

ORIGINAL ARTICLE

Periapical status and technical quality of root-filled teeth in Swedish adolescents and young adults: A retrospective study

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Abstract

Objective. The aim was to study periapical status and the technical quality of root-filled teeth in Swedish adolescents and young adults in Malmö, Sweden. **Material and Methods.** The sample, collected from dental records in the Public Dental Service, consisted of notes and radiographs of all root-filled permanent teeth in all 19-year-olds born in 1979 (mean age at root filling = 16.2 years). The sample for assessing periapical status and technical quality consisted of 124–153 teeth. The criterion for inclusion for assessing periapical status was a follow-up time of at least one year. Periapical status was assessed with the Periapical Index (PAI). Technical quality was analyzed from radiographs in two respects: sealing quality of the root canal and distance from the root filling to the radiographic apex. The radiographs were analyzed independently by two observers with inter-examiner kappa values of 0.82–0.85. **Results.** Apical periodontitis was found in 52% of the teeth and occurred significantly more often among molars than among anterior teeth. As judged radiographically, 51% of the teeth were inadequately sealed. In 38%, the distance to the apex was >2 mm and overfilling was registered in 14% of the teeth. Compared with anterior teeth, significantly more root fillings of molars had a distance to the apex of >2 mm. Technical quality was statistically significantly correlated with periapical status at follow-up. **Conclusions.** The technical quality and periapical status of root-filled teeth in adolescents and young adults were unsatisfactory in about half of the teeth.

Key Words: *Epidemiology, radiology, root filling*

Introduction

In spite of the considerable improvement in dental health in Sweden and most other industrialized countries, caries is still the most common and resource-consuming dental disease among children and young adults. Consequently, both regional and national epidemiological data focus on summary figures for caries, that is, the number and distribution of decayed and filled teeth or tooth surfaces. Comparatively little attention is paid to endodontic treatment in these age groups, even though this therapy is relatively common and time-consuming. Thus, recent studies show that 0.3–1.1% of all teeth in Scandinavian adolescents and young adults have been subjected to endodontic treatment [1–3] and according to a recent study the most common primary cause was caries [2].

Several Scandinavian studies have evaluated the outcome of endodontic treatment in general practice in adults, for whom the prevalence of apical period-

ontitis ranges from 25% to 52% [4–9]. In addition, studies on the technical quality of root fillings show that 44–74% were unsatisfactory [7–10]. There is not much literature on the periapical status after endodontic treatment in young permanent teeth. In a cross-sectional study, Hugosson et al. [3] reported that 29% of root-filled teeth in 20-year-olds had apical periodontitis.

The outcome of endodontic treatment is dependent on a number of factors [11]. One is the technical quality of the root filling, for which there is a strong association with the outcome of endodontic treatment in adults [6,8,9,12,13]. To our knowledge, the technical quality of root fillings in young permanent teeth has not been reported in the literature.

Using data from a previous study on the prevalence of endodontic treatment in 19–20-year-olds, the aim of the present study was to examine radiographically the periapical status after root filling in

young permanent teeth and to assess the technical quality in terms of seal and distance from the root filling to the apex. The aim was also to estimate the relationship between the technical quality of the root fillings and the periapical status at follow-up.

Material and methods

Sample

The sample originates from a previous study on the prevalence of endodontic treatment in a population of adolescents and young adults [2]. In that study, which was conducted in 1999 and included all individuals born in 1979 and belonging to the reception area of the Public Dental Services (PDS) in Malmö ($n=1971$), the prevalence of individuals with endodontic treatment was 9.1%. The data were based on information from files from the PDS.

The present data were obtained from the same PDS files as in the previous study and included all radiographs of endodontically treated teeth and information about gender, age of the individuals at the time of root filling, follow-up time, type of tooth, reason for endodontic treatment, and the number of decayed, missing, and filled teeth (DMFT) at age 19. The material consisted of 240 endodontically treated and/or root-filled teeth in 175 individuals (96 F and 79 M), comprising all the individuals subjected to endodontic treatment in the original sample. One-hundred-and-thirty-two individuals had one endodontically treated tooth and 43 had two or more. The number of DMFT at age 19 was 9.6 ($SD=5.2$). Teeth that had been extracted before root filling ($n=13$) and teeth where the endodontic treatment had not included root filling for other reasons ($n=26$) were excluded, which reduced the

material to 201 teeth in 159 individuals. Radiographs of the apical area were missing in 36 teeth. Thus, the sample consisted of 165 teeth in 129 individuals (74 F and 55 M) (Figure 1). The regional Ethics Committee gave ethical approval.

The mean age of the individuals at the time of root filling was 16.2 years ($SD=2.5$); the median age was 16.4 years. The age-related number of root-filled teeth is given in Table I. The mean follow-up time of the root fillings was 4.6 years ($SD=3.3$). The distribution of teeth according to follow-up time is given in Table II.

A follow-up examination at the Faculty of Odontology in Malmö was organized in order to get updated and more detailed information about the status of the root-filled teeth than could be obtained from the files. In a letter, all individuals with endodontic treatment were invited to a comprehensive dental examination free of charge. Two reminders were sent to those who did not answer and telephone calls were made to those with available numbers. The examination included two periapical radiographs taken with paralleling technique and with different horizontal angulations. The film type used was Kodak Insight (Eastman Kodak, Rochester, N.Y., USA). Film processing was automated (Dürr Dental, XR 24 Nova, Bietigheim – Bissingen, Germany). The individuals belonged to a heterogeneous and mobile age group and only 27% (48/175) answered the invitation and attended the examination. The analyses and results were therefore based mainly on data from the PDS files. The radiographic follow-up was based on radiographs taken either during the examination (27%) or on radiographs obtained from the PDS files (73%). The film type used at the PDS clinics was Kodak

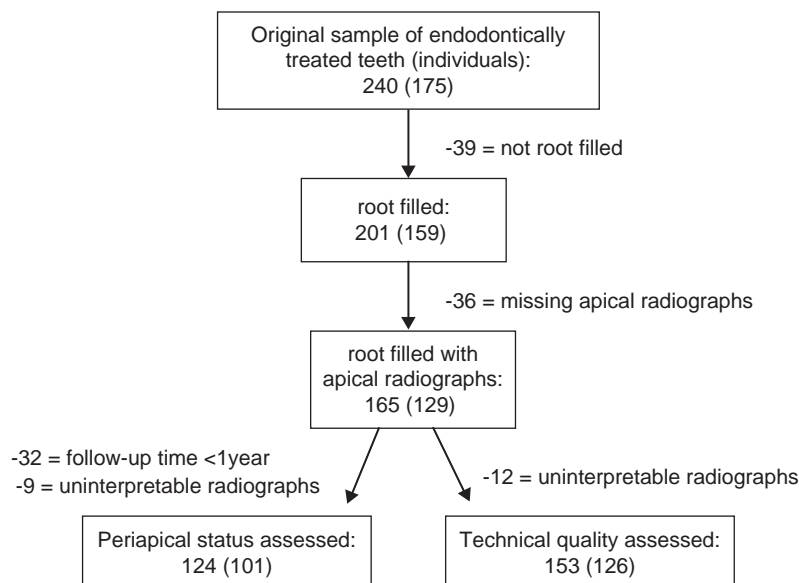


Figure 1. The original number of endodontically treated teeth (individuals), the number and reasons for exclusion, and those finally evaluated for periapical status and technical quality.

Table I. Number and percentage of root-filled teeth according to age of the individuals at the time of root filling

Age, years	No. of teeth (%)
10–13	37 (18)
14–16	82 (42)
17–18	59 (29)
19–24	23 (11)
Total	201 (100)

Ektaspeed Plus or Kodak Ultraspeed. Automated film processing was used.

Radiologic evaluation

Periapical status after root filling was assessed with the Periapical Index (PAI) from Ørstavik et al. [14]. PAI is a visual index consisting of five scores representing categories on an ordinal scale from healthy periapical bone to severe apical periodontitis [15] (Table III). The tooth to be judged is compared with reference pictures and given the score that corresponds most closely. A multi-rooted tooth is given the score corresponding to the most severely affected root. In the event of uncertainty about what score to assign to a tooth, the higher alternative is chosen. Before using the PAI, a calibrating test is performed in which 100 radiographs with or without root fillings and with or without apical periodontitis are judged according to PAI scores 1 to 5. Each tooth has a “true apical status”, representing the consensus of a group of experts [14]. This “gold standard” is compared with the observer’s judgement and training continues until a certain degree of agreement is achieved, that is, a kappa value of at least 0.61. One pedodontist (KR) and one radiologist (AP) completed the calibrating test separately. All the radiographs in the present sample were then interpreted and coded independently by the two observers. In cases of disagreement, a third observer was consulted. For the evaluation of periapical status, the minimum follow-up time after root filling

Table II. Periapical status of root-filled teeth according to follow-up time and age of the individuals at the time of root filling. AP = apical periodontitis

	Periapical status, <i>n</i> (%)		Total
	Healthy	AP	
Follow-up time, years			
1	11 (42)	15 (58)	26
2–3	8 (40)	12 (60)	20
≥4	41 (53)	37 (47)	78
Total	60 (48)	64 (52)	124
Age, years			
10–13	14 (47)	16 (53)	30
14–16	28 (47)	32 (53)	60
17–18	11 (52)	10 (48)	21
19–24	7 (54)	6 (46)	13
Total	60 (48)	64 (52)	124

was set at one year, reducing the material by 17 teeth. Another 24 teeth had a radiograph only at the time of root filling ($n=15$) or were uninterpretable ($n=9$). Periapical status could thus be assessed in 124 teeth in 101 individuals (Figure 1).

The technical quality of the root fillings was assessed for sealing quality and distance from the root filling to the radiographic apex. For the latter purpose, a ruler graded in millimeters was used. The criteria of technical quality are given in Table III. Uninterpretable radiographs ($n=12$) reduced the material for assessing technical quality to 153 teeth in 126 individuals (Figure 1).

The viewing conditions were standardized using a light-box (Lysta, Cabin, Farum, Denmark) and a magnifying viewer [16]. To calculate intra-observer agreement, 25 randomly selected radiographs were evaluated twice by each observer after a time lapse of about 4 months.

Data analysis

The five scores of the Periapical Index (PAI) were dichotomized so that 1 and 2 represented healthy periapical status and 3, 4, and 5 apical periodontitis (Table III). In a first step, bivariate analyses were used and differences in proportions were tested with the chi-squared test or the Fisher exact test. The level of significance was set to 0.05. The tested independent variables included gender, age of individuals at the time of root filling, follow-up time, type of tooth, reason for endodontic treatment (caries, trauma, and tooth developmental disturbance), technical quality of the root fillings in terms of sealing quality, and distance to radiographic apex and operator. As no statistically significant differences were found for the distribution of the investigated variables by gender, their data were combined in the analyses. The strength of relationships between the outcome variable and significant independent variables was analysed by calculating odds ratios (OR) in a logistic regression model. The null hypothesis was that there were no statistically significant differences in outcome (periapical status) between the categories of the independent variables. Inter- and intra-observer agreement was assessed by calculating Cohen’s kappa [17]. The software used for analysing the data was SPSS, version 12.0.

Analyses of teeth lost to follow-up

In the assessment of the periapical status of the root-filled teeth, 38% (77/201) of the teeth were lost to follow-up due to either too short a follow-up time ($n=32$) or missing ($n=36$) or uninterpretable radiographs ($n=9$). A previous study has shown that the prevalence of endodontic treatment is strongly related to socio-economic conditions [2]. Since caries prevalence is also clearly correlated to socio-economic

Table III. Criteria used to assess periapical status according to Ørstavik [15] and technical quality of root-filled teeth

Variable	Criteria	Grouped criteria
Periapical status (PAI scores)	1 =normal apical periodontium 2 =bone structural changes indicating, but not pathognomic for apical periodontitis 3 =bone structural changes with some mineral loss characteristic of apical periodontitis 4 =well-defined radiolucency 5 =radiolucency with radiating expansions of bone structural changes	1 and 2 =normal periapical status 3, 4, and 5 =apical periodontitis
Sealing quality of root filling	1 =adequate seal (no visible lateral or apical voids) 2 =inadequate seal (visible lateral or apical voids or canal lumen in the apical third of the root canal)	
Distance of root filling to apex	1 =root filling ending ≤ 2 mm from radiographic apex 2 =root filling ending > 2 mm from radiographic apex 3 =over-filling; root filling material visible in the periapical area	

conditions in children and adolescents [18], it was considered relevant to evaluate whether the individuals lost to follow-up differed in caries prevalence from the others. No statistically significant difference was found in the DMFT distributions between the two groups. Corresponding analyses were made for age of the individuals at the time of root filling and on tooth level for the causes of endodontic treatment: caries, trauma, and tooth developmental disturbances. Neither of these variables differed between those lost to follow-up and those who could be followed.

Results

The kappa values of inter- and intra-observer agreement are given in Table IV.

Periapical status after root filling

Apical periodontitis was found in 52% of the root-filled teeth (Table II). There were no statistically significant differences in the frequency of apical periodontitis between different follow-up times or between different age groups (Table II). The frequency of apical periodontitis did not differ between the causes of endodontic treatment (caries, trauma,

and developmental disturbance). The difference in the frequency of apical periodontitis between different types of teeth was statistically significant; premolars and molars had apical periodontitis more often than anterior teeth ($p < 0.01$) (Table V). In anterior teeth, the reason for endodontic treatment was caries in 34% of the cases, traumatic injuries in 65%, and tooth development disturbances (all dens invaginatus in lateral incisors) accounted for 1%. There was no difference in periapical status between these three categories. The frequency of apical periodontitis in incisors root-filled due to a traumatic injury was 18/42 (43%). Root development was complete in all but two teeth. Among premolars and molars, caries was the reason in 94% and 99%, respectively. Thirteen root fillings had been revised due to failure of previous endodontic treatment. Six of them had a follow-up time of at least one year; four had apical periodontitis, and two had healthy periapical status.

Technical quality

The sealing quality of the root fillings was inadequate in 51% of the teeth (Table VI). No statistically significant differences in the frequency of inadequate seal were found either between different types of teeth or between the different reasons for endodontic treatment (caries, trauma, and developmental disturbance). The distance from the root fillings to the radiographic apex according to type of tooth is given in Table VII. In 49% this distance did not exceed

Table IV. Inter- and intra-examiner agreement in the assessment of periapical status (Periapical Index, PAI), sealing quality, and distance of the root filling to the radiographic apex expressed as kappa values

	PAI score*	Seal**	Distance***
Inter-examiner	0.82	0.71	0.85
Intra-examiner:			
Observer A	0.91	0.92	1.0
Observer B	0.82	0.84	1.0
Categories:			

* 1–2 = normal periapical status; 3–5 = apical periodontitis.

** 1 = adequate seal; 2 = inadequate seal.

*** 1 = distance to the apex ≤ 2 mm; 2 = distance > 2 mm; 3 = overfilling.

Table V. Periapical status according to type of tooth. Minimum follow-up time = 1 year (mean = 4.6 years). AP = apical periodontitis

Type of tooth	Normal, n (%)	AP, n (%)	Total
Anterior	39 (62)	24 (38)	63
Premolars	7 (37)	12 (63)	19
Molars	14 (33)	28 (67)	42
Total	60 (48)	64 (52)	124

Table VI. Sealing quality of root-filled teeth according to type of tooth

Type of tooth	Adequate, <i>n</i> (%)	Inadequate, <i>n</i> (%)	Total
Anterior	41 (59)	28 (41)	69
Premolars	10 (46)	12 (55)	22
Molars	24 (39)	38 (61)	62
Total	75 (49)	78 (51)	153

2 mm, in 37% it was more than 2 mm, and 14% of the teeth had root-filling material in the surrounding bone. Compared with molars, significantly more anterior teeth had root fillings ending <2 mm from the apex ($p < 0.001$). Technical quality – both sealing quality and distance from root filling to apex – was statistically significantly related to periapical status at follow-up. The odds ratios (OR) were 6.2 (CI = 2.61–14.78) for sealing quality and 3.6 (CI = 1.44–8.90) for distance to the apex (Table VIII). This means that the probability of a tooth with apical periodontitis having an inadequate seal was 6.2 times higher than for a tooth with a healthy periapical status at follow-up and, correspondingly, that the probability of a tooth with apical periodontitis having a root filling with a distance to apex of >2 mm from radiographic apex or being overfilled was 3.6 times higher. The logistic regression (Table VIII) also indicates that the type of tooth (anterior teeth versus premolars/molars) did not significantly help to explain apical periodontitis.

In 14% of the root-filled teeth ($n = 17$), the endodontic treatment was done by an endodontist. The periapical status and technical quality of these root fillings did not differ from those made by the general practitioner. In eight teeth, an already started endodontic treatment was referred to the specialist. The other nine teeth consisted of complicated cases, such as progressive root resorptions after a traumatic injury. Twenty-two percent ($n = 44$) of the root fillings were not made in the city of Malmö; a majority of these were root-filled abroad. The frequency of apical periodontitis in these teeth did not differ from those that were root-filled in Malmö.

Discussion

All retrospective studies involve certain sources of bias. One concern is the content and quality of the relevant information. In the present study, quality

Table VII. Distance to the radiographic apex of root fillings according to type of tooth

Type of tooth	Distance to apex, <i>n</i> (%)			Total
	≤2 mm	>2 mm	Overfilling	
Anterior	49 (71)	11 (16)	9 (13)	69
Premolars	10 (45)	7 (32)	5 (23)	22
Molars	16 (26)	39 (63)	7 (11)	62
Total	75 (49)	57 (37)	21 (14)	153

Table VIII. Logistic regression model used to estimate the probability of apical periodontitis (AP) from the independent variable's sealing quality, distance to the apex, and type of tooth. CI = confidence interval

Independent variable	Odds ratio (OR)	95% CI
Sealing quality		
Adequate (reference)		
Not adequate	6.2	2.6–14.8
Distance to apex		
0–2 mm (reference)		
>2 mm or overfilling	3.6	1.4–8.9
Type of tooth		
Anterior (reference)		
Premolars and molars	2.0	0.8–5.1

and timing of the radiographic examinations were of particular interest. Teeth with missing or uninterpretable radiographs made up about a third of the material. However, the analyses of teeth lost to follow-up showed that there were no statistically significant differences in the number of DMFT, the age of the individuals at the time of root filling, or the reason for treatment between those that were lost and those that could be followed. It is therefore reasonable to assume that the results were not notably distorted by the loss.

The minimum follow-up period for assessing the outcome of the endodontic treatment was set at one year. Strictly, this is too short, since the healing process can take much longer; ideally, the follow-up time after root filling should be at least 4–5 years [19,20]. The present results must therefore be interpreted with caution. It should be noted, however, that almost 80% of the root fillings were followed for at least 4 years and there was no statistically significant difference in the frequency of apical periodontitis between the follow-up periods.

It may be argued that the PAI system would not be valid for molars, since the basis for its evaluation originates from an autopsy material with a histologic material including only maxillary incisors [21]. Presumably, however, the radiographic appearance of periapical status should be comparable in all teeth. Furthermore, the possibility of bias when assessing the apical status from radiographs is inherent in all radiographic material; this problem also applies to other indices, such as the criteria suggested by Strindberg [22]. The main reason for using the PAI index in this study was to facilitate comparisons between different epidemiological studies [23]. In two recent studies [15,24], the cut-off between healthy and pathologic apical conditions was set between scores 2 and 3, which seems logical since score 2 represents a borderline where it is difficult to decide whether or not the tooth needs treatment or re-treatment [25].

The relatively high failure rate of root fillings in the present sample is probably due to faulty techniques, since more than half of the teeth were not sealed properly, had too short a length of root-filling material (more than 2 mm from the apex), or were overfilled. In accordance with results from other studies, these factors were strongly associated with the presence of apical periodontitis [6,8–10,12,13]. One can only speculate about the reasons for the relatively high failure rate in the present material. One explanation could be that young permanent teeth have relatively wide root canal lumens that are more difficult to clean and seal properly than the narrower root canals in older teeth. Another reason claimed to be of importance is the quality of the crown restoration [7], which was not evaluated in the present study. The same applies to the presence of an apical radiolucency before endodontic treatment, which leads to a lower success rate than if the tooth is without apical radiolucency before treatment [13,22,26].

The finding that molars had apical periodontitis significantly more often than anterior teeth is in accordance with the results of Kirkevang et al. [1], in whose study premolars also had less apical periodontitis than molars, whereas in our study there was no such difference between molars and premolars. However, as there was only a small number of premolars in the present sample, any inferences would be uncertain.

The outcome of endodontic treatment in traumatized incisors was investigated by Kerekes et al. [27], who reported that successful endodontic treatment was achieved in 91% of the teeth in individuals aged 13–18 years (when the apical foramen is closed). The treatments were performed at a dental faculty by specialists in endodontics or pediatric dentistry. In agreement with others, the authors found that the quality of the seal was important for the outcome of treatment. In the present sample, the majority of teeth belonged to individuals aged 13 years or more at the time of completion of the root filling, and all but two teeth had completed root development prior to endodontic treatment. Therefore, a major part of the difference in successful treatments is probably explainable by the relatively high frequency of inadequate sealing in the present material (Table VI).

It is generally agreed that an overall success rate of 85–90% can be achieved when root canals are adequately sealed after a negative bacterial sample [13]. However, epidemiological data in adult populations indicate that the good results obtained in controlled environments at dental schools or in specialist clinics are not achieved in general dental practice [23]. The present results indicate that this may also be true of young permanent teeth, since about half of the root fillings showed radiographic signs of apical periodontitis. It is important, how-

ever, to realize that the present results may not be representative of other populations of adolescents and young adults. Thus, apical periodontitis was more prevalent in the present material than among 20-year-olds in the study by Hugosson et al. [3], who found apical periodontitis in 29% of root-filled teeth.

Nevertheless, the high frequency of apical periodontitis in root-filled young permanent teeth and its strong correlation with inadequate technical quality deserves attention. Furthermore, the possibility of improving the documentation of clinical and radiographic diagnosis at the time of endodontic treatment and at follow-up should be considered.

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