

ORIGINAL ARTICLE

## Is apical periodontitis in root filled teeth associated with the type of restoration?

FREDRIK FRISK<sup>1,2</sup>, ANDERS HUGOSSON<sup>3</sup> & THOMAS KVIST<sup>2</sup>

<sup>1</sup>Institute for Postgraduate Dental Education, Jönköping, Sweden, <sup>2</sup>Department of Endodontology, Institute of Odontology, The Sahlgrenska Academy, University of Gothenburg, Göteborg, Sweden, and <sup>3</sup>School of Health Sciences, University of Jönköping, Jönköping, Sweden

### Abstract

**Objective.** To study the association between type of restoration and apical periodontitis (AP) in root filled teeth. **Materials and methods.** The present study used data from surveys conducted in 1983, 1993 and 2003. In 1983, 130 randomly selected subjects aged 3–80 years in the city of Jönköping, Sweden, were invited for a clinical and radiological examination. The study was repeated in 1993 and 2003. New participants were, thus, recruited with the same sampling criteria and sample size in the same geographical area in 1993 and 2003, respectively. In the present study, only dentate individuals aged 20–70 years with  $\geq 1$  root filled tooth were included, yielding a sample of 788 subjects with 2634 root filled teeth. Apical periodontitis on the tooth level was the dependent variable. Periapical status was assessed according to Periapical Index (PAI). Independent variables were root filling quality, recurrent caries, type of restoration, number of teeth with apical periodontitis, age and gender. Root fillings appearing homogenous and ending within 2 mm from radiographic apex were regarded as adequate, otherwise inadequate. All radiographs were re-studied by one observer regarding periapical status and root filling quality. Risk was analyzed by means of a GEE model. **Results.** Type of restoration, root filling quality, number of teeth with apical periodontitis within the individual and age were found to be predictors of AP in root filled teeth. Presence of recurrent caries and gender were not found to be associated with AP. **Conclusions.** According to the present study, root filling quality and type of restoration may be predictive of AP in root filled teeth.

**Key Words:** cross-sectional, endodontics, epidemiology

### Introduction

Endodontically-treated teeth are prevalent in adult European populations. Depending on country and age groups examined, epidemiological studies have reported that 1.4–20.3% of all teeth are root-filled [1–8].

The clinical outcome of endodontic treatment has mainly been studied in terms of tooth survival and radiographic signs of persistent or evolving infection and inflammation, i.e. apical periodontitis (AP). A systematic review of tooth survival following root canal treatment [9] concluded that the pooled proportion of teeth surviving for a 2–10 year period ranged from 86–93%. Even if the evidence was weak it was found that a crown restoration was a favorable factor for tooth survival after root canal treatment.

In cross-sectional epidemiological studies, apical radiolucency, indicating the presence of AP, has been observed in 25–54% of the root filled teeth [7,8,10,11]. Root fillings of poor technical quality are frequently observed and several studies report a positive correlation between the presence of AP and poor quality root fillings [7,8,10,12]. Despite technical developments of root canal treatment procedures in recent years, available studies indicate that the frequency of AP in root filled teeth remains relatively constant [7,8,11,13,14].

In posterior vital teeth with deep cavities and pulpal exposures, composites have been associated with more pulpal breakdown than amalgams [15]. Information on the influence on periapical status of different types or material of coronal restorations in root filled teeth is scarce. Hoskinson et al. [16] and

Ng et al. [17] included type of restoration in their analyses, but in none of the studies was the type of restoration found to be predictive of AP in root filled teeth.

As an additional risk indicator for persistent AP in root filled teeth, the association between the quality of the coronal restoration and periapical status has gained growing attention during recent years. Ray and Trope [18] reported that the technical quality of the coronal restoration was ‘... significantly more important than the technical quality of the endodontic treatment for apical periodontal health’ Ray and Trope [18]. Several studies on this issue have since been published, most of them unable to repeat the results from Gillen et al. [19]. Also, a clinical follow-up study on root filled teeth with lost coronal restorations reported low prevalence of AP [20].

Most studies in this field have used radiological data only. However, Hommez et al. [21] and Dugas et al. [22] combined radiological and clinical data. They found a weak correlation between radiological and clinical registrations regarding variables assessing the status of the coronal restoration. Thus, they underlined the importance of combining clinical and radiological registrations in order to reduce registration bias when investigating possible correlations between coronal restorations and the presence of AP. Also, clinical studies reporting on outcome of endodontic treatment have included both radiological and clinical data [16,17].

The aim of the present study was to analyze the association between periapical status and type of restoration in three randomly selected cross-sectional samples examined clinically and radiographically.

**Materials and method**

In 1983, 1993 and 2003, random samples of subjects aged 3, 5, 10, 15, 20, 30, 40, 50, 60, 70 and 80 years from four parishes in the city of Jönköping, Sweden were selected for cross-sectional surveys of oral health. In each age group, 130 randomly selected individuals were invited for a clinical and radiographic examination. The participation rate was 77.2% in 1983, 75.4% in 1993 and 69% in 2003. For details regarding attendance rate and reasons for non-attendance, see Hugoson et al. [23–25].

In the present study, only dentate individuals aged 20–70 years were included, yielding the material presented in Figure 1. The attendance rate for those aged 20–70 years was ~65–80%.

*Clinical examinations*

Examiners calibrated to a set of diagnostic criteria carried out all examinations. Type of restoration and material (amalgam, silicate, composite, gold inlays and full crowns and porcelain crowns) was recorded for each surface. In the analyses, all restorations with silicate and composite were categorized as composite

Original samples. Number of participating dentate subjects (participating rate (%) in parenthesis). In eachage cohort 130 subjects were invited.

Year sex age	1983			1993			2003		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
20	45	55	100 (77)	50	50	100 (77)	46	38	84 (65)
30	50	48	98 (75)	63	39	102 (78)	42	50	92 (71)
40	47	52	99 (76)	54	39	93 (72)	47	36	83 (64)
50	42	57	99 (76)	45	52	97 (75)	41	50	91 (70)
60	46	38	84 (65)	45	38	83 (64)	44	42	86 (66)
70	38	32	70 (54)	26	51	77 (59)	40	47	87 (67)
Total			550 (71)			552 (71)			523 (67)



Study sample  
Subjects aged 20 – 70 years with ≥ 1 root filled tooth from the original samples in 1983, 1993 and 2003.

No of subjects:	788		
No of root filled teeth:	2634		
Sex age	Male	Female	Total
20	9	6	15
30	31	31	62
40	56	65	121
50	112	89	201
60	101	96	197
70	108	84	192
Total	417	371	788

Figure 1. Description of original samples of dentate subjects and study sample.

fillings. Full crowns and porcelain crowns were categorized as full crown coverage. Recurrent caries was recorded when cavities could be verified next to the restoration by probing on the restored surfaces.

#### *Radiographic examinations*

1983.. Subjects aged 20–70 years were examined with both full mouth radiographic examination (FMR) and a panoramic radiograph (PR). In cases where an individual recently had a radiographic examination, radiographs were obtained from the subject's dentist and, if necessary, supplemented with additional apical radiographs. All apical radiographs were taken with an Eggen film holder.

1993.. In subjects aged 20–30 years, six bite-wing radiographs and a PR were taken. In cases with deep carious lesions and root filled teeth, the examination was supplemented with apical radiographs. Subjects aged 40 years and older were examined with FMR and PR. Apical radiographs were taken with an Eggen film holder.

2003.. In subjects aged 20–40 years, a PR and six bitewing radiographs were taken. In cases with deep caries lesions and root filled teeth, additional periapical radiographs were taken. Subjects aged 50–70 years were examined by means of FMR, consisting of 16 periapical and four bitewing radiographs, as well as PR.

#### *Radiographic registration of recurrent caries and root filled teeth*

Recurrent caries was recorded when a clearly defined reduction in mineral content of a proximal surface could be seen adjacent to a restoration. A tooth was considered endodontically treated when the radiograph showed filling material inside the pulp chamber and/or the root canals. Registrations were recorded in conjunction with each clinical examination in 1983, 1993 and 2003, respectively.

#### *Radiographic evaluation of periapical status and root filling quality*

For the purpose of the present and a previous study [7], all periapical radiographs from the three different examinations were re-examined using observer binoculars according to Mattson [26]. For length measurement of root fillings, a magnifying device was used (Eschenbach, 7×, Eschenbach Optik of America, Ridgefield, CT). The length between the root filling and the radiographic apex was measured to the nearest 0.1 mm and then categorized as adequate if

the root filling ended within 2 mm of the radiographic apex and appeared homogenous (no voids were discernible along the full length of the root filling). The root filling was judged as inadequate if it was shorter than 2 mm of the radiographic apex, ended beyond the radiographic apex or appeared inhomogeneous (voids were discernible along the length of the root filling). Periapical status was assessed according to the periapical index (PAI) from periapical radiographs. PAI-scores 1–5 were dichotomized to 1–2 (AP not present) and 3–5 (AP present). Teeth with filling material visible only in the pulp chamber or with retrograde fillings were excluded.

#### *Analysis of observer variation; fillings and recurrent caries*

In 1983, seven calibrated examiners performed all examinations. Reliability was tested for three clinical and 10 radiographic variables. Reliability was expressed as intra-class correlations coefficient (ICC), where ICC close to 1 indicates good agreement. In the context of the present study, reliability was tested for filled surfaces (ICC = 0.996) (clinical variable) and surfaces with recurrent caries (ICC = 0.810) (radiographic variables) by three examiners in 20 randomly selected subjects. For the 1993 and 2003 clinical examinations no reliability tests were performed.

#### *Analysis of observer variation; root filling quality and periapical status*

One observer performed all registrations regarding periapical status and quality of the root filling. Observer agreement to PAI scores from reference radiographs was  $\kappa = 0.7$  and intra-observer agreement over 7 months was 0.73. Intra-observer agreement regarding length and seal of the root filling over 7 months was 0.8 and 0.73, respectively.

#### *Statistical methods*

Differences in frequencies were studied with the Chi-squared test. Assessment of risk was analyzed with a GEE-model. The statistical computer program used in the analyses was SAS 9.2 (Cary, NC). Age and number of teeth with apical periodontitis were dichotomized according to the approximated median. This resulted in groups 20–50 vs 60–70 years of age and 0–1 vs  $\geq 2$  teeth with apical periodontitis, respectively (Table I).

## **Results**

The examinations provided data on 788 individuals regarding the quality of root fillings and type of

Table I. Distribution of root-filled teeth according to independent variables. Absolute number of root filled teeth (percentages in parentheses).

	Non-AP (n = 2040)	AP (n = 594)
<i>Restoration</i>		
1–3 surfaces amalgam	241 (82.2)	52 (17.8)
4–5 surfaces amalgam	416 (77.6)	120 (22.4)
1–3 surfaces composite	105 (73.4)	38 (26.6)
4–5 surfaces composite	45 (71.4)	18 (28.6)
2–3 surfaces amalgam/composite	55 (83.3)	11 (16.7)
4–5 surfaces amalgam/composite	36 (62.1)	22 (37.9)
Inlay	12 (70.6)	5 (29.4)
Full crown	1130 (77.5)	328 (22.5)
<i>Root filling quality</i>		
Adequate	704 (87.6)	100 (12.4)
Inadequate	1336 (73.0)	494 (27.0)
<i>Recurrent caries</i>		
No	1720 (77.7)	494 (22.3)
Yes	320 (76.2)	100 (23.8)
<i>No of AP</i>		
≤1	1295 (83.0)	265 (17.0)
>1	745 (69.4)	329 (30.6)
<i>Age</i>		
20–50	815 (75.5)	264 (24.5)
60–70	1225 (78.8)	330 (21.2)
<i>Gender</i>		
Male	937 (75.2)	309 (24.8)
Female	1103 (79.5)	285 (20.5)

Non-AP, Root filled teeth without apical periodontitis; AP, Root filled teeth with apical periodontitis; No of AP, Number of teeth with apical periodontitis on individual level.

restoration in 2634 root filled teeth. Of those, 594 (22.6%) teeth were diagnosed with AP.

#### *Quality of root fillings and restorations*

Of all root filled teeth, 804 (30.5%) were judged as adequately root filled and 2214 (84.1%) restorations were without registered recurrent caries.

#### *Periapical status and independent variables*

Table I shows the distribution of root filled teeth presenting with and without AP according to independent variables; type of restoration, root filling quality, recurrent caries, number of teeth with AP within the individual, age and gender. There are only small variations in the frequency of AP with regard to recurrent caries. Greater variations are seen for the other independent variables as confirmed in the

univariate GEE models (Table II). All independent variables except for recurrent caries were tested in a multivariate GEE model (Table III) after which gender was no longer predictive of AP. However, composite fillings with 1–3 and 4–5 surfaces and mixed amalgam and composite fillings with 4–5 surfaces were predictive of apical periodontitis as well as inadequate root filling quality, number of teeth with AP within the individual and age below 60 years.

## Discussion

In this study, type of restoration, root-filling quality, number of teeth with AP within the individual and age below 60 years were demonstrated to be statistically significant predictors of AP in root filled teeth.

The present study used data from cross-sectional examinations without control for some pre-operative and intra-operative factors that may influence the periapical status of root-filled teeth [27]. In particular, the presence or absence of apical periodontitis pre-operatively has repeatedly been shown to

Table II. Univariate analyses. Periapical status in root-filled teeth dependent factor (CI = 95%).

	OR (CI)	p-value
<i>Restoration</i>		
1–3 surfaces amalgam	Reference	
4–5 surfaces amalgam	1.33 (0.92–1.93)	0.1343
1–3 surfaces composite	1.64 (1.00–2.69)	0.0497
4–5 surfaces composite	1.88 (0.96–3.66)	0.0649
2–3 surfaces amalgam/composite	0.91 (0.44–1.88)	0.8067
4–5 surfaces amalgam/composite	2.78 (1.52–5.10)	0.0010
Inlay	1.89 (0.64–5.55)	0.2475
Full crown	1.34 (0.97–1.85)	0.0805
<i>Root filling quality</i>		
Adequate	Reference	
Inadequate	2.61 (2.06–3.30)	< 0.0001
<i>Recurrent caries</i>		
No	Reference	
Yes	1.01 (0.98–1.03)	0.5408
<i>No of teeth with AP</i>		
≤1	Reference	
>1	1.25 (1.19–1.32)	< 0.0001
<i>Age</i>		
20–50	Reference	
60–70	0.95 (0.92–0.99)	0.0147
<i>Gender</i>		
Male	Reference	
Female	0.78 (0.64–0.95)	0.0121

CI, Confidence interval; OR, Odds ratio; No of AP, Number of teeth with apical periodontitis on individual level.

Table III. Multivariate analysis. Periapical status in root-filled teeth dependent factor (CI = 95%).

	OR (CI)	p-value
<i>Restoration</i>		
1-3 surfaces amalgam	Reference	
4-5 surfaces amalgam	1.22 (0.83-1.79)	0.3037
1-3 surfaces composite	1.94 (1.17-3.23)	0.0106
4-5 surfaces composite	2.20 (1.10-4.38)	0.0257
2-3 surfaces amalgam/composite	0.98 (0.47-2.05)	0.9526
4-5 surfaces amalgam/composite	2.70 (1.44-5.06)	0.0019
Inlay	1.87 (0.63-5.54)	0.2586
Full crown	1.39 (0.98-1.97)	0.0613
<i>Root filling quality</i>		
Adequate	Reference	
Inadequate	2.77 (2.17-3.52)	< 0.0001
<i>No of teeth with AP</i>		
≤1	Reference	
>1	1.26 (1.19-1.33)	< 0.0001
<i>Age</i>		
20-50	Reference	
60-70	0.94 (0.90-0.98)	0.0022

CI, Confidence interval; OR, Odds ratio; No of AP, Number of teeth with apical periodontitis on individual level.

influence periapical healing [17,27]. Also clinical factors such as ability to reach the apical parts of the root canal for instrumentation and choice of antiseptic irrigation and medicaments may influence the result of root canal treatment [17]. Personal skills of the operator are also likely to influence the post-operative status of periapical tissues, since root canal treatment often is technically complex and demanding [28].

The data from this study did not provide any possibilities to analyze the correlation between clinical and radiological judgments. However, according to Homme et al. [21] and Dugas et al. [22], the correlation is poor between clinical and radiological findings. The results in this report are based on both clinical and radiological status, which consequently should be expected to improve the validity. Moreover, all individuals examined were randomly selected from the population in Jönköping, Sweden, making the results representative of an adult urban Swedish population. Most similar studies cited have used patients in dental schools and only registered data from radiographs.

In this study recurrent caries was included in the analysis as a proxy for restoration quality. Recurrent caries was not found to be predictive of AP in root filled teeth. Other relevant information relating to restoration quality, such as under- and overfill, was lacking and, hence, not possible to analyze.

Type of restoration (composite and large mixed fillings with composite and amalgam) was associated with AP. Micro-leakage due to poor marginal integrity without clinically identifiable defects may account for the association when comparing with amalgam fillings [29,30]. However, interpretation of data must be done with caution. The fact that type of restorations was found to be predictive of AP could be a result of clinical decision-making. If the endodontic prognosis was assessed as poor or doubtful when the endodontic treatment had been completed, the clinician may have opted for a less expensive restoration in composite, even if he or she judged that there was a need for a full crown to provide good marginal adaptation.

The finding that root fillings of poor quality are associated with presence of apical periodontitis is in concordance with the results from previous similar studies [1-8].

Most studies in endodontic epidemiology do not account for individual risk factors. We found that the number of teeth with AP within individuals could be an indicator for individual risk for AP in root filled teeth. The number of teeth with AP was predictive of AP in root filled teeth also in the multivariate analysis (Table III). Kirkevang and Wenzel [31], in a cross-sectional analysis on individual risk indicators for AP, found root filled teeth, several caries lesions, quality of dental treatment, regularity of dental visits and smoking to be predictive of AP. Socio-economic status was not found to be a significant risk indicator of AP. A cross-sectional analysis of a cohort of Swedish women aged 38-84 years concluded that socio-economic variables and dental visiting habits were not predictive of AP whilst root filled teeth and caries lesions were predictive of AP in the individual [32]. Habits or socio-economic factors were not accounted for in our study. Marending et al. [33] found that compromised integrity of the non-specific immune system due to disease or medication was predictive of AP as outcome after root canal treatment as well as initial periapical status and root filling quality. It is possible that the individual risk factor for AP disclosed in our study could be explained by habits or was associated with other diseases or disorders within the individual. However, it may also be a result of and reflect factors attributed to the operator given that the patient has been treated by the same dentist for a long period of time. The finding is interesting and calls for further research. Also, age and gender were tested as potential risk indicators for AP. In the multivariate analysis only age below 60 remained a statistically significant predictor of AP. This may be explained by the fact that individuals below 60 have a higher number of retained teeth and have not been subjected to extensive prosthodontic treatment warranting extraction or conservative treatment of non-symptomatic root filled teeth with AP [34]. Moreover, the participating rates for 60- and 70-year olds were

lower than for other age groups, which may indicate a selection of healthy individuals.

In conclusion, type of the restoration had a statistically significant association with AP. This result coincides with findings from other studies indicating that type of restoration (e.g. full crown vs large fillings) also has significance for recurrent caries [35] and tooth survival [36] in root filled teeth. However, controlled clinical trials are needed to elucidate whether these associations found in population surveys prevail in a clinical context. If so, cost-benefit analyses are warranted before new clinical guidelines can be issued.

**Declaration of interest:** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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