The relation between apical periodontitis and root-filled teeth in patients with periodontal treatment need

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Abstract

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Aim To investigate a number of clinical and treatment variables that might have influenced the prevalence of apical periodontitis in root-filled teeth in a population of periodontally compromised patients.

Methodology This investigation was a retrospective cross-sectional study on data collected from periodontal charts in addition to intra-oral full-mouth radiographs from patients attending the Department of Periodontology of the Dental School of the Ghent University Hospital. Periodontal parameters (clinical attachment loss and the lowest marginal bone level, the history of periodontal treatment), endodontic treatment (length, homogeneity and overall quality of the root filling) and the quality of coronal restorations were related to the prevalence of apical periodontitis. A total of 272 root-filled teeth in 94 patients were evaluated.

Results The periapical condition was significantly influenced by the quality of the root filling and the coronal filling ($P < 0.05$). More apical periodontitis was seen when the coronal level of the root filling exceeded the marginal bone level ($P < 0.005$). The marginal periodontal condition seemed to influence the periapical status. Teeth with apical periodontitis were associated with significantly more extended marginal bone loss ($P < 0.001$). Significantly less apical periodontitis was seen in patients that had received marginal periodontal treatment ($P < 0.005$), compared with untreated periodontal patients.

Conclusions Signs of periodontal disease, as reflected by marginal bone loss, are of importance for the periapical condition of root-filled teeth. Efforts should be taken in preventing spread of infection through the periodontal-endodontic pathway by periodontal infection control and a high quality of root filling and coronal filling. Care should also be taken to seal the coronal cavity up to the level of the root filling, where it is advisable to reduce the coronal level of the root filling below or at least at the level of the surrounding marginal bone.

Keywords: apical periodontitis, coronal restoration, epidemiology, marginal periodontitis, periodontal treatment, root filling.

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Introduction

Apical periodontitis is a local inflammatory response to infection of endodontic origin (Möller *et al.* 2004). Dental pulp infection generally occurs as a sequel to dental caries, trauma or operative procedures whereby bacteria and their toxins enter the pulpal space. The root canal micro-flora in teeth with apical periodontitis is very diverse, although comprising mostly anaerobic micro-organisms (Sundqvist 1992, Dahlén & Haapasalo 1998, Munson *et al.* 2002). Failure of root-canal treatment is generally believed to be caused by inadequate treatment procedures and ineffective control or elimination of bacterial infection (Nair *et al.* 1990,

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1999). Bacteria persisting in root-filled teeth may also be a result of poor aseptic procedures (Sirén *et al.* 1997) or coronal leakage (Saunders & Saunders 1994, Hommez *et al.* 2002). Another possible pathway for bacteria entering the pulpal space may be through accessory canals or even dentinal tubules, although this pathway remains controversial (Stashenko 1998).

Similarity exists between the physiopathology of apical periodontitis and marginal periodontitis. A mixture of micro-organisms, mostly anaerobic are established as the main cause of both endodontic and periodontal disease (Zehnder *et al.* 2002). Most species present in endodontic infections were also found in periodontal pockets (Moore 1987, Sundqvist 1994) although the root-canal flora appears to be less complex than the flora present in periodontal pockets (Kurihara *et al.* 1995). The similarity between the endodontic and periodontal micro-flora suggests that cross-infection between the root canal and the periodontal pocket and *vice versa* can occur (Zehnder *et al.* 2002). A number of pathways connecting endodontic and periodontal tissues have been described. The most common anatomical pathways are the apical foramen, accessory canals and dentinal tubules. One study described invasion of bacteria residing in the periodontal pocket into the dentinal tubules, although pulpal invasion was infrequent (Adriaens *et al.* 1987). In this study, however, no attention was paid to the relation of the presence of these bacteria and pulp vitality or pulpal condition. Tubular invasion also occurs from the pulpal side (Peters *et al.* 1995).

Clinical studies have shown that endodontic infection can influence the periodontal condition (Ehnevid *et al.* 1993, Jansson *et al.* 1993a). In these studies, treatment of the apical periodontitis in order to promote healing after periodontal therapy was advised. The relation between endodontic treatment failures and the periodontal condition has not yet been investigated thoroughly. Sjögren *et al.* (1990) found no influence of the periodontal condition on the outcome of endodontic treatment. Ørstavik *et al.* (2004) found the reduction of marginal bone support to be a significant negative factor for the prognosis of root-canal treatment. Apparently, data on the effect of the periodontal condition on the presence of apical periodontitis in root-filled teeth are scarce.

The purpose of this study was, therefore, to investigate (i) the relation of periodontal pocket depths on the periapical condition of root-filled teeth; and (ii) a number of parameters related to endodontic and restorative treatment on the prevalence of apical periodontitis, in patients with moderate to severe periodontal treatment need as measured by the CPITN-index.

Materials and methods

Patient selection

This investigation was a retrospective cross-sectional study and was approved by the local ethics committee (no. 2004/356). Case notes from patients attending the Department of Periodontology at the Ghent University Hospital, Ghent, Belgium, were selected randomly. Data were collected from available clinical periodontal charts (pocket depth measurements, bleeding on probing, recession, plaque index) and corresponding full-mouth intra-oral radiographic examinations. Age and gender of the patients were noted, as well as the number of remaining teeth and the CPITN-index (Ainamo *et al.* 1982). The CPITN-index was solely used for rough elimination of subjects with a healthy periodontal condition or gingivitis (score 1 and 2). Only CPITN-index 3 (pathological pockets of 4–5 mm) and 4 (pathological pocket ≥6 mm) were considered. All root-filled teeth in this patient sample were then selected for this study.

Radiographic and periodontal examination

A number of parameters related to the coronal restorations, the root fillings and the periodontal condition were scored on periapical radiographs (Table 1). The choice of the parameters was based on previous research on the prevalence of apical periodontitis (Hommez 2004). Multi-rooted teeth were classified according to the root exhibiting the most severe periapical condition. All periapical radiographs were evaluated under optimal conditions, using a light box and an X-ray viewer with 2× magnification.

Periodontal therapy prior to the clinical and radiographic examination was noted. If a patient had received periodontal treatment, it was noted whether extractions were undertaken.

All data were collected by two examiners (IS and GH). They were calibrated before the start of the study. Inter-observer and intra-observer agreement were assessed by computing Cohen's Kappa. All Kappa values exceeded 0.80.

Table 1 Parameters scored on radiographs

Parameter	Score
Type of coronal restoration	1. Filling 2. Crown 3. Lost restoration
Material used for coronal filling	1. Amalgam 2. Composite
Presence or absence of a base under the coronal filling	0. No base present 1. Base present
Quality of coronal restoration	0. Good – intact restoration without signs of leakage 1. Poor – marginal decay or caries, lost restoration
Presence or absence of a post in the root canal	0. No post present 1. Post present
Length of the root filling	1. Root filling terminating 0–2 mm from the radiographic apex 2. Root filling extending beyond the radiographic apex 3. Root filling terminating >2 mm from the radiographic apex
Homogeneity of the root filling	1. Homogeneous – good condensation, no voids visible 2. Inhomogeneous – poor condensation, voids visible
Overall quality of the root filling	0. Acceptable – homogeneous and good length 1. Unacceptable – inhomogeneous and unacceptable length
Coronal level of the root filling in relation to the marginal bone level	1. Positive – coronal level of the root filling above lowest level of marginal bone 2. Negative – coronal level of the root filling below lowest level of marginal bone
Material used for root filling	1. Gutta-percha 2. Paste 3. Silver cone 4. Silver point
Distance between cemento-enamel-juction (CEJ) and the lowest marginal bone level (in mm)	
Periapical status	0. Normal – good periapical condition 1. Apical periodontitis (AP) – widening of the periodontal ligament or periapical radiolucency in connection with the apical part of the root

Statistical analysis

SPSS 11.0.1 software was used for data processing and statistical analysis (SPSS Inc., Chicago, IL, USA). Chi-squared test, ANOVA and Mann–Whitney *U*-test were used as the univariate approach to detect statistically significant differences between groups. Logistic regression (multivariate analysis) was used to explain the periapical condition by explanatory variables.

Results

A total of 272 root-filled teeth were scored in 94 patients. This was an average of 2.89 root-filled teeth per patient. Signs of apical periodontitis were detected on 134 teeth (49.3%). The distribution of the patient sample according to age and gender is shown in Fig. 1. Gender had no statistically significant effect on the prevalence of apical periodontitis. Apical periodontitis was detected significantly more frequently in older age groups ($P < 0.05$, $\chi^2 = 14.2$).

Coronal restoration and periapical condition

The coronal status in relation to the periapical health is presented in Table 2. The type of coronal restoration had no influence on the prevalence of apical periodontitis, neither did the material used for the coronal filling

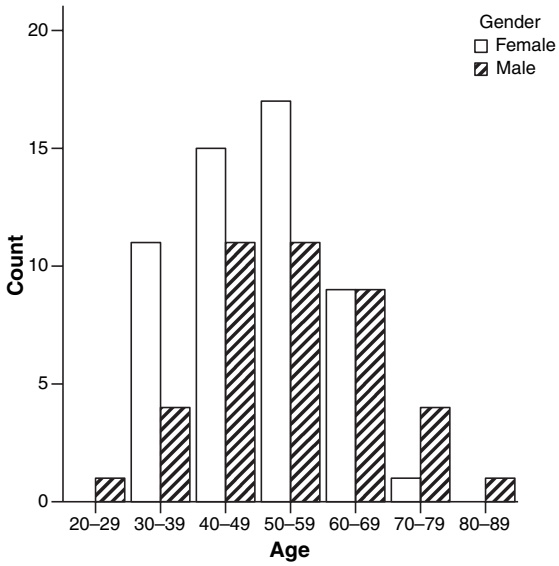

Figure 1 Distribution of the patient sample according to age and gender.

nor the presence of a base under the filling. Radiographic signs of apical periodontitis were detected in 61.2% of the teeth with unacceptable coronal restorations and in 45.4% of the teeth with acceptable coronal restorations. This difference was statistically significant ($P < 0.05$, $\chi^2 = 5.061$).

Root filling and periapical condition

Data on the relation between the endodontic parameters investigated and the periapical status are shown in Table 3. The presence of a post in the root canal had no statistical influence on the periapical condition; neither did the root-filling material. Forty-one per cent of the root canals were filled to an acceptable length; apical periodontitis was seen in 35.4% of these cases. Root fillings ending beyond the radiographic apex (7.7% of the teeth) showed signs of apical periodontitis in 71.4% of cases and root canals filled >2 mm short (50.7% of teeth) showed apical periodontitis in 57.2% of cases. The length of the root filling had a statistically significant effect on the prevalence of apical periodontitis ($P < 0.05$, $\chi^2 = 16.338$). Poorly condensed root fillings showed statistically more signs of apical periodontitis (64.6%) than homogeneous root fillings (44.4%) ($P < 0.05$, $\chi^2 = 8.052$). When the overall quality of the root filling was evaluated, there were significantly less signs of apical periodontitis with acceptable root fillings (31.5%) compared with unacceptable root fillings (58.3%) ($P < 0.05$, $\chi^2 = 17.510$). The coronal level of the root filling in relation to the marginal bone level significantly influenced the prevalence of apical periodontitis ($P < 0.05$, $\chi^2 = 8.216$). Apical periodontitis was more prevalent when the coronal extent of the root-filling ended coronal to the lowest marginal bone level (positive; 55.7%) compared with root fillings with a coronal level below the marginal bone level (negative; 37.5%).

Periodontal parameters in relation to the periapical status

Of the selected patients, 79.8% exhibited CPITN-index 4. Probing pocket depths of >6 mm were found. This means that a periodontal risk group was predominant. Only 20.2% had a score of 3.

Teeth with signs of apical periodontitis showed a significantly ($P < 0.05$) larger distance between CEJ and lowest marginal bone-level ($\mu = 5.16$; SD = 2.548) when compared with teeth without signs of apical periodontitis ($\mu = 4.18$; SD = 1.964).

Table 2 Parameters scored for the coronal restoration in relation to the periapical condition

			Periapical status		
Parameter	Score	Total	Normal	AP	AP %
Type of coronal restoration ($n = 272$)	1. Filling	137	60	77	56.2
	2. Crown	122	71	51	41.8
	3. Lost restoration	13	7	6	46.1
Material used for coronal filling ($n = 137$)	1. Amalgam	78	37	41	52.6
	2. Composite	59	23	36	61.0
Presence or absence of a base under the restoration ($n = 137$)	0. No base present	79	32	47	59.5
	1. Base present	58	28	30	51.7
Quality of coronal filling* ($n = 272$)	0. Good	205	112	93	45.4
	1. Poor	67	26	41	61.2

*$P < 0.05$.

Table 3 Endodontic parameters in relation to the periapical condition

Parameter	Score	Total ($n = 272$)	Periapical status: Normal ($n = 138$)	Periapical status: AP ($n = 134$)	AP %
Presence of a post in the root canal	0. No post	167	78	89	53.3
	1. Post-present	105	60	45	42.9
Length of the root filling*	0. Good	113	73	40	35.4
	1. Overfilled	21	6	15	71.4
	2. Short	138	59	79	57.2
Homogeneity of the root filling*	0. Homogeneous	207	115	92	44.4
	1. Inhomogeneous	65	23	42	64.6
Overall quality of the root filling*	0. Acceptable	92	63	29	31.5
	1. Unacceptable	180	75	105	58.3
Coronal level of the root filling in relation to the marginal bone level*	1. Positive	176	78	98	55.7
	2. Negative	96	60	36	37.5
Material used for root filling	1. Gutta-percha	193	97	96	49.7
	2. Paste	11	3	8	72.7
	3. Ag cone	20	8	12	60.0
	4. Ag point	48	30	18	37.5

*$P < 0.05$.

Table 4 Influence of periodontal treatment

Parameter	Total	Periapical status: Normal (*n*)	Periapical status: AP (*n*)	AP (%)
Teeth that did not receive periodontal treatment prior to evaluation	205	92	113	55.1
Teeth that received periodontal treatment prior to evaluation	67	46	21	31.3

$\chi^2 = 11{,}413$; $P < 0.05$.

A total of 67 teeth had received periodontal treatment in the period preceding evaluation. These teeth showed significantly ($P < 0.05$, $\chi^2 = 11.423$) less apical periodontitis (31.3%) than the teeth that had not received periodontal treatment (55.1%) (Table 4). The treatment group consisted of 19 patients. Within this group, extractions were executed in 12 patients for periodontal reasons. Only one of these patients had extractions of root-filled teeth.

Periodontal condition in relation to coronal restoration and root filling

The results from the ANOVA are listed in Table 5. A statistically significant relation was found between increased marginal bone loss and the CPITN-index ($P < 0.05$), the quality of the coronal restoration on the radiograph ($P < 0.05$), the presence of a post ($P < 0.05$), the coronal level of the root filling ($P < 0.05$), the periapical status ($P < 0.05$) and the gender of the patient ($P < 0.05$).

Analysis executed on a subgroup of teeth with adequate coronal restorations

This subgroup consisted of 205 teeth, showing no radiographic signs of coronal leakage. The results of this analysis are listed in Table 6. A statistically significant relation ($P < 0.05$) was found between apical periodontitis and the type of coronal restoration, presence of a post in the root canal, length of the root filling, homogeneity of the root filling, overall quality of the root filling, coronal level of the root filling in relation to the marginal bone level and previous periodontal treatment. Subsequently, a comparison between the subgroup and the total group of teeth was made for the apical and marginal periodontal condition. The radiographically measured bone loss on all teeth was 4.66 mm (SD = 2.31) and on teeth without signs of coronal leakage was 4.49 mm (SD = 2.38). This difference was not significant. The presence of apical periodontitis was not significantly different between both groups.

Logistic regression model

The data set was subsequently analysed according to the logistic regression model. The following explanatory variables significantly influenced the periapical condition (Table 7): the length and homogeneity of the root

Table 5 Relation between marginal bone loss and the investigated parameters

Parameter	Score	Total (*n*)	Mean marginal bone loss (mm)	SD (mm)	*P*-value (ANOVA)
CPITN	3	47	3.47	1.558	<0.001
	4	225	4.91	2.376	
Quality of coronal restoration	0. Good	205	4.49	2.380	0.035
	1. Poor	67	5.18	2.052	
Presence or absence of a post in the root canal	0. No post-present	167	4.29	2.191	0.034
	1. Post-present	105	4.90	2.371	
Coronal level of the root filling in relation to the marginal bone level	1. Positive	176	5.02	2.368	0.001
	2. Negative	96	4.01	2.085	
Periapical status	0. Normal	138	4.18	1.964	<0.001
	1. Apical periodontitis	134	5.16	2.548	
Gender	1. Male	122	5.08	2.738	0.007
	2. Female	150	4.32	1.851	

Only statistically significant parameters (*P*-value < 0.05) are listed.

Table 6 Analysis of teeth without coronal leakage

Parameter	Score	Total	Periapical status		
			Normal	AP	AP %
Type of coronal restoration ($n = 205$)*	1. Filling	106	47	59	55.7
	2. Crown	99	65	34	34.3
Material used for coronal filling ($n = 106$)	1. Amalgam	64	30	34	53.1
	2. Composite	42	17	25	59.5
Presence or absence of a base under the restoration ($n = 137$)	0. No base present	59	22	37	62.7
	1. Base present	46	24	22	47.8
Presence or absence of a post in the root canal ($n = 205$)*	0. No post present	121	59	62	51.2
	1. Post present	84	53	31	36.9
Length of the root filling ($n = 205$)*	1. Good	89	62	27	30.3
	2. Overfilled	15	5	10	66.6
	3. Short	101	45	56	56.1
Homogeneity of the root filling ($n = 205$)*	1. Homogeneous	155	93	62	40.0
	2. Inhomogeneous	50	19	31	62.0
Overall quality of the root filling ($n = 205$)*	0. Acceptable	74	54	20	27.0
	1. Unacceptable	131	58	73	55.7
Coronal level of the root filling in relation to the marginal bone level ($n = 205$)*	1. Positive	129	61	68	52.7
	2. Negative	76	51	25	32.9
Material used for root filling ($n = 205$)	1. Gutta-percha	148	79	69	46.4
	2. Paste	8	2	6	75.0
	3. Silver cone	12	6	6	50.0
	4. Silver point	37	25	12	32.4
Previous periodontal treatment ($n = 205$)*	Yes	150	71	79	52.7
	No	55	41	14	25.4

*$P < 0.05$.

filling, the distance between CEJ and the lowest marginal bone level and periodontal treatment prior to evaluation.

Discussion

In the present study, radiographic signs of apical periodontitis were found on 49.3% of the teeth investigated. This figure was higher than in previous studies dealing with a Flemish general dental population (De Moor *et al.* 2000, Hommez *et al.* 2002, Hommez 2004). The present study differs from the latter studies as the periapical condition of root-filled teeth was evaluated only in a group of patients with periodontal treatment need.

The quality of coronal restorations is of interest with regard to the periapical status of root-filled teeth (Ray &

Table 7 Regression table of the periapical condition explained by explanatory variables ($n = 272$)

Variable	Significance *P*-value	Odds	95% CI for Odds	
			Lower	Upper
Length of the root filling	0.009	1.445	1.097	1.903
Homogeneity of the root filling	0.047	1.899	1.007	3.578
Distance between CEJ and the lowest marginal bone level	0.001	1.236	1.089	1.402
Periodontal treatment prior to evaluation	0.005	0.416	0.224	0.771

Trope 1995, Kirkevang *et al.* 2000, Tronstad *et al.* 2000, Hommez *et al.* 2002). Seventy-five per cent of the coronal restorations were found to be radiographically acceptable. Adequate coronal restorations, however, were associated with signs of apical periodontitis in 45.4% of the teeth. This was significantly different from the 61.2% of apical periodontitis in root-filled teeth with inadequate restorations. This figure also differs from studies with general populations. In the present study, the prevalence of apical periodontitis was not influenced by the presence of a root-canal post, which was in agreement with other studies (Kvist *et al.* 1989, Tronstad *et al.* 2000, Hommez *et al.* 2002).

The length of the root filling had a statistically significant influence on the periapical status. When the root-canal filling was overextended or short, more apical periodontitis was seen. Other studies found similar results (Sjögren *et al.* 1990, Wu *et al.* 2000, Hommez *et al.* 2002, Dammaschke *et al.* 2003, Ørstavik *et al.* 2004). Poorly condensed root fillings showed significantly more signs of apical periodontitis, comparable with the results of Hommez *et al.* (2002). When the overall quality of the root filling was considered, an inadequate root filling showed more signs of periapical disease than a homogeneous filling with an acceptable length.

A parameter that has to our knowledge not yet been scored before in radiographic studies was the coronal level of the root filling in relation to the marginal bone level. This study demonstrated a statistically significant difference in prevalence of apical periodontitis between teeth with root-fillings ending above (positive) and below (negative) the marginal bone level. In case of a positive level, more signs of apical periodontitis were seen. A number of studies have investigated the importance of coronal leakage along restorative margins (Ray & Trope 1995, Tronstad *et al.* 2000, Hommez *et al.* 2002); a possible effect of leakage through dentine or lateral canals has never been investigated. As coronal restorations have a better sealing ability than root fillings, the data in this study suggests that bacterial penetration through dentine can be stopped by placing a base or composite resin below the level of the marginal bone. Several authors have reported that even with satisfactory root fillings, leakage of bacteria and bacterial products along the length of the root canal is inevitable (Swanson & Madison 1987, Torabinejad *et al.* 1990, Khayat *et al.* 1993, Trope *et al.* 1995). This seems also to be the case for bacterial penetration through dentine or lateral canals.

Little attention has been paid to the periodontal-endodontic pathway in root-filled teeth. Based on two studies, it is inconclusive whether the presence of periodontal defects impairs (Matsumoto *et al.* 1987) or does not affect (Sjögren *et al.* 1990) the outcome of endodontic therapy. Exposure of the root cementum due to gingival retraction and/or periodontal disease resulting in cementum dissolution may result in exposure of dentinal tubules, which are a pathway for periodontal pathogens to invade the root-canal space. It has also been shown that, during scaling and root planning, most of the cementum is removed and the root surface exposed (Adriaens & Adriaens 2004). This would also enhance the risk for bacterial invasion through tubules and/or accessory canals. In case of periodontal disease, it is thus possible that microorganisms from infected periodontal pockets gain access to the root canal via the dentinal tubules and/or accessory canals within the dentine. Bacterial studies have indicated that similar flora could be found in periodontal pockets as well as inside the pulp of intact infected teeth (Rupf *et al.* 2000). It is not known whether this is caused by leakage through the dentine. As there is no hermetic seal with the currently favoured root-filling materials, the root-canal space of teeth with a positive coronal level of root-canal filling could be prone to more bacterial invasion along the obturation. From a therapeutic point of view, this may suggest that it is important (i) to keep the coronal level of the root filling below the marginal bone level; and (ii) to put an hermetic seal coronal of the root filling up to the level of the surrounding marginal bone in order to minimize

bacterial invasion from pocket to root and consequently spreading of the infection, as is achieved by placement of a base under a coronal restoration (Saunders & Saunders 1994, Hommez *et al.* 2002).

In this study, it has been found that the prevalence of apical periodontitis was significantly lower on teeth that had received marginal periodontal treatment (scaling and root planning). This result could be explained by the large number of extractions executed as a part of the periodontal treatment plan. However, if the number of extractions of root-filled teeth were taken into account, the association between periodontal treatment and apical periodontitis was still statistically significant. Another possible explanation could be that, due to periodontal treatment and supportive therapy, the amount of pathogens in the periodontal pocket is reduced. In this respect, there has always been concern about the removal of the cementum layer during thorough scaling and root planning, promoting the patency of the dentinal tubules. The results of the current study, however, do not seem to support this concern. Moreover, in a study by Adriaens *et al.* (1988), where bacterial invasion in root cementum and radicular dentine of periodontally diseased human teeth was examined, no correlation between the presence of bacterial invasion in the dentinal tubules and the absence of radicular cementum was demonstrated.

As far as the endodontic-periodontal pathway is concerned, a number of studies demonstrated that pulpal infection was a risk factor in periodontal disease progression (Jansson *et al.* 1993a, 1995). Haapasalo & Ørstavik (1987) concluded that bacteria present in the root canal were much less able to invade the dentinal tubules when the cementum layer was intact. In areas where the tubules ended in histologically sound cementum, bacteria only reached the inner third of the tubules. Ehnevid *et al.* (1995) also found that endodontic pathogens or their products were not able to penetrate the cementum barrier. The need for removal of all root cementum during periodontal treatment is currently under discussion. Aggressive scaling and root planning aiming at the complete removal of all contaminated root cementum is no longer a desired and meaningful clinical goal of periodontal therapy (Adriaens & Adriaens 2004). These recent findings tend to support a gentler approach of the root surface, leaving in place most of the cementum but at the same time removing and disturbing as much as possible the bacterial biofilm attached to the surface of the root cementum, thus avoiding patent tubules.

Radiographs provide information on the height and configuration of the interproximal alveolar bone. This information was used in the present study to assess the periodontal condition. More apical periodontitis was seen in teeth that had more signs of marginal breakdown. This is in agreement with studies by Sjögren *et al.* (1990) and Ørstavik *et al.* (2004), where it was found that marginal support influenced the outcome of endodontic treatment. More apical periodontitis was seen in cases with reduced marginal support (less than or equal to half of the root length supported by alveolar bone). Other studies have confirmed this relationship (Jansson *et al.* 1993b, Jansson & Ehnevid 1998). The mean difference in marginal bone loss between teeth with and without apical lesions is approximately 1 mm. It remains unclear whether the endodontic infection is aggravating the periodontal condition or that an increased periodontal pocket depth promotes leakage through dentinal tubules or accessory canals.

More marginal bone loss was seen in relation to poor quality of the coronal restoration. It is known that a restoration with poor marginal adaptation influences the alveolar bone height (Hakkarainen & Ainamo 1980, Lang *et al.* 1983). The present study, however, did not allow evaluation of the relationship between marginal overhang and alveolar bone loss.

Coronal leakage could be regarded as a confounding factor. Therefore, statistical analysis was executed on a subgroup of teeth with adequate coronal restorations (intact restoration without signs of leakage, Table 7). The results of this analysis were comparable with the results for the total group of teeth. There was a statistically significant relation between apical periodontitis and type of restoration, presence of a post, length of the root filling, homogeneity of the root filling, overall quality of root filling, coronal level of the root filling in relation to the marginal bone level, periodontal treatment prior to evaluation, marginal bone loss. Moreover, when the periodontal condition was considered, no statistical difference was found between the subgroup and the total group of teeth. From these results, coronal leakage could not be considered as a confounding factor.

From the periapical lesions seen on a radiograph, it is not possible to determine whether or not it is healing. In this respect, Petersson *et al.* (1991) found that after a 10 year period the number of healed periapical lesions was equal to the number of newly developed lesions, indicating the reliability of cross-sectional studies for scoring the long-term success of endodontic treatment. The results are also supported by data reported by Hugoson *et al.* (1995).

Conclusions

A high prevalence of radiographic signs of apical periodontitis was found in association with root-filled teeth in the present group of patients with radiographic signs of bone loss. The coronal level of the root filling in periodontally compromised teeth significantly influenced the prevalence of apical periodontitis. This implies that reduction of the coronal level of the root filling below or at least to the level of the marginal bone is advisable. An hermetic seal of the remaining root-canal space with restorative materials is necessary to obtain a better seal than can be achieved with current root-filling materials.

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