
Periapical status and quality of root fillings and coronal restorations in a Danish population

L.-L. Kirkevang¹, D. Ørstavik², P. Hörsted-Bindslev³ & A. Wenzel¹

¹Department of Oral Radiology, Royal Dental College, University of Aarhus, Aarhus; ²NIOM, Scandinavian Institute of Dental Materials, Haslum; and ³Department of Dental Pathology, Operative Dentistry and Endodontics, Royal Dental College, University of Aarhus, Aarhus, Denmark

Abstract

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Aim The aim of this study was to investigate the quality of endodontic and coronal restorations and the association with periapical status in a Danish population.

Methodology A total of 614 randomly selected individuals (20–60+ years of age) from Aarhus County had a full-mouth radiographic examination. The quality of endodontic and coronal restorations and the periapical status of endodontically treated teeth were assessed by radiographic criteria. Root fillings were categorized as 'adequate' or 'inadequate' with regard to root filling length and lateral seal. Coronal restorations were categorized into 'adequate' and 'inadequate', defined by the absence or presence of radiographic signs of overhangs or open margins. Results were analysed statistically using the chi-squared test.

Results The total number of endodontically treated teeth was 773, and 52.3% had apical periodontitis (AP). Root-filled teeth with an adequate lateral seal had a lower incidence of AP than teeth with an inadequate seal (44.3% vs. 57.8%), and teeth with an adequate root filling length were associated with a better periapical status than teeth with inadequate length of the root filling (42.0% vs. 67.6%). Similarly, adequate coronal restorations were associated with better periapical status than inadequate restorations (48.0% vs. 63.9%). When both root filling and coronal restoration quality were assessed, the incidence of AP ranged from 31.2% (optimal quality) to 78.3% (all parameters scored as inadequate).

Conclusions Inadequate root canal and coronal restorations were associated with an increased incidence of AP.

Keywords: apical periodontitis, coronal restoration, periapical status, root filling.

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Introduction

Current information on the quality and prognosis of root canal treatment has mainly been based on clinical studies made in controlled environments at dental schools or in specialist clinics (Strindberg 1956, Kerekes & Tronstad 1979, Sjögren *et al.* 1990, 1997, Ørstavik & Hörsted-Bindslev 1993, Friedman *et al.* 1995, Çalışkan & Sen 1996, Ørstavik 1996). The results from such longitudinal studies showed success rates up to 96%

for periapical health after endodontic treatment. Epidemiological population studies of endodontic treatment performed by general practitioners show a different picture. They reveal a high frequency of inadequate root fillings and a high rate of apical periodontitis associated with the endodontically treated 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). These epidemiological studies point to an association between the quality of endodontic treatment and the periapical bone status, and they have concluded that there is room for improvement of the endodontic treatment in general dental practice in order to promote

Correspondence: Lise-Lotte Kirkevang, Department of Oral Radiology, Royal Dental College, Vennelyst Boulevard, DK-8000 Århus C, Denmark (fax: +45 86196029; e-mail: llkirkevang@odont.au.dk).

Table 1 Parameters recorded on endodontically treated teeth

Parameters	Registrations and codes
Coronal restorations (filling and crown)	1 = Adequate (radiographically sealed) 2 = Inadequate (radiographic signs of overhangs or with open margins)
Lateral seal of root filling	1 = Adequate in the coronal 1/2 of the root filling + adequate in the apical 1/2 of the root filling 2 = Adequate in the coronal 1/2 of the root filling + inadequate in the apical 1/2 of the root filling 3 = Inadequate in the coronal 1/2 of the root filling + adequate in the apical 1/2 of the root filling 4 = Inadequate in the coronal 1/2 of the root filling + inadequate in the apical 1/2 of the root filling
Length of root filling	1 = Root filling ending \leq 3 mm from radiographic apex 2 = Root filling ending >3 mm from radiographic apex 3 = Pulpotomy, material seen only in the pulp chamber 4 = Flush, root filling ending at the radiographic apex 5 = Over-filling, root filling material seen in the periapical area
Periapical index (PAI) (Ørstavik <i>et al.</i> 1986)	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

periapical health. In addition, focus has recently been set on the quality of the coronal restoration (Ray & Trope 1995, Sidaravicius *et al.* 1999). It has been suggested that the quality of the coronal restoration may be of greater importance for the periapical status than the quality of the endodontic treatment (Ray & Trope 1995).

The aim of the present study was to relate the quality of endodontic and coronal restorations to the periapical status of the endodontically treated teeth in an adult Danish population based on radiographic examination.

Materials and methods

The material consisted of 1199 individuals from Aarhus County selected randomly in 1997. A systematic sample was drawn by 'Det Centrale Person Register' (The Central Person Register, CPR) using two birth dates and year of birth as extracting keys. The year of birth ranged from 1935 to 1975. All individuals included in the study had \geq 1 tooth. The individuals, 601 males and 598 females, were contacted by correspondence, in which they were offered a full-mouth radiographic survey. The regional Ethics Committee approved the study design. Written informed consent was given by 311 males and 303 females that attended the radiographic examination. Five hundred and eighty-five individuals abstained or were not included for various reasons such as illness, lack of time, lack of interest and unknown address. An analysis of

nonattendees was made by use of information from Statistics Denmark (1999) and has been described in a previous study (Kirkevang *et al.* 2000, in press).

Radiographic recording

All participants underwent a full-mouth radiographic survey, consisting of 14 periapical and two bite-wing radiographs. All radiographs were taken by a 'GX 1,000' X-ray unit (Gendex Corporation, Milwaukee, WI, USA), using the paralleling technique, 70 kV, 10 mA, film-focus distance 28 cm, and Kodak Ektaspeed Plus film (Eastman Kodak, Rochester, NY, USA). Film processing was automated (Dürr 1330, AC 245 L, Bietigheim-Bissingen, Germany).

Radiographic registration methods

From the full-mouth radiographic survey all endodontically treated teeth were recorded. Third molars were excluded. In the endodontically treated teeth the parameters listed in Table 1 were assessed.

Observer

One observer (LLK) examined all the radiographs. For the PAI scoring, the observer was calibrated against a set of 100 reference teeth. Intra-observer agreement for PAI scores, as well as other radiographic parameters,

was assessed by calculating Cohen's Kappa after rescaling 60 individuals' radiographs. Calibration of PAI against a set of reference teeth gave a Kappa of 0.813, and the intraobserver agreement scores gave Kappas of 0.613 for lateral seal, 0.736 for length, 0.779 for PAI, and 0.834 for coronal restoration.

Data treatment

Diagnostic thresholds for the present study were:

- 1** Lateral seal of the endodontic treatment: adequate if no voids were present in the root filling; score 1 = adequate and score 2, 3 and 4 = inadequate (Table 1)
- 2** Length of an endodontic treatment: adequate if ending ≤ 3 mm from, or flush with, the radiographic apex: score 1 and 4 = adequate, and score 2, 3 and 5 = inadequate (Table 1)
- 3** Periapical bone: score 1 and 2 = sound, and score 3, 4 and 5 = diseased (Table 1)

The chi-squared test was used for evaluation of differences amongst subgroups of teeth.

Results

The total number of endodontically treated teeth was 773. Approximately half of the teeth had apical periodontitis. Pulpotomies were found in five teeth (0.6%). Table 2 shows the relationship between the lateral seal and periapical status. Apical periodontitis was found in less than half of the adequately root canal-sealed teeth, whereas if voids were detected, disease was present in more than half of the teeth ($P < 0.001$). In Table 3, the relationship between the length of the endodontic filling and the periapical status is shown. Apical periodontitis was found in less than half of the teeth with adequate length of the endodontic filling, whereas if it was too short or too long, periapical lesions were present in more than two-thirds of the teeth ($P < 0.001$). The relationship between the quality of the coronal restoration and the periapical status is presented in Table 4. Apical periodontitis was found in less than half of the teeth with adequate coronal restorations, whereas if the coronal restoration was inadequate, disease was present in approximately two-thirds of the teeth ($P < 0.001$).

Table 2 Quality of lateral seal of endodontic filling and the relation to the periapical status, percentage for sound/diseased

Treatment	Total no. of teeth	Sound (%)	Diseased (%)
Adequate lateral seal	316	55.7	44.3
Inadequate lateral seal	457	42.2	57.8
Total	773	47.7	52.3

Table 3 Quality of length of endodontic filling and the relation to the periapical status, percentage for sound/diseased

Treatment	Total no. of teeth	Sound (%)	Diseased (%)
Adequate length	464	58.0	42.0
Inadequate length	306	32.4	67.6
Total	773	47.7	52.3

Teeth that had endodontic treatments with adequate length, as well as adequate lateral seal of the filling, were tested against any other combination of treatment quality (adequate length/inadequate lateral seal, inadequate length/adequate lateral seal, and inadequate length/inadequate lateral seal). Both length and lateral seal were found to be adequate in 205 teeth, and approximately one-third of these teeth had periapical lesions, significantly less than any other combination ($P < 0.001$, Table 5). When the 198 teeth with both inadequate length and lateral seal of endodontic fillings were compared with any of the other combinations of treatment quality, these teeth had significantly more periapical lesions (78.3%, $P < 0.001$, Table 5).

Finally, all three quality parameters were combined. Coronal restoration, lateral seal, and length were found to be adequate in 154 teeth and less than one-third of these teeth had apical periodontitis. When tested against any other combination of the quality parameters, this was significantly better than any other combination ($P < 0.001$, Table 5). In 69 teeth both the coronal and the endodontic restoration were inadequate, and when they were tested against any other combination of the quality parameters, these teeth had significantly more apical periodontitis (78.3%, $P < 0.001$).

Table 4 Quality of coronal restoration on endodontically treated teeth and the relation to the periapical status, percentage for sound/diseased

Treatment	Total no. of teeth	Sound (%)	Diseased (%)
Adequate coronal restoration	568	51.9	48.1
Inadequate coronal restoration	205	36.1	63.9
Total	773	47.7	52.3

Table 5 Quality of combined treatments and the relation to the periapical status, percentage for sound/diseased

Treatment	Total no. of teeth	Sound (%)	Diseased (%)
Adequate lateral seal + length	205	64.9	35.1
Any other quality combination	568	41.5	58.5
Total	773	47.7	52.3
Inadequate lateral seal + length	198	28.8	71.2
Any other quality combination	575	54.3	45.7
Total	773	47.7	52.3
Adequate lateral seal + length + crown	154	68.8	31.2
Any other quality combination	619	42.5	57.5
Total	773	47.7	52.3
Inadequate lateral seal + length + crown	69	21.7	78.3
Any other quality combination	704	50.3	49.7
Total	773	47.7	52.3

Discussion

The study population has previously been described in detail (Kirkevang *et al.* 2000, in press). In the present study the quality of the lateral seal, the length of the endodontic filling, and the quality of the coronal restoration of endodontically treated teeth were evaluated in relation to the periapical status. Epidemiological studies have shown frequencies of apical periodontitis ranging from 21.7 to 58.1% (Marques *et al.* 1998, Saunders *et al.* 1997). A number of epidemiological studies on apical periodontitis have been performed with the PAI scoring system (see Kirkevang *et al.* 2000, in press), facilitating comparisons of results. In these studies the frequencies of apical periodontitis ranged from 21.7 to 39.4% (Marques *et al.* 1998, Sidaravicius *et al.* 1999). In the present study 52.3% of the endodontically treated teeth had apical periodontitis at the chosen disease threshold.

A number of reports on the effects of endodontic treatment on periapical status have been published. The populations included in the various studies were inhomogeneous, and the methods evaluating the quality of endodontic treatment and periapical status also differed.

Different thresholds have been used when categorizing endodontic treatments as adequate or inadequate. Some studies have concentrated merely on the length of the root fillings (De Cleen *et al.* 1993, Saunders *et al.* 1997); others have used both length and lateral seal of root filling without combining the two (Eriksen *et al.* 1988, 1995, Eriksen & Bjertness 1991), and some have used both length and lateral seal and a combination of the two recordings (Petersson *et al.* 1986, Bergström *et al.* 1987, Eckerbom *et al.* 1987, Ödesjö *et al.* 1990, Buckley & Spångberg 1995, Marques *et al.* 1998, Sidaravicius

et al. 1999). When studies have included the lateral seal as one of the criteria to judge if an endodontic treatment was adequate, they have all agreed that if a void was present in the lateral aspect, the endodontic treatment was categorized as inadequate. Eckerbom & Magnusson (1997) demonstrated that the reliability of only one orthoradial intraoral radiograph was poor when evaluating the lateral seal of endodontic treatments. In the present study most of the teeth could be evaluated in more than one projection, thereby increasing the reliability of the quality score of the lateral seal. About 60% of the endodontic treatments had an inadequate lateral seal, and of these, 58% had apical periodontitis (Table 2). In studies of Norwegian adults, about 30% of the endodontic restorations had an inadequate seal, and about 70% of these had apical periodontitis (Eriksen *et al.* 1988, Eriksen & Bjertness 1991).

The length of the root filling has been measured in different ways, and few studies have used the same criteria. Some have categorized endodontically treated teeth filled flush with the apex as adequate and some as inadequate. The apical limit of obturation of the root canal has been a topic for discussion amongst endodontists for decades, and numerous studies have been carried out to assess its importance. It has been looked upon from epidemiological, anatomical and microbiological points of view. Most studies indicate that the apical limit of the root filling should be placed at the apical constriction of the root canal, and that extrusion of root filling material into the periapical tissue should be avoided. Several authors have suggested 'practical limits' of instrumentation and obturation, ranging from 0.5 to 2 mm from the radiographic apex. The position of the apical foramen/foramina has also been investigated and found to be from 0.2 to 3.8 mm from the

radiographic apex (Ricucci 1998). It is quite obvious that the differences in measurements and success criteria have consequences when results have been compared.

The results from the present study indicate that the length of the root filling is associated with the periapical status. If the length was 0–3 mm short of apex, 58% of the teeth showed no periapical lesion, whereas for other end-points (shorter or longer) combined, only 32% were judged free of apical periodontitis (Table 3). In studies of other European populations, it has been found that from about 10 to 46% of the teeth with adequate length of the root filling have apical periodontitis (Eriksen *et al.* 1988, Eriksen & Bjertness 1991, De Cleen *et al.* 1993, Saunders *et al.* 1997). If the endodontic treatment was too short, 43 to 65% of the teeth had apical periodontitis, and if the endodontic treatment was too long, about 57 to 75% of the teeth showed periapical lesions (Eriksen *et al.* 1988, Eriksen & Bjertness 1991, De Cleen *et al.* 1993, Saunders *et al.* 1997).

Despite the many differences in populations, diagnostic criteria and evaluation methods, it seems that most authors agree that the quality of the endodontic treatment strongly influences the periapical status. Furthermore most epidemiological studies agree that an improvement of the quality of endodontic treatment in general dental practice is essential, because if success rates of endodontic treatment from epidemiological studies and from controlled clinical environments are compared, higher success rates are found in the latter (Strindberg 1956, Bergenholtz *et al.* 1973, Kerekes & Tronstad 1979, Petersson *et al.* 1986, Eckerbom *et al.* 1987, Eriksen *et al.* 1988, 1995, Ödesjö *et al.* 1990, Sjögren *et al.* 1990, 1997, Eriksen & Bjertness 1991, De Cleen *et al.* 1993, Ørstavik & Hörsted-Bindslev 1993, Friedman *et al.* 1995, Çalışkan & Sen 1996, Ørstavik 1996, Saunders *et al.* 1997, Marques *et al.* 1998). In the present study it was shown that despite technically adequate endodontic fillings, 35.1% of the teeth still had apical periodontitis. This indicates that the quality of the root filling is not the only parameter to influence the periapical status. Whilst the technical quality of the fillings as illustrated by radiographs seems to be of importance for the outcome of the treatment, it may not reflect the quality of treatment in general. The antiseptic and aseptic efforts during treatment may play an important role for the outcome. The role of bacteria in the pathogenesis of apical periodontitis has been well established (Kakehashi *et al.* 1965, Sundqvist 1976, Möller *et al.* 1981), and the microbial activity in relation to the root filling procedures may be of primary concern. The current understanding supports the role of the root filling as:

a blockade of any communication between the oral cavity and the periradicular tissue, an entombment of any surviving bacterial cells in the root canal, and a blockade of tissue fluid derived from the periapical tissue which could feed remaining bacteria in the root canal (Sundqvist & Figdor 1998). When focusing on the biological aspect of periapical repair, several explanations for retarded or missing bone formation have been pointed out. When a root filling is too short, the low success rates are probably due to infection of dentine chips or pulp remnants in the apical part of the root canal. Overfilling may induce an inflammatory reaction caused by extrusion of root filling material or infected debris into the periapical area, combined with a physical tissue damage caused by over-instrumentation.

In recent years emphasis has been placed also on the quality of the coronal restoration and its relation to the periapical status in root filled teeth. 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. In a study of 1010 endodontically treated teeth, Ray & Trope (1995) found that the technical quality of the coronal restoration was even more important for the periapical status than the quality of the endodontic treatment. Sidaravicius *et al.* (1999) also found a correlation between the quality of the coronal restoration and the periapical status of root filled teeth, but not as pronounced as Ray & Trope (1995). The results of the present study also showed that the quality of the coronal restoration influenced the periapical status, since as much as 63.9% of the teeth with inadequate coronal restorations had a diseased apical periodontium. When the quality of the coronal restoration and the quality of the endodontic treatment were combined, an even more pronounced pattern was seen. When both were of high quality, almost 70% of the teeth had sound periapical bone, but if both were inadequate, almost 80% of the teeth had apical periodontitis. This strongly indicates that both factors play important roles in obtaining an efficient seal of the root canal.

The results of the present study point out that the rate of technically inadequate endodontic treatment and the high frequency of endodontically treated teeth with apical periodontitis in this population is high. Treatment may become more difficult to perform due to age changes of and treatment traumas to the pulp, and because the elderly form a continuously increasing group in the society and tend to keep their natural teeth longer, the problems with obtaining adequate quality of endodontic treatment is presumably becoming more

pronounced. To improve the periapical status it is important that each phase of the endodontic treatment is performed according to accepted clinical standards: aseptic working conditions, adequate disinfection, precise canal length measurement, adequate canal preparation, irrigation, complete root canal obturation and a seal-tight coronal restoration (Sundqvist & Figdor 1998).

Conclusion

Results from the present study indicate that the periapical status of endodontically treated teeth depends on both the quality of the endodontic treatment and of the coronal restoration, and efforts should be made to optimize the treatment of teeth with pulpal or periapical infection.

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