Longitudinal radiological study of the oral health parameters in an elderly Finnish population

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In the oldest elderly, an increase in the number of remaining teeth may increase oral infection foci. The aim of this follow-up study was to examine the radiologically detected oral health condition of a group of home-living elderly in Helsinki at 5-year intervals. The population of this study comprised 103 home-living elderly people, all participants of the population-based Helsinki Aging Study. Panoramic radiography supplemented by intraoral radiographs was performed on all these participants at the Institute of Dentistry, University of Helsinki, in 1990–1991. Follow-up radiographic examination was completed in 1995–1996. Mean number of teeth decreased during the follow-up period from 13.2 ± 9.0 to 12.5 ± 9.2 ($P = 0.0001$). Mean number of teeth with periapical lesions decreased in men from 1.3 ± 1.4 to 0.6 ± 0.9 ($P = 0.007$), but no differences in number of teeth with periapical findings were observed in women. There were relatively few changes in the subjects' radiographic periodontal findings. However, fewer teeth with vertical bone pockets >1–3 mm deep were found in the follow-up study than 5 years earlier (0.6 ± 1.2 vs 1.1 ± 1.8; $P = 0.0008$). In both the baseline and the follow-up studies the radiographic findings occurred in the subjects who had retained more natural teeth. In the follow-up study, 68% of the subjects had radiographically detected signs of chronic oral infection foci. It may be concluded that radiographically detected oral health parameters remain relatively unchanged, but treatment need is higher among those who have successfully retained their natural dentition into old age. □ *Endodontics; gerodontology; radiography; periodontitis*

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Old age has been stereotyped as meaning rapidly deteriorating general health, subsequently increasing the risk for dental and oral diseases. Thus far, periodontal diseases of the elderly have been rare because most elderly have been edentulous, and even among dentate persons periodontal and periapical lesions have been treated by extraction. However, the number of elderly with periodontal diseases and periapical lesions is expected to increase as a result of the increasing number of individuals retaining their natural teeth in old age (1).

The presence of chronic infection in the oral cavity has recently gained more recognition as a possible risk factor for cardiovascular diseases (2–5). In this respect, the dentate old elderly (over 75 years) (6) could be a significant risk group that may have been exposed to other well-known risk factors for cardiovascular diseases over a long period of time. However, information on prevalence of chronic infection foci among the dentate old elderly is sparse.

Panoramic radiography is an effective method for evaluating the signs of oral diseases and their sequelae, yet only a few studies have reported dental radiographic findings in the old elderly.

The number of sites with significant bone loss as well as the rate of bone loss increases steadily over time (7, 8). In their study, Markkanen and co-workers showed that the age of the patient is a significant factor for periodontal treatment need (8). According to a Swedish study (9), multiple periapical lesions were more usual in the age group 75 years and older than in the group 65–74 years.

The aim of our 5-year follow-up study was to evaluate possible changes in radiographically detected oral health parameters in an elderly home-living Finnish population.

Material and methods

Subjects

In 1989 a random sample of prospective age cohorts ($n = 8035$), 300 subjects each from those born in 1904, 1909, and 1914, was collected for the Helsinki Aging Study (HAS) from the public register according to gender and street address. From this total sample of 900 elderly individuals, 795 were located, and 651 (82%) participated in the medical examination. These 651 were available for a dental and oral radiographic examination; in the meantime, however, 51 subjects died, so 600 were invited to the oral examination. The proportion of home-living elderly in this sample was 81% ($n = 484$).

Panoramic radiographs were successfully made of 293 of these home-living subjects (61% of all those available) during our baseline clinical oral examination in 1990–91 (10, 11). All these participants were identified and invited

Table 1. Home-dwelling elderly in the dental sample ($n = 600$), in the baseline radiographic study (1990–91), and follow-up study (1995–96) by gender and birth-year

	Home-dwelling subjects in sample			Participants, baseline study			Participants, follow-up study		
Year of birth	Men	Women	Total	Men	Women	Total	Men	Women	Total
1904	24	90	114	14	42	56	4	6	10
1909	39	122	161	28	59	87	11	20	31
1914	60	149	209	44	106	150	16	46	62
All subjects	123	361	484	86	207	293	31	72	103

to attend a 5-year follow-up examination; however, because 63 had died, those available for our follow-up study numbered 230.

A letter describing the follow-up study was sent to all available subjects, who were then contacted by telephone to arrange appointments for clinical and radiographic examinations. If a subject could not be contacted by telephone, another letter was sent, and the telephone contact was attempted again. It was found that 78 subjects were institutionalized or had moved into old people's homes. Altogether 152 subjects were located, and the present study population consists of those 103 who agreed to participate in the follow-up examination (Tables 1 and 2).

All participants completed a comprehensive medical examination, and information on their diseases came from the physicians' records. Those who had previously experienced myocardial infarction or stroke were identified ($n = 14$) in order to study the presence of possible oral infection foci.

The subjects were examined by means of panoramic radiography supplemented by intraoral radiographs; the former taken with a PM 2002 radiographic apparatus (Planmeca Oy, Finland). Trimax T16 intensifying screens and GTU X-ray film (3M) were used. For areas poorly visible in the panoramic radiograph, intraoral radiographs were made with a Siemens Heliodent 70 dental radiographic unit and Kodak Ultra-speed X-ray film. All films were developed by automatic processing. The quality of the radiographs was evaluated immediately after processing. At baseline, 18 panoramic radiographs were supplemented with 19 intraoral radiographs. Three panoramic radiographs were remade. In the follow-up study, no panoramic radiographs were remade and only 2 were supplemented with 2 intraoral radiographs. All the radiographs were studied under standardized conditions by 2 faculty members of the Department of Oral Radiology (KL and JW) using Mattson's binoculars and a viewing light of adjustable brightness when necessary. The radiographs were studied for:

1. Number of teeth: Total number of teeth and number of impacted teeth, supernumerous teeth, and intrabony roots were recorded.
2. Caries: Number of carious teeth and carious roots was recorded. Caries was judged to be present in the radiograph when a clearly defined reduction in mineral content of the proximal, occlusal, and/or restored surfaces was evident.
3. Endodontically treated teeth: Number of teeth with pulp amputation, endodontic fillings, or both were recorded.
4. Periapical findings: Number of periapical radiolucencies indicating periapical periodontitis or radicular cysts as well as sclerotic periapical lesions indicating condensing osteitis was recorded. The number of endodontically treated teeth with periapical lesions was also registered.
5. Periodontal status: Periodontal status was recorded with regard to calculus and overhanging restorations. All the radiographically clearly visible overhangs of restorative material at the junction of the tooth surface and the restoration were registered as overhanging restorations. Number of furcation lesions and number of teeth with vertical bone pockets were registered. Depth of any vertical bone pocket was determined as the amount of vertical bone loss measured in millimeters from the level of horizontal bone loss or from the level of the healthy marginal bone. The measurements were made from the

Table 2. Study population according to dental status in the baseline and follow-up studies by gender

	Baseline			Follow-up		
Gender	Dentate	Edentuolus	Total	Dentate	Edentulous	Total
Women	51	23	74	48	26	74
Men	26	3	29	22	7	29
Total	77	26	103	70	33	103

Table 3. Radiographic dental and jaw bone findings in the elderly in the baseline and follow-up studies

Dental findings	Baseline	Follow-up
Carious teeth	150	148
Teeth with overhanging restorations	117	107
Teeth with periapical periodontitis	49	35
Teeth with condensing osteitis	13	6
Teeth with radicular cyst	–	2
Endodontically treated teeth	214	205
Endodontically treated teeth with periapical lesion	30	25
Bone changes in the jaws	Baseline	Follow-up
Cementifying fibromas	3	3
Recidual cysts	1	2
Stafne's cyst	–	1

Total number of findings is given. Statistical evaluation by paired two-tailed *t* test.

mesial and distal surfaces of each tooth with a ruler having the same magnification as in the radiographs. The vertical bone pockets were divided into 3 groups: >1–3 mm, >3–6 mm, and >6 mm deep pockets. Each tooth was taken into consideration only once, according to the deepest pocket measured.

6. The presence of tumors, cysts, enostoses, and other bone changes in the jaws was recorded.
7. Temporomandibular joints: Flattening, osteoarthrosis (flattening, subcortical sclerosis, osteophytes, and subchondral cysts), osteoarthritis (erosions), and other pathologic findings or abnormalities were recorded for the condyles.
8. Maxillary sinuses: Findings of increased opacity in the maxillary sinuses were recorded and divided into 3 categories: mucosal thickening, mucosal cysts, and other changes.

The presence of periapical periodontitis, radicular cysts, condensing osteitis, and periodontal pockets deeper than 3 mm, as well as furcation lesions, were considered as potential infection foci. The numbers of teeth with any of these lesions were added together to form a panoramic index[2].

Subjects were divided into 3 groups (1–7 teeth, 8–20 teeth, 21–32 teeth) to aid in analysis of any association between number of remaining teeth and occurrence of radiographically detected oral diseases. Each group comprised one-third of the dentate subjects in the baseline study.

Statistical analysis was performed by means of the StatView + Graphics program (BrainPower, Inc., Calabasas, CA). Comparisons among three groups of subjects were done with an ANOVA, and differences between genders were analyzed with an unpaired two-tailed *t* test. A paired two-tailed *t* test was used to study the differences in number of findings between the baseline and follow-up studies.

Results

Of the 103 participants in the follow-up examination, 77 were dentate at the time of our baseline study (1990–91). Up until the year 1995, because 7 subjects had lost their natural teeth, the number of dentate subjects decreased to 70, and the edentulous increased to 33 (Tables 1 and 2).

Significantly fewer teeth were found in the follow-up examination among those who had been dentate during the baseline study, a difference found in both men and women, with no difference between genders (Tables 3 and 4). In the follow-up study, mean number of teeth among those who had retained some natural teeth ($n = 70$) was 14.1 ± 8.6, more, but not significantly, than among the dentate subjects 5 years earlier (13.2 ± 9.0).

The mean number of carious teeth in the dentate subjects was 1.8 ± 2.0 in both studies, with no differences between genders or among age groups.

In the baseline study, dentate men had significantly more teeth with periapical periodontitis than did dentate women. Total number of periapical lesions was also higher in men than in women. However, number of periapical lesions decreased in men during the follow-up and no gender-related differences were found in the follow-up study (Table 5), nor were there differences among age groups.

Radiographically detectable calculus was found in 27

Table 4. Number of remaining teeth in the baseline and follow-up studies by jaw and gender in elderly subjects dentate during the baseline study

	Maxilla		Mandible		Total	
Gender	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Women	6.1 (5.3)	5.8 (5.3)	7.9 (4.0)	7.7 (4.2)	14.0 (8.2)	13.5 (8.4)
$n = 51$	$P = 0.02$[1]		$P = 0.002$[1]		$P = 0.0003$[1]	
Men	4.7 (5.6)	4.4 (5.4)	6.9 (5.1)	6.0 (5.4)	11.6 (10.3)	10.5 (10.4)
$n = 26$	$P = 0.02$[1]		$P = 0.0005$[1]		$P = 0.0001$[1]	
Total	5.6 (5.4)	5.3 (5.4)	7.6 (4.4)	7.1 (4.6)	13.2 (9.0)	12.5 (9.2)
$n = 77$	$P = 0.001$[1]		$P = 0.0001$[1]		$P = 0.0001$[1]	

Mean values (SD) are given.
Difference between genders not significant. Statistical evaluation by unpaired two-tailed *t* test.
[1] Difference between baseline and follow-up studies. Statistical evaluation by paired two-tailed *t* test.

Table 5. Teeth with radiographic periapical findings in the baseline and follow-up studies by gender in elderly subjects dentate during the baseline study

	Periapical periodontitis		Condensing osteitis		Radicular cyst		Total number of lesions	
Gender	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Women $n = 51$	0.4 (0.7)*	0.4 (0.9)	0.2 (0.4)	0.1 (0.4)	0.0 (0.0)	0.1 (0.1)	0.6 (0.9)*	0.5 (1.2)
Men $n = 26$	1.1 (1.4)*	0.5 (0.8)	0.2 (0.4)	0.1 (0.2)	0.0 (0.0)	0.1 (0.2)	1.3 (1.4)*	0.6 (0.9)
	$P = 0.03$[1]		$P = 0.04$[1]		$P = 0.007$[1]		$P = 0.03$[1]	
Total $n = 77$	0.6 (1.0)	0.5 (0.9)	0.2 (0.4)	0.1 (0.3)	0.0 (0.0)	0.1 (0.2)	0.8 (1.1)	0.6 (1.1)

Mean values (SD) are given.
Difference between genders, *$P < 0.01$. Statistical evaluation by unpaired two-tailed t test.
[1] Difference between baseline and follow-up. Statistical evaluation by paired two-tailed t test.

subjects (35% of the dentate) in the baseline and in 25 (36%) in the follow-up. Significantly fewer teeth with >1–3 mm deep vertical bone pockets were found in the follow-up study than in the baseline study 5 years earlier. This decrease was noticeable in women, although no other differences were found in subjects' periodontal status (Table 6).

Condylar flattening in one or both condyles was found in 22 (21%) and osteoarthrosis in 10 (10%) of all 103 participants during the baseline study. In the follow-up examination, the numbers were 25 (24%) and 12 (12%). In both studies, 2 subjects each had post-traumatic changes in 1 condyle. Osteoarthritis was not found in either the baseline or the follow-up.

In the baseline study, 2 subjects had mucosal cysts and 13 thickening of the sinus mucosa. In the follow-up, mucosal cysts were found in 3 and sinus mucosal thickening in 14. Both cyst and mucosal thickening occurred in one subject.

During the baseline study, 64% of the dentate had 1 or more teeth with radiographically detectable oral infection foci, which increased to 68% in the follow-up. New infection foci was found in 16% of the subjects. However, the mean panoramic index did not differ significantly between the studies: 1.8 ± 2.4 (range 0–10) in the baseline and 1.5 ± 2.5 (range 0–15) in the follow-up. Of the dentate subjects who had experienced a myocardial infarction or a stroke ($n = 14$), 75% had one or more infection foci in the baseline study; this figure fell to 56% in follow-up. There was no difference in the panoramic index between subjects with or without previous myocardial hazards in either of the studies.

The occurrence of radiographically detected oral diseases was more frequent among those who had retained more natural teeth (Table 7), and only minor changes occurred in subjects' radiographic findings during the follow-up.

Discussion

Distribution of subjects by age in our baseline radiographic examination was comparable with that of home-living elderly in the whole dental sample. However, men were over-represented in the baseline study: 30%, compared to 25% in the dental sample. The relatively high number of subjects who dropped out of the study before the radiological examinations is understandable because of the advanced age of the elderly subjects. The participants in the radiological study tended to be healthier and live closer to the Institute of Dentistry than

Table 6. Teeth with radiographic periodontal findings in the baseline and follow-up studies by gender in elderly subjects dentate during the baseline study

	>1–3 mm vertical pocket		>3–6 mm vertical pocket		>6 mm vertical pocket		Furcation lesion	
Gender	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Women $n = 51$	1.2 (2.0)	0.7 (1.3)	0.2 (0.5)	0.3 (0.7)	0.1 (0.4)	0.2 (0.5)	0.6 (1.2)	0.5 (1.0)
				$P = 0.003$[1]				
Men $n = 26$	0.8 (1.1)	0.5 (0.9)	0.3 (0.7)	0.3 (0.7)	0.3 (0.6)	0.2 (0.5)	0.6 (1.1)	0.5 (1.0)
Total $n = 77$	1.1 (1.8)	0.6 (1.2)	0.2 (0.5)	0.3 (0.7)	0.1 (0.4)	0.2 (0.5)	0.6 (1.1)	0.5 (1.0)
					$P = 0.0008$[1]			

Mean values (SD) are given.
Difference between genders not significant. Statistical evaluation by unpaired two-tailed t test.
[1] Difference between baseline and follow-up; others not significant. Statistical evaluation by paired two-tailed t test.

Table 7. Dental radiographic findings in the elderly by number of teeth in the baseline and follow-up

	Number of teeth in baseline						
	1–7 ($n = 26$)		8–20 ($n = 26$)		21–32 ($n = 25$)		Difference among groups in baseline[1]
Radiographic finding	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up	
Teeth	3.5 (2.3)	2.8 (2.6)**	13.7 (4.1)	12.7 (4.5)**	24.0 (7.6)	23.5 (3.0)***	0.0001
Caries	0.6 (0.2)	0.5 (1.0)	2.3 (0.4)	2.0 (2.3)	2.7 (0.5)	2.9 (1.9)	0.0002
Root canal fillings	0.8 (0.3)	0.6 (1.6)	2.8 (0.5)	2.7 (2.5)	3.4 (0.6)	3.6 (3.1)	0.0004
Periapical lesions	0.4 (0.8)	0.3 (0.5)	1.0 (1.3)	0.3 (0.8)	1.0 (1.1)	0.8 (1.1)	0.06
Overhanging restorations	0.1 (0.3)	0.1 (0.2)	1.6 (2.0)	1.4 (1.3)	3.0 (2.7)	2.8 (2.6)	0.0001
>1–3 mm vertical bone pockets	0.2 (0.5)	0.2 (0.5)	0.9 (1.4)	0.5 (1.1)*	2.2 (2.4)	1.2 (1.6)**	0.0002
>3–6 mm vertical bone pockets	0.1 (0.2)	0.0 (0.0)	0.1 (0.3)	0.2 (0.4)	0.5 (0.8)	0.6 (1.1)	0.007
>6 mm vertical bone pockets	0.1 (0.4)	0.1 (0.4)	0.1 (0.3)	0.2 (0.5)	0.2 (0.6)	0.2 (0.5)	ns
Furcation lesions	0.0 (0.0)	0.0 (0.0)	0.4 (0.6)	0.3 (0.5)	1.4 (1.6)	1.3 (1.5)	0.0001
Panoramic index[2]	0.5 (1.3)	0.4 (0.6)	1.6 (1.7)	1.1 (1.5)	3.2 (3.1)	3.1 (3.5)	0.0002

Mean values (SD) are given.
[1] Statistical evaluation by ANOVA.
[2] Panoramic index = total number of teeth with >3 mm periodontal pocket, furcation lesion, or any periapical lesion.
Difference between baseline and follow-up *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$; others not significant. Statistical evaluation by paired two-tailed t test.

did the non-participants. Therefore, the subjects of our study obviously represent the healthiest segment of their age cohorts, and may not be representative for the entire home-living old elderly population of Helsinki. However, our subjects may be considered to represent the fraction of old elderly who are potential users of dental care services. Factors affecting subjects' non-attendance in the baseline dental study have recently been documented (12). The participation rate of all subjects located in the follow-up radiographic study was 77%, which may be considered good for such an elderly population (mean age 83 ± 3 years during the follow-up study). However, concerning the 94 subjects who could not be located, as they were hospitalized or had moved into old-people's homes, no attempts were made to locate their relatives for further information on their current place of residence.

The relative and absolute number of dentate elderly has been reported in all industrialized countries as increasing (13). In our study population the number of dentate subjects decreased slightly during the 5-year follow-up period, and number of lost teeth was distributed evenly between maxilla and mandible. Number of lost teeth, however, was relatively small.

During the 5-year follow-up, only few changes occurred in our subjects' caries, periapical, and periodontal findings. However, in both studies, almost 15% of all remaining teeth had carious lesions. The number of periapical lesions decreased in men during the follow-up, as several teeth with periapical changes in the baseline study had been extracted. The overall number of periodontal lesions remained relatively unchanged during the follow-up, although women had fewer vertical bone pockets then. In our previous studies we have evaluated the baseline data on horizontal bone loss in dentate and edentulous elderly (10, 11). The amount of horizontal bone loss was not taken into consideration in this study because it was assumed that no significant changes in the horizontal bone level could have been detected with the measurement method we used at baseline.

The number of elderly with condylar flattening or osteoarthrosis increased slightly during the 5-year follow-up, with prevalence in accordance with previous studies (14–16). The condylar flattening and osteoarthrosis found may be considered as signs of temporomandibular disorder, but with no association with symptomatic dysfunction in the elderly (17). Although the prevalence of condylar flattening and osteoarthrosis increases with increasing age, minimal condylar flattening seems to have no clinical significance (16), and such findings can be considered normal among the elderly populations.

It was clearly obvious that radiographically detectable oral diseases concentrate in those retaining more teeth, a finding in accordance with Douglass and Furino (18), who stated that retention of more teeth seems to result in increased need for dental care. A large cross-sectional epidemiological study (19) also showed that the elderly who retain more teeth have more caries and periodontal disease, and more frequently use dental care services.

The panoramic index has served as a marker of oral health status in patients with myocardial infarction (2). In this study we used a modified panoramic index to describe the number of radiographically detected infection foci. The number of elderly with possible chronic infection foci seemed to increase, although mean number of teeth with infection foci did not differ significantly between our two studies. Risk for myocardial infarction or stroke is higher in persons who have previously experienced chronic infections, and because oral infection foci may further increase the risk for cardiovascular diseases (2–5) we used the panoramic index to study their occurrence in those with a history of myocardial hazards. Owing to the nature of our study it was impossible to demonstrate any associations

between oral infection foci and development of cardiovascular diseases, but it was noteworthy that fewer subjects who had previously experienced myocardial hazards had oral infection foci in the follow-up study, even though more than half of them had some infection foci remaining. According to a recent study, dentogenic infections are frequent among the elderly referred to an acute geriatric hospital due to unexpected worsening of their general health (20). Therefore the occurrence of radiographically detected infection foci in more than two-thirds of our dentate subjects is alarming. Healthcare providers should institute preventive services among the elderly. This is especially important in countries like Finland, where the majority of the adult and elderly population do not receive dental care services reimbursed by the national healthcare system. In Finland, private dental insurance is uncommon, so dental services are often used only when treatment need is noticed. Early treatment would prevent many of the lesions to develop. Thus, more effort should be put into making dental care economically achievable for the entire elderly population.

Within the limitations of this study and taking into consideration the relatively small number of subjects examined, it can be concluded that only a few changes occurred in the radiographically detected oral health parameters among the dentate old elderly. However, disease is higher among the elderly who retain more teeth, a fact that should be borne in mind when dental care services are being planned for elderly populations.

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