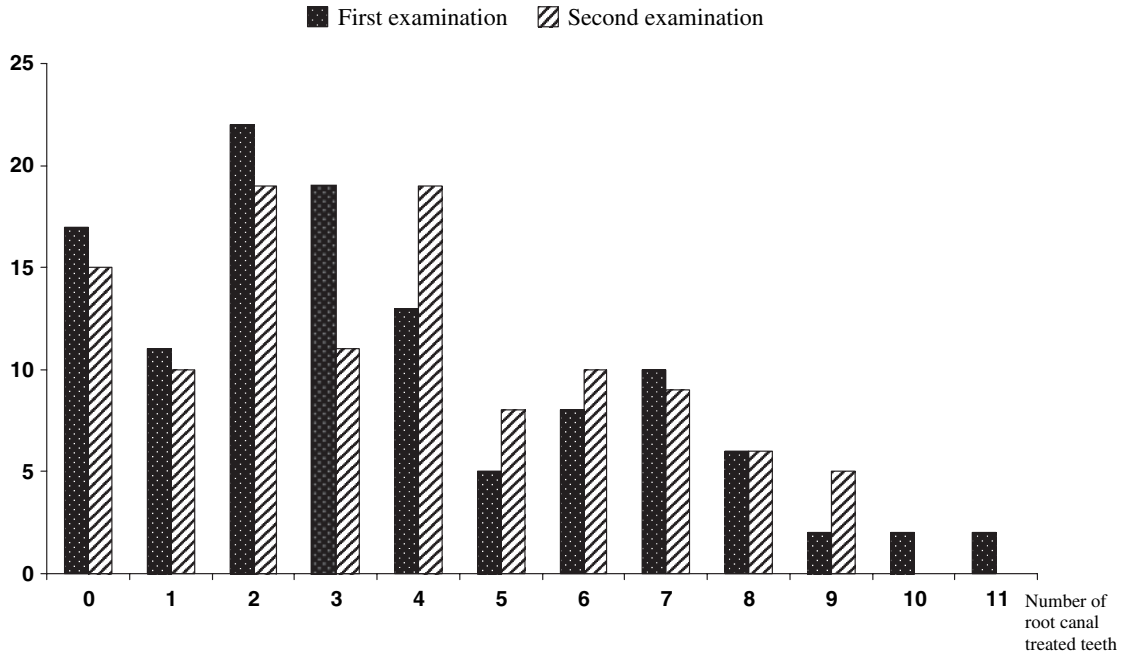

Figure 2 Distribution of 115 patients according to the number of root canal treated teeth on two occasions with an interval of 20 years.

20 years later was 435 (17.7%, mean: 3.8/subject, range: 0–9). This increase was statistically significant ($P < 0.05$), but there were no differences between the different age groups. The number of root canal treated teeth/subject at the two examinations is illustrated in Fig. 2.

At the first examination, the 393 root canal treated teeth included 575 roots. Out of these, 505 (87.8%, mean: 4.4/subject) were root filled and 70 (12.2%, mean: 0.6/subject) were pulpotomized. At the second examination, the number of root canal treated roots was 598, out of which 562 were root filled (94.0% mean: 4.9/subject) and 36 were pulpotomized (6.0%, mean: 0.3/subject). Both the increase of root-filled roots and the decrease of pulpotomized roots was statistically significant ($P < 0.05$).

Of the 393 teeth that were root canal treated at the first examination, 113 (28.8%) were lost during the time period covered by the investigation. The corresponding figure for teeth without root canal treatment was 251 (10.2%). A total of 155 teeth with new root fillings was registered at the follow up. Root canal treated teeth were lost significantly more often than other teeth ($P < 0.05$), and molars were lost more often than premolars ($P < 0.05$), and premolars more often than anterior teeth ($P < 0.05$). Only 17 subjects (14.8%) had no root canal treated teeth at the first examination, and the corresponding figure was 15 (13.0%) at the second examination. Thirty patients (21.1%) had more than five root canal treated teeth on both occasions.

Table 4 Distribution of 115 patients according to number of teeth/patients with apical periodontitis with an interval of 20 years

Number of apical periodontitis	First examination, number of patients (%)	Second examination, number of patients (%)
0	44 (38.3)	42 (36.8)
1	25 (21.7)	23 (20.2)
2	13 (11.3)	17 (14.9)
3	15 (13.0)	8 (7.0)
4	8 (7.0)	13 (11.4)
5	6 (5.2)	3 (2.6)
>5	4 (3.5)	8 (6.9)

The distribution of subjects according to the number of teeth with apical periodontitis at the first and second examination is presented in Table 4. Forty-four participants (38.5%) had no apical periodontitis, and four (3.5%) had more than five affected teeth at the first examination. The corresponding figures at the

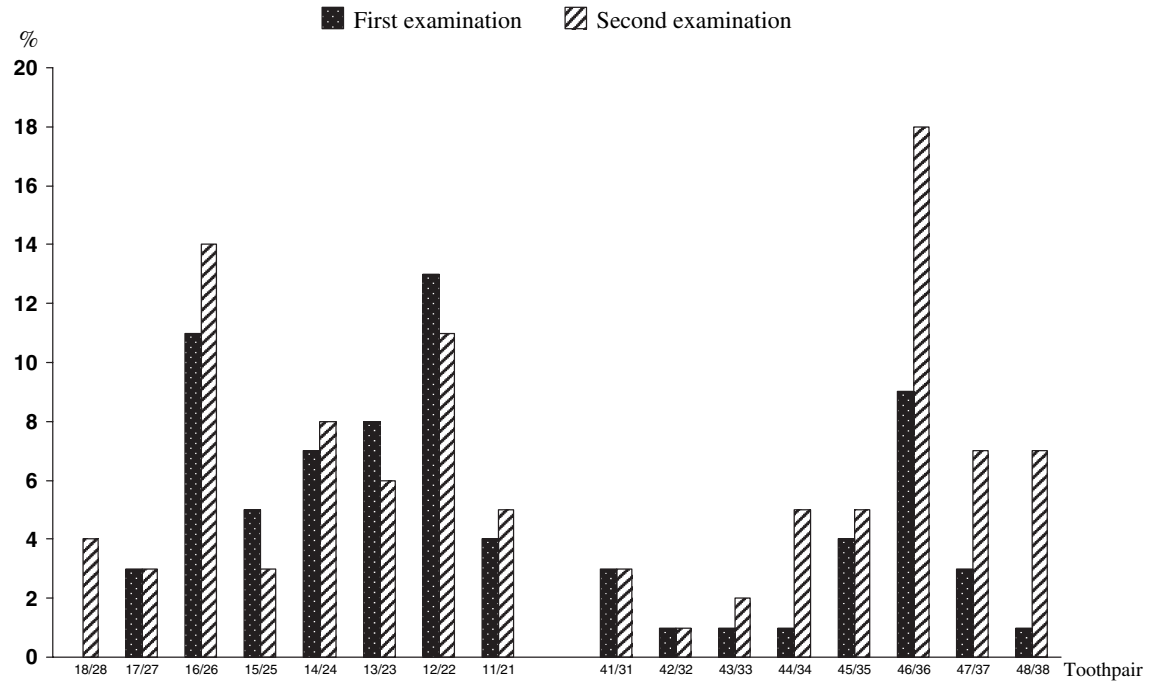

Figure 3 Percentage distribution of 97 and 168 teeth with apical periodontitis, expressed as percentage of remaining teeth on two occasions with an interval of 20 years.

second examination were 42 (36.8%) and eight (6.9%), respectively. The distribution of apical periodontitis in association with the remaining teeth and in root canal treated teeth, respectively, at the first and second examination is illustrated in Figs 3 and 4. The number of teeth with apical periodontitis had increased from 97 at the first examination (3.3%, mean: 0.8/subject) to 168 at the second (6.8%, mean: 1.5/subject, $P < 0.05$). Almost three-quarters (70.1%) of the teeth registered with apical periodontitis at the first examination were root-filled teeth. The corresponding figure 20 years later was 55.3%. Thus, at the first examination, 29.9% of the cases with apical periodontitis was associated with teeth without endodontic treatment, a figure that had increased to 44.7% after 20 years.

Apical periodontitis was present in association with 68 (17.3%) and 93 (21.4%) of the root canal treated teeth at the first and second examinations, respectively. During the 20-year follow-up period, 47 root canal treated roots had either developed new apical periodontitis ($n = 35$) or the apical pathosis had increased in size ($n = 12$); in another 41 roots with apical periodontitis, the lesions had decreased in size ($n = 6$) or healed ($n = 35$). Forty-nine roots, without endodontic treatment, had developed apical periodontitis. Of the 42 roots that had apical periodontitis at both examinations, 32 (76.1%) were root canal treated.

The quality variables of the root fillings are presented in Table 5. The increase in root fillings ending ≤2 mm from the apex was statistically significant ($P < 0.05$). Root fillings, judged to have a proper seal, had increased from 53.1% to 61.2% ($P < 0.05$). There was also a statistically significant increase of roots with no visible lumen apical to the root filling; from 83.8% to 91.3% ($P < 0.05$).

Discussion

A loss of participants from a research project always creates a risk when the results are interpreted, and in longitudinal studies, the rate of attrition tends to increase in the long-term. If the explainable losses are deducted (18 deceased, 28 unknown addresses, 13 living far from the clinic), the participation rate in the present study was 82%. Considering the 20-year time interval between the two examinations, the participation rate is acceptable, and a loss of 18% of the sample is explicable. In comparison, a longitudinal study covering 8–10 years had a drop-out rate of 53.8% (Sjögren *et al.* 1990).

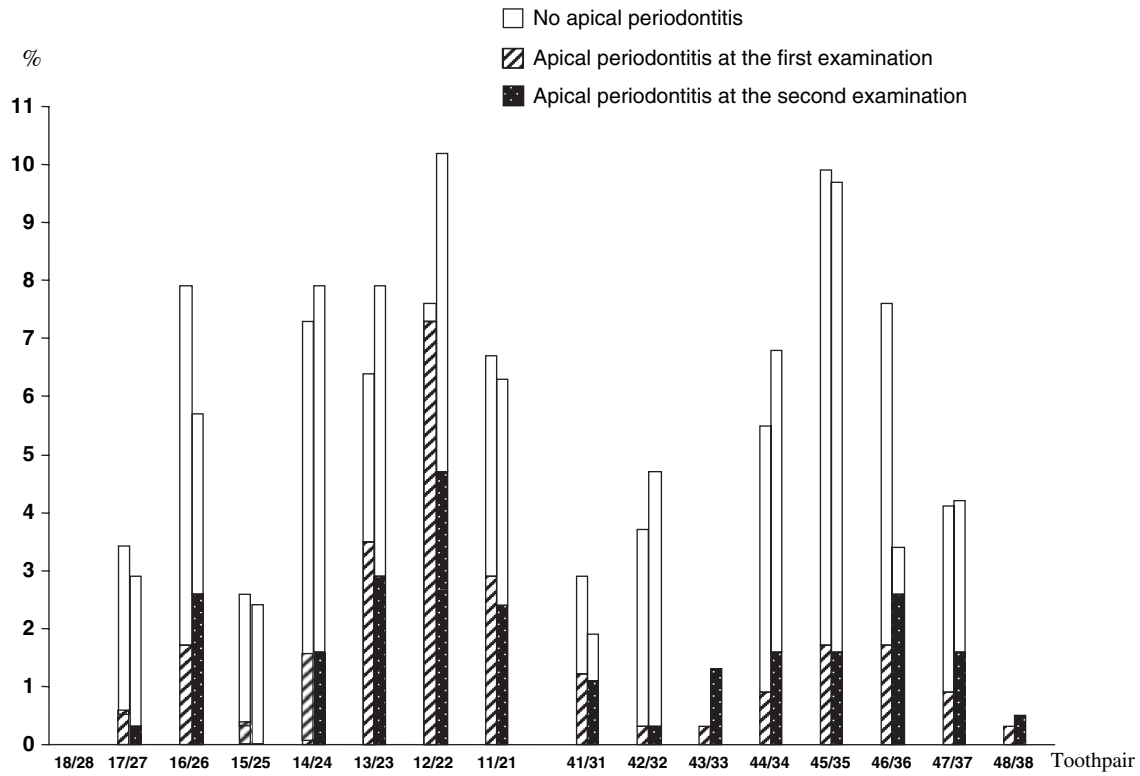

Figure 4 Percentage distribution of root canal treated teeth with and without apical periodontitis on two occasions with an interval of 20 years as percentage of remaining teeth. There were 393 root canal treated teeth at the first examination and 435 at the second examination.

Table 5 Differences in endodontic quality variables between the two examinations

Variable	First examination, number of roots ($n = 505$; %)	Second examination, number of roots ($n = 562$; %)	*P*-value
Root filling ending >2 mm from the apex	233 (46.1)	246 (43.8)	NS
Root filling ending ≤2 mm from the apex	197 (39.0)	236 (42.0)	<0.05
Root filling flush with apex	49 (9.7)	65 (11.6)	NS
Over filling	26 (5.1)	15 (2.7)	NS
Proper seal	268 (53.1)	344 (61.2)	<0.05
No visible lumen apical of root filling	423 (83.8)	513 (91.3)	<0.05

Since only subjects of over 20 years of age were included in the first examination, all the participants were at least 40 years old at the second examination. Because of this, the prevalence figures reported from the second examination are not representative of an adult Swedish population. The male–female ratio is also not representative for Sweden.

Another drawback, when interpreting the results, is that no information was available on the dental care habits of the participants, or what kind of dental treatment, including possible revisions of root fillings, had been provided during the follow-up period.

An interobserver difference always exists when more than one observer is involved (Eckerbom *et al.* 1986). In order to minimize the risks, strict criteria were used for positive recordings, and the two observers were calibrated. Furthermore, after having examined half of the material each, the material was re-examined by

both examiners together to reach full consensus in all the cases (Molven *et al.* 2002). The use of periapical radiographs instead of panoramic radiographs, increases the sensitivity of detecting apical periodontitis in some regions (Molander *et al.* 1995), but it has to be considered that even periapical radiographs will involve a risk for misinterpretations (Eckerbom & Magnusson 1997). Overall, the risk for interobserver variations in this material should be small and acceptable with the method used.

The mean number of teeth decreased during the follow-up period, and the oldest age group had lost more teeth than the other age groups. This is a logical finding, and corroborates the results presented by Björndal & Reit (2004). The tooth losses were almost evenly distributed between the different groups of teeth, but mandibular canines were retained more often than other teeth.

The mean number of root canal treated teeth increased from 13.9% to 17.7%. This increase of root canal treated teeth with increasing age has been reported by others (Björndal & Reit 2004, Hugoson *et al.* 2005), but the prevalence figure is still lower than the figures of 26% and 21% found in elderly subjects in Switzerland and Finland, respectively (Imfeld 1991, Soikkonen 1995).

Many of the teeth that were lost were root canal treated teeth. Almost 30% of the root canal treated teeth were lost, whilst the corresponding figure for teeth without root fillings was only 10%, meaning that a root canal treated tooth had a three times greater risk of being lost during this 20-year period.

Molar teeth were lost more often than premolars, and premolars more often than anterior teeth. The reasons for this finding could include caries and periodontal diseases in the posterior segments of the mouth, but it is most likely also a consequence of greater therapeutic efforts to keep anterior teeth for aesthetic reasons.

During the 20-year period, 364 of the 2825 teeth were lost, making a yearly incidence of 0.7%. This is exactly the same incidence that was found in the previous 5- to 7-year follow up of the same material (Eckerbom *et al.* 1989).

There was a statistically significant increase of root canal treated teeth at the 20-year follow up. Such an increase has also been reported by Björndal & Reit (2004). The total number of new root-filled teeth in the present sample was 155, making it a yearly incidence of 0.3%. This is almost the same incidence figure as the 0.4% that was found in the 5- to 7-year follow up (Eckerbom *et al.* 1989).

This constant, but small loss of teeth over time, and the continued increase of root canal treated teeth, supports previous statements that root canal treatment is a popular alternative to extractions in Swedish dentistry (Eckerbom *et al.* 1989).

In the present material, the number of pulpotomized roots had decreased. This is most likely due to the fact that almost half of the pulpotomized roots had been lost, and only a small number had been provided. Indeed, this treatment modality has not been taught in dental schools in Sweden for many years due to its poor prognosis (Boltacz–Rzepkowska & Pawlicka 2003). The same decreased frequency for pulpotomized teeth has also been found in other Scandinavian studies (Kirkevang *et al.* 2001b, Björndal & Reit 2004).

The number of teeth with apical periodontitis increased significantly during the 20-year period. In the earlier longitudinal study over 5–7 years (Eckerbom *et al.* 1989), no such increase could be seen. The explanation to this discrepancy is not clear, but might reflect a change in dental care habits in this, now older, population due to, for example, economic reasons.

The percentage of root canal treated teeth with apical periodontitis increased. This was the opposite to that noted in the previous study, where apical periodontitis in connection with root-filled teeth had decreased (Eckerbom *et al.* 1989). An increase of apical periodontitis over time has also been reported by Kirkevang *et al.* (2001b).

Of the teeth that had apical periodontitis at both examinations, 76.1% was associated with root canal treated teeth. This might indicate the reason why dentists are reluctant to re-treat root canal treated teeth, or more willing to accept apical periodontitis in connection with root canal treated teeth. It should be emphasized, however, that it is not possible to detect from one single radiograph whether an apical area of bone loss is growing in size or healing. There might, thus, be a possibility that some of these teeth had been re-treated recently, and that some of the apical lesions were healing.

An interesting finding was that in 10 cases where apical pathology was seen in connection with teeth without endodontic treatment both at first and second examination, for some reason, no intervention had been made.

As described earlier by many authors (Kerekes & Tronstad 1979, Eckerbom *et al.* 1989, Buckley & Spångberg 1995, Saunders *et al.* 1997, Boucher *et al.* 2002, Lupi-Pegurier *et al.* 2002, Loftus *et al.* 2005)

apical periodontitis is found less frequently when the quality of the endodontic treatment is good. An interesting finding in the present investigation was that the number of root fillings ending ≤2 mm from the apex, a proper seal, and no visible lumen apical of the root filling increased statistically significant during the observation period. However, despite this improvement, the number of apical lesions in connection with the root-filled teeth increased from 17.3% to 21.4%. This finding indicates strongly that it is not only the quality of the root fillings that influences the outcome of endodontic treatment. Other factors might be: the particular bacteria involved in the infection (Sundqvist 1976), diagnosis (Kerekes & Tronstad 1979, Sjögren *et al.* 1990) and maintenance of long-term coronal seal (Buckley & Spångberg 1995, Saunders *et al.* 1997, Kirkevang *et al.* 2001b). These factors are not possible to be measured in a study such as this (Eriksen *et al.* 2002). As the subjects in the present study were older than the average Swedish population, it will probably also lead to more difficult endodontic cases due to calcification of the root canal system and more re-treatment cases (Kirkevang *et al.* 2001b). It should also be stressed that the two-dimensional information from radiographs does not provide complete information about the quality of root fillings (Eckerbom & Magnusson 1997).

Conclusions

Both the number of root canal treated teeth and apical periodontitis increased during the time period covered by the investigation. Thus, there is still a great need for endodontic treatment in the Swedish population. Despite an improvement in the quality of the endodontic treatment, no improvement in apical health in connection with the root-filled teeth was noted.

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