Caries prevalence and salivary and microbial conditions in 88-year-old Swedish dentate people*

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As part of a comprehensive investigation of 88-year-old people, caries prevalence, stimulated salivary secretion rate, buffer capacity, and the prevalence of lactobacilli and mutans streptococci were studied in a subsample of 92 dentate subjects. The mean number of remaining teeth was 14.1 ± 7.3. The DMFT was 25.2 ± 3.0, and DF surfaces 38.3 ± 22.7. Root caries experience was found in 85% of the subjects, with a mean root caries index of 36.6 ± 28.5%. The men had significantly higher mean values of salivary secretion rate (2.0 ± 1.3 ml/min) than the women (1.1 ± 0.6 ml/min) ($p < 0.001$). The mean final pH of buffer capacity was 6.3 ± 1.3. High counts of lactobacilli ($>10^5$) and mutans streptococci ($>10^6$) were found in 49% and 55% of the subjects, respectively, of whom most were denture wearers. The mean number of total mutans streptococci was higher in persons harboring both *Streptococcus mutans* and *S. sobrinus* than in subjects with only *S. mutans*. □ *Caries; elderly; lactobacilli; mutans streptococci; saliva*

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Population changes during the past decades have continuously led to an increasing number of individuals who have reached old age, in which incompensated functional impairments, chronic diseases, and a high consumption of drugs are common (for a review, see Ref. 1). Cohort comparisons of different cross-sectional studies of younger elderly people have indicated a decreasing number of edentulous persons and an increasing number of remaining teeth in dentate individuals (2–4). It is therefore of interest to investigate the dental health in high age groups.

The physiologic aging process seems not to be a dominant risk factor for a decreasing salivary secretion rate (5–8), which instead is often due to disease and to side effects of medication (9–12). Epidemiologic studies have shown that many elderly people have high counts of cariogenic bacteria (13–16). With age, root surfaces become exposed to the oral environment and are then susceptible to decay. Declining health and functional ability can in a short period of time result in conditions that can lead to root caries and be a problem for older dentate persons (for a review, see Ref. 17).

Many studies of the elderly include the very old, even though their number in a sample may be very small. The aim of the present study was therefore to focus the examination on a cohort of very elderly individuals defined by a single birth year. Thus in a representative sample of dentate 88-year-old Swedish people tooth retention, prevalence of caries, salivary secretion rate, buffer capacity, lactobacilli and mutans streptococci were examined.

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Materials and methods

Study population

The investigation was part of the interdisciplinary, gerontologic, and geriatric population studies in Göteborg, Sweden, during the years 1989–90 (18), in which 172 subjects had various numbers of natural teeth. A subsample of 92 dentate subjects, 40 men and 52 women, accepted and was able to come in for a clinical cariologic examination. An analysis indicated that the dentate non-participants in this study were significantly more disabled and had more difficulties with oral hygiene procedures.

Ninety-three per cent of the participants were receiving drug treatment, 53% taking 4 or more medications. Toothpaste was used by 85% of the participants, and six persons rinsed regularly with a fluoride solution. One man used fluoride tablets.

Clinical examination

The examination, performed by one examiner (ML), was carried out in the morning in a room with a dental chair and operating light, using a mirror and explorer. Bitewing radiographs were taken only when the approximal surfaces were not accessible for inspection.

Saliva collection

The subjects had been fasting for about 10 h. Whole saliva, stimulated by chewing a piece of paraffin wax, was collected for 5 min—less if the secretion rate was very high and longer if the secretion rate was very low. Saliva was collected for a minimum of 2 min. Dentures

Table 1. Number of subjects in different Eichner classes

	Eichner index				Modified Eichner index			
	A1–3	B1–2	B3–4	C1–2	A1–2	B1–2	B3–4	C1–2
Men	6	10	9	15	14	17	8	1
Women	3	13	20	16	14	28	9	1
Total	9	23	29	31	28	45	17	2

were in situ during the saliva collection. One milliliter of the saliva was transferred to a vial with VMG II transport medium (19) for microbiologic cultivation, and the graduated glass with the remaining saliva was then sealed with Parafilm and within 2 h transported to the laboratory for examination. The final pH of buffer capacity was determined electrometrically in accordance with the method described by Ericsson (20). If less than 1 ml of saliva was available, 0.5 ml was used and the method modified accordingly. The pH of the saliva was measured with a pH-electrode.

Bacteriologic examination

The saliva samples were dispersed on a Whirlimixer for 30 sec, and serial 10-fold dilutions were made in 0.05 M phosphate buffer (pH 7.3). Duplicate samples of 25 µl of the appropriate dilutions were placed on mitis salivarius bacitracin (MSB) agar (21) for growth of mutans streptococci and in Rogosa selective lactobacillus (SL) agar. The MSB plates were incubated for 2 days at 37 °C in 5% CO_2 in N_2, and the SL plates aerobically for 3 days at 37 °C. Counts were made of colonies on MSB agar with the morphology characteristic of *Streptococcus mutans* and *S. sobrinus* as described by Emilson (22) and of colonies with the morphology typical of lactobacilli in Rogosa SL agar. The number of colony-forming units (CFU) of these microorganisms per milliliter of saliva was determined. Several representative and atypical colonies on MSB agar were isolated and identified using both specific fluorescent antisera and procedures described by Bratthall (23).

Variables examined

Clearly visible plaque on the smooth surfaces of all teeth without previous staining was recorded. If the accumulation of plaque and calculus was large, a limited depuration was then performed. Root surfaces with gingival recession were recorded when the root surface was clinically visible.

The number of natural teeth (including the third molar), caries, restorations, and fixed and removable prostheses were recorded. The criteria for coronal caries were those described by Koch (24) as 'loss of tooth substance having reached the stage of cavitation that can be diagnosed with certainty by clinical examination with mirror and explorer after drying with air and where the probe with a little pressure requires a definite pull for removal'.

Active root caries was recorded when a root surface with or without frank cavitation showed, according to Katz (25), 'a darkened, discolored appearance and a tacky or leathery feel upon probing with moderate pressure'. Inactive arrested root lesions were diagnosed when a root surface showed a frank cavitation with a darkened, discolored appearance but without a tacky or leathery feel on probing with moderate pressure. A root surface was scored as filled when a restoration was confined to the root surface or when a coronal filling obviously extended beyond the cemento-enamel junction. Secondary lesions on the roots were recorded if they were diagnosed adjacent to such restorations. Cast crowns extending onto a root surface were for that surface not recorded as filled (25).

To describe the prevalence and the distribution of root caries, the root caries index (RCI) was calculated by the method of Katz (26)—that is, the number of decayed and filled root surfaces in proportion to the number of decayed, filled, and sound root surfaces with gingival recession. A remaining carious root was counted as having active caries on four surfaces. Arrested carious lesions were included in the RCI.

The intermaxillary relation was recorded in accordance with Eichner's classification (27) and also a modified Eichner classification (28). In addition to opposing contacts between natural teeth, the modified Eichner index also includes contacts with and between artificial teeth in bridges and dentures. Eichner class A (1–3) represents intermaxillary tooth contacts in four zones—that is, in two molar and two premolar regions. Class B (1–3) represents contacts in 3, 2, and 1 zones, respectively, whereas B4 represents the frontal region only. Class C represents lack of tooth contacts between the upper and lower jaw with teeth present in both jaws (C1) or in one jaw only (C2).

Statistics

The bacteriologic data were transferred to $\log_{10}$ before testing. One-factor analysis of variance (ANOVA) and Fisher's exact test were used for testing

Table 2. Distribution of subjects in various ranges of lactobacilli and mutans streptococci with regard to oral state

CFU/ml saliva	No. of subjects	Oral state†		
		1 (n = 15)	2 (n = 35)	3 (n = 42)
Lactobacilli				
ND	4 (4%)	1	1	2
$<10^5$	43 (47%)	9	21	13
10^5–10^6	17 (19%)	4	7	6
$>10^6$	28 (30%)	1 (33%)	6 (37%)	21 (64%)*
Mean CFU × 10^3	898	324	531	1409*
Median CFU × 10^3	86	28	60	630
Mutans streptococci				
ND	2 (2%)		1	1
$<10^5$	15 (17%)	3	8	4
10^5–10^6	25 (28%)	6	10	9
$>10^6$	50 (55%)	6 (40%)	16 (46%)	28 (67%)*
Mean CFU × 10^3	4682	2210	3345	6679
Median CFU × 10^3	1150	680	720	1680

* Significantly different from oral states 1 and 2 ($p < 0.05$).
† Oral state: 1 = natural teeth only; 2 = natural teeth and fixed prostheses; 3 = natural teeth and dentures.
CFU = colony-forming units; ND = not detectable.

Table 3. Prevalence of *Streptococcus mutans* and *S. sobrinus* and total mutans streptococci

Mutans streptococci	Subjects		CFU × 10^3/ml			
			S. mutans		Total mutans streptococci	
	No.	%	Mean	Median	Mean	Median
Not detected	2	2	—	—	—	—
S. mutans	53	58	3038	820	3038	820
S. sobrinus	1	1	—	—	6	—
S. mutans + *S. sobrinus*	36	39	5403	1460	7494	2630

differences between means and proportions of different subgroups, respectively. The level of significance was set at $p < 0.05$.

Results

Teeth

The total group of subjects had a mean of 14.1 ± 7.3 natural teeth with no significant difference by gender. More than 20 remaining teeth was noted for 23% of all subjects. Natural teeth only or combined with fixed prostheses (oral states 1 and 2) were recorded in 54% of the subjects, whereas 46% had natural teeth in combination with removable dentures (oral state 3). One woman and four men had residual roots (range, 1–9; mean, 3.6), representing a mean of 0.2 teeth of the whole subject group.

The distribution of subjects on the basis of intermaxillary tooth contacts is shown in Table 1. One-third of the persons showed lack of opposing tooth contacts between natural teeth (Eichner class C), but when prosthetic bridges and dentures were accounted for (modified Eichner index), only two persons showed absence of any intermaxillary tooth contacts.

Saliva

The men had significantly higher mean values of salivary secretion rate (2.0 ± 1.3 ml/min) than the women (1.1 ± 0.6 ml/min) ($p < 0.001$). A secretion rate below 0.7 ml/min was found in 25% of the women and 7.5% of the men, whereas in the intervals above 2 ml/min the men were in the majority. The final pH of buffer capacity did not differ significantly between men (6.2 ± 1.3) and women (6.5 ± 1.3). The mean saliva pH was the same for men and women (7.5 ± 0.4).

Table 4. Number of sound, decayed, and filled coronal surfaces (third molar included) and frequency of decayed (DSc%) and filled (FSc%) surfaces of total surfaces

Coronal surfaces	Men (n = 40)		Women (n = 52)		Total (n = 92)	
	Mean	SD	Mean	SD	Mean	SD
Total	64.0	36.0	60.8	30.9	62.2	33.1
Sound	30.5	24.2	22.4	19.0	25.9	21.7
Decayed						
Primary	0.2	0.4	0.1	0.4	0.2	0.4
Recurrent	1.0	1.7	0.9	2.0	0.9	1.9
Filled	32.3	24.5	37.4	19.7	35.2	22.0
DSc%†	2.4	3.7	2.0	4.4	2.2	4.2
FSc%†	50.8	28.6	65.7*	23.0	59.2	26.5

* Significantly different from men ($p < 0.05$).
† Mean based on individual values.

Table 5. Number of exposed, sound, and decayed primary, recurrent, and arrested carious lesions and filled root surfaces (third molar included) and root caries index (RCI) based on individual values

Root surfaces	Men (n = 39)		Women (n = 50)		Total (n = 89)	
	Mean	SD	Mean	SD	Mean	SD
Exposed	25.4	15.7	16.1	11.5	20.2	14.2
Exposed/total, %	49.0	28.8	39.0	30.5	43.4	30.0
Sound	16.2	11.8	11.2*	11.0	13.4	11.6
Decayed						
Primary	2.4	6.7	0.1*	0.4	1.1	4.6
Recurrent†	0.3	0.7	0.1	0.5	0.2	0.6
Recurrent‡	0.6	1.5	0.5	1.1	0.6	1.3
Arrested	0.8	1.3	0.3*	0.7	0.5	1.0
Filled	5.0	4.2	3.7	4.0	4.3	4.1
RCI, %	35.2	22.9	37.8	32.4	36.6	28.5

* Significantly different from men ($p < 0.05$).
† Secondary to a root surface filling.
‡ Secondary to a coronal filling or crown.

Plaque and microbial conditions

The mean percentage of tooth surfaces harboring clearly visible plaque was significantly higher in men (37%) than in women (24%) ($p < 0.05$).

Detectable levels of lactobacilli and mutans streptococci were found in 96% and 98% of the subjects, with no differences by gender. High counts of lactobacilli ($>10^5$ CFU/ml saliva) were found in 49% of the subjects, among whom most were denture wearers (Table 2). Of the subjects with natural teeth only or in combination with fixed prostheses (oral states 1 and 2) about one-third had $>10^5$ CFU of lactobacilli/ml saliva, and among denture wearers (oral state 3) the corresponding value was 64% ($p < 0.05$). A high salivary population of mutans streptococci ($>10^6$ CFU/ml) was detected in 55% of all subjects and in 67% of denture wearers.

The prevalence of *S. mutans* and *S. sobrinus* is shown in Table 3. *S. mutans* only was harbored by 53 subjects, whereas 36 subjects had both *S. mutans* and *S. sobrinus*. In one person *S. sobrinus* was detected as the only mutans species. The number of mutans streptococci was higher in subjects harboring both *S. mutans* and *S. sobrinus* as compared with individuals carrying only *S. mutans* ($p < 0.01$). The denture wearers had a significantly higher mean value of *S. sobrinus* than the non-denture wearers (1.6×10^6 and 0.2×10^6 respectively; $p < 0.05$).

Caries experience

The mean number (±SD) of decayed, missing, and filled teeth (DMFT) and coronal and root surfaces (DMFS) was 25.2 ± 3.0 and 104.3 ± 21.1, respectively.

The mean of DF surfaces was 38.3 ± 22.7. Thirty-nine per cent of the participants had no caries lesions (DS, both coronal and root), whereas 25% had 4 or more DS, men having significantly more DS than women (4.4 ± 8.0 and 1.8 ± 2.9, respectively).

The prevalence of sound, decayed (DSc), and filled (FSc) coronal surfaces is shown in Table 4. Untreated caries including both primary and recurrent decay was seen in a mean of 1 surface (2%), whereas the average number of filled surfaces was 35 (59%). The number of teeth with cast crowns for men and women was 3.8 ± 4.0 and 5.2 ± 4.1, respectively. The percentage of filled surfaces of total (FSc) was significantly higher in women than in men ($p < 0.05$).

Exposed root surfaces were found in all except three persons, who had their remaining teeth covered with cast crowns. The remaining 89 subjects had a mean of 20 exposed root surfaces, which constituted 43% of all available (Table 5). Caries experience on the root surfaces was found in 85% of the individuals. A wide distribution of decayed root surfaces was noted in men (range, 0–38), whereas women had a more limited distribution (range, 0–4). Active caries (primary and recurrent) was detected on 1.9 surfaces, with women having a significantly lower number of primary lesions ($p < 0.05$). Among recurrent caries more lesions were found secondary to a coronal filling or crown than to a root surface filling. The RCI was 36.6%, with no significant difference between men and women.

Discussion

Of the 172 dentate persons born in 1901–2 and participating in the gerontologic and geriatric population studies in 1989–90 in Göteborg, 92 subjects (54%) took part in the present examination. The remaining subjects did not accept or were not able to come for the clinical cariologic examination. They were more disabled and had more difficulties with oral hygiene procedures than the participating persons, factors that may have affected their oral health. The reported results may therefore be considered representative only for the least dependent part of the age group.

The present study showed that the 88-year-old persons had a mean of 14.1 remaining teeth. The distribution of subjects by the Eichner index showed that one-third of the persons were lacking opposing tooth contacts between natural teeth in the lateral segments. When prosthetic bridges and dentures were accounted for, most subjects had an improved intermaxillary support, with 78% of the subjects having two or more antagonist contacts in premolar and/or molar regions. This implies that most of the individuals had an acceptable level of mastication.

Of particular interest is that the mean number of remaining natural teeth (14.1) did not differ significantly from the number of teeth (13.6) found in a cohort born in 1901–2, who were examined 18 years earlier at the age of 70 years (29). The distribution of subjects on the basis of Eichner's index was also similar to that found 18 years earlier. Thus, on a group basis, these variables showed no changes between the ages of 70 years and 88 years. The main reasons may be the increased survival rate in subjects with the best preserved dental state (30).

The stimulated salivary secretion rate was within the normal range for most of the individuals. However, a secretion rate below 0.7 ml/min was found in 25% of the women and 7.5% of the men. Previous studies have shown that the stimulated salivary secretion rate differs significantly between medicated and unmedicated women but not in men (5, 9, 31). Thus, Baum (5) reported that post-menopausal medicated women had about 25% reduction in stimulated parotid salivary flow, whereas no significant difference was found between any age or medication group in men. However, Närhi et al. (12) reported significantly lower salivary secretion rate in men with more than four drugs than in unmedicated men, whereas no significant differences were found between medicated and unmedicated women. Thorselius et al. (11) observed that the negative correlation between secretion rate and the number of drugs became weaker when age, gender, and oral state were kept constant.

Most of the men and women had a buffer capacity above pH 5.75, the lower limit for normal buffer capacity (32). This proportion of subjects is higher than those reported in other studies of adults (11, 33, 34). The high buffer capacity might partly be explained by the fact that all saliva was collected in the morning after the subjects had been fasting for about 10 h. According to Ericsson (20), the buffer effect is high in the morning and decreases after breakfast. Another explanatory factor might be the high age of the study population, since an increasing buffer effect has been observed with age (34). However, contradictory findings of a decreasing buffer effect with increasing age from 55 to 75 years have also been reported (33).

Around half of the individuals had a high prevalence of salivary lactobacilli and mutans streptococci. The oral microflora is influenced not only by age but also by the presence of removable partial dentures (35, 36). In the present study most subjects with high counts of both lactobacilli and mutans streptococci were in the group of denture wearers. It has been suggested that the space under the denture offers suitable conditions and an increased area for the colonization of lactobacilli and mutans streptococci (37). Furthermore, removable dentures in elderly people contribute to less effective oral sugar clearance (38), another factor that also might favor the growth of lactobacilli and mutans streptococci.

S. sobrinus was identified in 40% of the subjects and together with *S. mutans* in all subjects except one. The carriers of *S. sobrinus* had a higher salivary numbers of

total mutans streptococci than subjects with only *S. mutans*, which is in agreement with other studies (13, 14, 33).

Most of the subjects (61%) had untreated coronal and root caries lesions, 25% having four lesions or more. When compared with some recent Swedish epidemiologic studies in adults, the prevalence of decayed surfaces found in our study was higher than corresponding data from the age group >80 years in the Jönköping study (39) but lower than data from the age group >79 years in the Älvsborg study (40). As the non-participating subjects in the present study were more disabled than the participants, it could be assumed that the missing data from these persons influence the results in such a manner that the number of untreated caries is underestimated (41). When the numbers of filled surfaces were accounted for, the differences between the three studies were very small, which indicates differences in utilization of dental services between the studied populations.

A mean of one carious coronal surface was diagnosed in our study group. Most lesions were recurrent caries, but a small number of primary lesions were registered, indicating the presence of enamel caries also in high age, a finding that agrees with previously reported observations (42).

Root caries experience was found in 85% of the subjects with exposed root surfaces. The higher mean number of primary root caries in the men was partly due to severe root decay in four of them. Unlike the coronal surfaces, root surfaces covered with cast crowns were not calculated as filled, in accordance with Katz (25). Therefore, in persons with a large number of cast crowns an underestimation of root decay may have occurred. In the present study all caries and fillings (except cast crowns) involving the root surfaces were included. This was done because it was not possible with certainty to judge whether such a lesion originated from the root surface and whether filled root surfaces were due to abrasion or caries.

In the present study the RCI (36.6%) was higher than in previous observations (17). The prevalence of root caries is reported to increase with advancing age, reaching a maximun and then, in the oldest age groups, showing a decreased RCI (17). The drop of RCI in the older age groups may be explained by the influence of dental treatment methods and the sensitivity of losses of restored teeth. However, the trend of dental care in Sweden is towards fewer tooth extractions, reduced treatment with removable partial dentures, and an increase in the number of restorations (43). This will result in more elderly people with remaining natural and restored teeth. Therefore, the high mean RCI value may partly be explained by the high age of the study population.

To conclude, most of the dentate 88-year-old persons had a stimulated salivary secretion rate within normal range and a good buffer capacity. High counts were, however, found of both lactobacilli and mutans streptococci, especially in denture wearers. Although untreated carious lesions were diagnosed in two-thirds of the persons, high numbers of carious lesions were restricted to a few of the subjects. With reservation for the fact that in the present study the sample size was small and the response rate low, the data indicate that old people in very high age groups with fairly good health do not differ markedly from younger elderly people (39).

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