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ORIGINAL ARTICLE

Radiographic assessments on prevalence and technical quality of endodontically-treated teeth in the Finnish population, aged 30 years and older

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Abstract

Objective. To assess the prevalence and technical quality of endodontic treatment (ET) in Finland by panoramic radiography. ***Materials and methods.*** As part of the Finnish nationwide Health 2000 Survey, panoramic radiographs of 5244 dentate subjects, aged 30–95 years, were analyzed. The criterion for a technically adequate ET was a distance from the root filling to the root apex of ≤3 mm. ***Results.*** Sixty-one per cent of subjects had one or more teeth with ET. ET was more prevalent in older subjects and among women. Of all teeth (n = 120 250), 7% had had ET, the percentages being greatest for molars and premolars. Technical quality was adequate in 47% of all ET, in 71% of anterior teeth, in 51% of premolars and in 25% of molars. ***Conclusions.*** Prevalence and technical quality of endodontic treatment in Finland are comparable to that reported elsewhere, but are still calling for improvement in endodontic treatment, especially regarding molars.

Key Words: *endodontics, panoramic radiography, prevalence, technical quality*

Introduction

Previous, nationally representative, surveys have not assessed the quality of endodontic treatment (ET). Instead there are numerous studies with a large set of approaches for choosing target cohorts of subjects to study the prevalence and quality of ET. Some studies have used random selection within restricted age groups [1–6], while others have covered a wide range of age groups [7] or made the selection according to the place of residence (rural/urban population) [8–13] or to socio-economic status [12,14]. In addition, some studies have selected patients of dental schools only [15–18]. Such a wide variety in selection of the study subjects can weaken both the comparability and generalization of reported findings.

It can be speculated that the presence and length of root filling are well discernible on panoramic radiographs; in addition, the relatively low radiation dose makes this method advantageous for large epidemiologic studies in particular. To our knowledge, panoramic radiography has not been used in previous nationwide studies, although it has been considered a suitable method in epidemiologic studies [19,20] and many of the previous endodontic studies have applied this method [3,7,15,18,21–28].

The prevalence of teeth with ET has shown a positive correlation with age in cross-sectional settings [12,13,29] and a negative one in longitudinal data [13]. Further, ET prevalence has been reported to increase alongside a decrease in tooth extractions [30]. In Sweden, recent regional studies report the tooth-based prevalence of ET ranging from 1% for 30-year-olds in Jönköping [31] to 22% for 38–60-year-old women in Gothenburg [22]. In Finland, according to the official statistics of the Social Insurance Institution of Finland, 10% of adults aged 30 years and older, receiving reimbursement for the costs of dental care in 2001, had undergone endodontic treatments [32].

Measurements and definitions of the technical quality of ET are principally based on the length of the root canal filling, but the criterion for the acceptable distance of the root canal filling from the apical

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foramen vary among studies. Both the gap of ≤2 mm, as recommended by the European Endodontic Society [33] and of ≤3 mm [12,14,34] have been used.

Over the past decades, improvements in the quality of ET have been verified. In Denmark, a comparison between two sets of patients, provided with ET at the Royal Dental College, reveals an increase in percentages of adequate ET, from 43% in 1974–1975 to 54% in 1997–1998 [12]. A Swedish study from Jönköping reports an increase in technically adequate ET, from 24% in 1973 to 36% in 2003 [13].

The aim of the present study was to assess the prevalence and technical quality of endodontic treatments in the adult Finnish population aged 30 years and older by means of panoramic radiography.

Materials and methods

Subjects

A nationally representative Health 2000 Health Examination survey was carried out in 2000–2001 by the National Public Health Institute of Finland [35]. The original survey sample consisted of 8028 subjects representing the Finnish population aged 30 years and older, 80% of which participated in the comprehensive health examinations including panoramic radiography (n = 6101) as part of the clinical oral examination [36]. The present study covers information based on panoramic radiographs of the dentate subjects (n = 5244). Their mean age was 49.8 years (range 30–95 years, median 48.0 years), 48% were men.

Ethical consideration

Participation in the study was strictly voluntary. Prior to the examinations, the subjects gave their written consent for participation and the use of the data. Panoramic radiographs were not taken if the subject was pregnant. The Radiation and Nuclear Safety Authority Finland approved the radiographic part of the study. Also, approval of the Ethics Committee of Epidemiology and Public Health in the Hospital District of Helsinki and Uusimaa was obtained for this study.

Calibration of observers

Prior to the analyses of the present radiographs, a calibration of observers was carried out on a set of 50 radiographs from a pilot phase of the Health 2000 Survey. Three specialists in oral and maxillofacial radiology diagnosed independently the radiographs. Their findings were compared with the reference diagnoses by a professor in radiology. The agreement with the reference diagnoses for the presence of teeth with ET was 98% (Kappa 0.96), for short fillings, 65% (Kappa 0.3) and for overfillings, 97% (Kappa 0.7) [36]. Thereafter, during a 1-day intensive calibration session the observers discussed the disparities found and resulted into clarification of the definitions for the diagnoses, to improve the inter-examiner reliability for the present assessments. The assessment on the homogeneity of root fillings reached a low reliability and was, therefore, excluded from the present diagnoses.

Radiographic examination

Digital panoramic radiography was carried out using PM 2002 CC Proline apparatus (Planmeca, Helsinki, Finland) using imaging values between 58–68 kV and 4–10 mA, depending on subject's size. Three specialists in oral and maxillofacial radiology analyzed the radiographs on either a Nokia MicroEmission Multigraph 445× (resolution 1600 × 1200 pixels) or a Samsung SyncMaster 900NF monitor (resolution 1280 × 1024 pixels) using Dimaxis-software (Planmeca, Helsinki, Finland). The observers were free to apply any image enhancement function, to get the best possible assessment. Image quality was good in 26% and adequate in 74%. Fourteen images (0.2%) were unacceptable and were excluded from the analysis.

Endodontically-treated teeth

The present data included all permanent teeth and root remnants and excluded unerupted teeth and intra-bony root remnants. Altogether 120 250 teeth were assessed, the mean number of teeth per subject being 23.1 (SD = 7.9) for men and 22.8 (SD = 7.6) for women. A tooth was defined as endodontically treated when any radio-opaque material or root canal post appeared in the pulp chamber and/or in any of the root canals. In the analyses the teeth were grouped, separately for maxilla and mandible, into molars, premolars and anterior teeth, the latter including both incisors and canines. The prevalence of ET was defined as percentages of those subjects with one or more teeth with ET among the dentate subjects. In addition, tooth-based percentages of teeth with ET among all teeth were calculated.

The technical quality of ET was assessed by measuring the distance between the end of the filling and radiographic apex by means of the measurement tool inbuilt in the software. For an adequate ET, the gap in the root canal was no more than 3 mm, for a short filling, it was greater than 3 mm; and for an overfilled root, the filling material was seen outside the radiographic apex. In addition, a pulpotomy was recorded if only the pulp chamber was filled and/or with a slight amount of filling in the coronal part of the root canal or if one or more roots were unfilled in a multi-rooted tooth. Recording for each multi-rooted tooth

was according to its most severe finding: if any of the roots was overfilled, the tooth was recorded as being overfilled.

Statistical analysis

A stratified two-stage cluster sampling design was used in the survey. Weights were used to correct the effects of non-response. Weighting of sample was based on post-stratification according to gender, age and geographical region. Data analyses were performed using STATA SURVEY DATA (version 10.0, Stata Corporation, 2008), procedures svytab and svylogit were used to take into account two-stage cluster sampling design. Comparison of the frequencies in various sub-groups was by the Chi-square test.

Results

One or more teeth with ET occurred in 61% of the present dentate subjects (n = 5244); 21% had one tooth with ET, 15% had two, 15% three-to-four and 10% had five or more teeth with ET. Among the subjects with ET (n = 3213), 34% had one ET, 25% had two, 25% three-to-four and 16% had five or more ET.

The prevalence of ET was greater among women than men (63% vs 59%; p = 0.001) and in the older age groups (Table I). The lowest prevalence (31%) was found among those aged 30–34 years, as compared with 57–70% in other age groups; the gender-difference was significant in all age groups.

Of all teeth (n = 120 250), 7% (n = 8796) were with ET. The mean number of teeth with ET was 1.7 (SD = 2.1) for all dentate subjects and 2.7 (SD = 2.1) for those having one or more ET. The number of teeth with ET was greater the older the subjects. ET was most prevalent in the mandibular molars (12%), followed by maxillary premolars (11%), maxillary molars (9%), maxillary anteriors (8%), mandibular premolars (8%) and mandibular anteriors (2%). Table II shows tooth-based prevalence of ET by type of tooth in both jaws, according to subjects' age and gender. For all tooth groups, prevalence of ET was the greater the older the subjects were. In the oldest age group one of four maxillary premolars had ET.

Technical quality of ET was adequate for 47% of all teeth, more frequently for the maxillary than for the mandibular teeth (53% vs 41%). Adequate root fillings were most prevalent in the anteriors (71%) and less prevalent in the premolars (51%) and molars (25%). Table III shows these percentages for each type of tooth by jaw according to subjects' age and gender. The older the subjects, the fewer adequate root fillings were found in anteriors of both jaws and in maxillary premolars, these figures still exceeded those for molars in each age group. Among those aged 55 years and older, adequate ET appeared in 16–19% of the maxillary molars and in 16–29% of the mandibular molars.

Figure 1 shows details of the quality assessments on ET by type of tooth and gender. The most frequent diagnosis for the inadequacy was a short filling (42%) followed by a pulpotomy (10%) and an overfilling (1%). Pulpotomies were most frequent in molars (21%) and over-fillings in mandibular anteriors (6%). For subjects aged 45 years and older, 23% of the ET molars were with pulpotomy, in comparison with 9% for the 30–34-year-olds.

Discussion

In this nationally representative study of adult population living in Finland, 61% of all dentate subjects had one or more teeth with ET, the youngest subjects (30–34-year-olds) showing the smallest prevalence. One of the reasons for a better dental health among the 30–34-year-olds [36] and thus also for their fewer ET teeth might be the free-of-charge, comprehensive and preventively oriented dental healthcare, offered in Finland to all citizens up to 18 years of age since 1972. On the other hand, in line with the trend in most Western countries, patients tend to keep their teeth longer [37], carious teeth or teeth with other dental

Table I. Percentages of subjects having one or more teeth with endodontic treatment as assessed by panoramic radiography in the adult dentate Finnish population (n = 5244), by age and gender.

Age (years)	n	All[a] (%)	Women (%)	Men (%)	p-value for gender
30–34	646	31	30	32	0.034
35–44	1406	57	58	57	0.031
45–54	1508	69	74	65	0.001
55–64	912	70	74	65	0.002
65+	771	68	70	66	0.008
All[b]	5244	61	63	59	0.001
p-value for age		0.001	0.001	0.001	

[a]adjusted by gender; [b]adjusted by age. Statistical evaluation by chi square test.

Table II. Percentages of teeth with endodontic treatment among all teeth ($n = 120\,250$) in the adult dentate Finnish population ($n = 5244$), by type of tooth and subjects' age and gender. Anterior teeth include incisors and canines.

	Anterior teeth		Premolars		Molars	
Age (years)	Women (%)	Men (%)	Women (%)	Men (%)	Women (%)	Men (%)
Teeth by type in maxilla						
n	13 453	12 091	7819	7129	8526	8070
30–34	1	2	3	3	2	4
35–44	5	5	6	5	6	6
45–54	10	9	13	9	12	10
55–64	11	12	25	19	13	12
65+	16	15	26	24	20	17
All[a]	8	8	12	9	9	8
Teeth by type in mandible						
n	15 956	14 260	9075	8261	7888	7722
30–34	0.2	0.5	1	2	4	4
35–44	1	1	4	4	9	9
45–54	2	2	9	7	16	14
55–64	2	2	14	11	24	18
65+	4	6	19	15	22	22
All[a]	2	2	8	7	13	11

[a]Adjusted by age.

problems may be less likely to be extracted today than in the recent past. Consequently, among the present subjects the oldest ones (65–95-year-olds) had fewer ET teeth than had those aged 45–54 years. This corresponds with the finding from Denmark, where increasingly more endodontic treatments have been performed, especially for the 40–60-year-olds, and the number of tooth extractions has more than halved

Table III. Percentages of adequate root fillings[a] among all teeth with endodontic treatment ($n = 8796$) by type of tooth and subjects' ($n = 5244$) age and gender.

	Anterior teeth		Premolars		Molars	
Age (years)	Women (%)	Men (%)	Women (%)	Men (%)	Women (%)	Men (%)
Adequate ET by type of tooth in maxilla						
n	1042	926	921	671	744	685
30–34	95[b]	78[b]	71[b]	75[b]	40[b]	49[b]
35–44	88	88	66	59	32	33
45–54	80	79	57	51	21	24
55–64	72	66	43	40	19	16
65+	57	65	38	38	19	16
All[c]	76	75	52	42	29	34
Adequate ET by type of tooth in mandible						
n	311	309	753	556	993	885
30–34	100[b]	56[b]	81[b]	80[b]	65	45
35–44	73	64	65	68	32	33
45–54	63	63	49	51	24	23
55–64	53	53	49	54	16	18
65+	46	50	37	57	29	19
All[c]	59	57	49	58	27	26

[a]gap of the root filling from root apex ≤3 mm; [b]$n < 50$; [c]All, adjusted by age.

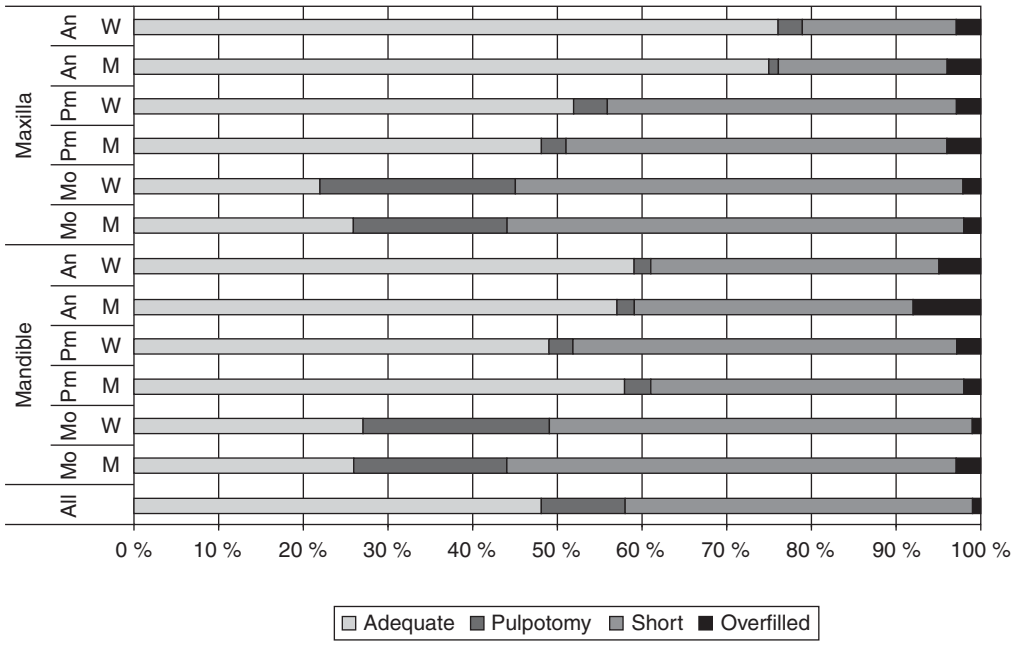

Figure 1. Distributions (%) of the quality assessments of endodontic treatment by type of tooth ($n = 8796$), in the Finnish dentate population aged 30 years and older ($n = 5244$). Mo: molars; Pm: premolars; An: anterior teeth (incisors and canines); separately for women (W) and men (M).

from 1977 to 2003 [30]. In the present study, women aged 45 and older had a higher prevalence of ET teeth than had men in the same age groups, in line with previous studies [12,38].

A total of 7% of all teeth was with ET, most frequently in mandibular molars, followed by maxillary premolars. This is partly in accordance with many of the previous studies reporting the greatest ET prevalence for molars of both jaws [15,39]. On the contrary, a German study reports most of the root fillings being found in anterior teeth and in premolars, but rarely in molars [25]. In line with previous studies [16,40], maxillary anteriors had significantly more often ET than mandibular ones. This may be partly due to maxillary incisors being more prone to dental caries and trauma than mandibular incisors.

About 16–51% of the ET resulted in an adequate quality in this and in previous studies [9,15,16,41]. Differences in study designs, treatment philosophies as well as technical difficulties in dentists' daily practice may influence these findings. In the present study, pulpotomies were least frequent in the youngest age group, thus supporting reports of decreasing frequencies of pulpotomized teeth in Scandinavian countries [12,30,42]. This may indicate that the former practice of treating the curved root in a multi-rooted tooth with pulpotomy has been replaced by the modern one where each root canal is instrumented and obturated.

The present study assessed technical quality of ET as being adequate most frequently in anteriors of both jaws, which is in line with previous reports [9,43]. For molars, reaching an adequate technical quality seems to be a demanding challenge. Only 26–34% of ET in molars was assessed as technically adequate in our study. These figures seem to be somewhat poorer than in a previous report from Sweden [44], but the differences in study populations must be kept in mind when making comparisons. In addition, the reliability of the diagnoses must be kept in mind. At the calibration phase, our observers resulted in high kappa-values for overfilling, but for short fillings the kappa was 0.3, which means a fair agreement [45]. The present diagnoses were, however, based on digital measurements using a tool inbuilt in the software, undeniably improving the accuracy of the actual measurements.

When comparing results of different reports, consideration should be given to the variability in measurements and definitions of the quality of ET. Some studies have used solely the length of the root canal filling [15,18,46], whereas other studies have described quality by means of both the length and seal of root fillings [9,38,47]. In this study, the assessment on the homogeneity of root fillings was excluded from the present diagnoses because of the low reliability achieved between the observers during the calibration.

Also the criterions for the adequate length of the root canal filling from the root apex vary among studies. Both the gap of ≤2 mm, as recommended by the European Society of Endodontology [33] and of ≤3 mm [3,12,14,34] has been used. Therefore, it can be speculated that, as epidemiologic studies can be interpreted as demonstrating what is achieved with endodontic treatment in general practice, other criteria than in clinical studies or clinical recommendations can be used.

This nationwide survey in adults aged 30 years and older in Finland demonstrated that the prevalence

and technical quality of endodontic treatment was comparable to that reported elsewhere. The results also indicated a need for improved quality of endodontic treatment, especially regarding molars.

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