A Ten-year Cross-sectional and Follow-up Study of Salivary Flow Rates and Mutans Streptococci and Lactobacillus Counts in Elderly Swedish Individuals

Solveig Fure[a]

Purpose: The whole salivary flow rates and microbial conditions were examined in a 10-year follow-up and cross-sectional study in a random sample of elderly inhabitants of Gothenburg.

Material and Methods: Of the 208 individuals examined at baseline, forty-nine per cent participated in the follow-up, 56, 37 and nine persons, respectively, in the age groups of 65, 75 and 85 years. In addition, a new random sample of 98 individuals aged 55 year was examined.

Results: The mean secretion rate decreased significantly with increasing age in terms of unstimulated and stimulated whole saliva. Of the 200 participants, 50% were taking medication, which could have hyposalivatory side-effects. Persons with a daily intake of ≥4 drugs had significantly lower unstimulated and stimulated secretion rates. Forty-five persons reported subjective dryness in the mouth. The mean saliva secretion rates among these persons were significantly lower and the number of drugs consumed significantly higher than in people with no such complaints. The overall salivary counts of lactobacilli and mutants streptococci increased with age. Higher counts of these bacteria were found in persons wearing removable dentures than in persons without dentures.

Conclusion: The salivary and microbial conditions ought to be continuously monitored in old people, in order to identify those who need oral health promotive measures.

Key words: elderly subjects, incidence, lactobacilli, mutans streptococci, salivary flow

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Saliva performs a vital function in maintaining good oral health. An appropriate secretion rate is therefore a decisive factor in this respect. The elderly are, however, more frequently subject to functional disorders and diseases that involve an increase in the consumption of medicines with hyposalivatory side-effects. Several recent studies have reported a reduction in the salivary flow rate of either unstimulated or stimulated saliva in elderly people (Percival et al, 1994; Sivarajasingam et al, 1995; Billings et al, 1996; Närhi et al, 1999; Bergdahl, 2000). Among the many negative factors associated with a reduced saliva secretion rate, the condition is often associated with a shift towards a more caries-related acidogenic oral flora.

A five-year follow-up study of randomly-selected 60-, 70-, and 80-year-old inhabitants of Göteborg revealed decreased secretion rates of unstimulated and stimulated saliva with increasing age (Fure, 1998). It was also found that the salivary counts of lactobacilli and mutans streptococci, particularly the species *Streptococcus sobrinus*, had increased

[a] *Department of Cariology, Faculty of Odontology, The Sahlgrenska Academy at Göteborg University, Göteborg, Sweden.*

Reprint requests: *Solveig Fure, DDS, PhD, The Sahlgrenska Academy at Göteborg University, Faculty of Odontology, Box 450, SE-405 30 Göteborg, Sweden. Fax: +46 (0)31 773 3220. E-mail: fure@odontologi.gu.se*

Table 1 Number of men and women who partcipated at baseline in 1987 and at the 10-year follow-up examination in 1997. Number of remaining teeth, number of persons on medication and on ≥4 drugs in the different age groups

Age group	Participants in 1987			Age group	Participants in 1997			Remaining teeth in 1997	On medication ≥4 drugs			
	Men	Women	Total		Men	Women	Total					
				55	51	47	98	23.7 ± 5.2	38	39%	10	10%
55	47	41	88	*65*	32	24	56	22.5 ± 6.1	28	50%	5	9%
65	40	32	72	*75*	17	20	37	17.3 ± 7.2	26	70%	14	38%
75	20	28	48	*85*	4	5	9	14.2 ± 6.4	8	89%	3	33%
Total	107	101	208		104	96	200	21.8 ± 6.5	100	50%	22	16%

with age. Persons wearing removable dentures had higher counts of these organisms than those without dentures. These findings are in accordance with other studies of salivary counts of acidogenic micro-organisms in the elderly and wearers of dentures (Emilson and Thorselius, 1988; Beighton et al, 1990; Köhler and Persson, 1991; Marsh et al, 1992; Lundgren et al, 1996; Närhi et al, 1999).

The purpose of this 10-year cross-sectional and follow-up study was to investigate the consistency of an age-related reduction in the saliva secretion rate and an increase in the salivary counts of some acidogenic micro-organisms.

MATERIALS AND METHODS

Study Population

In each of the age groups 55, 65 and 75 years some 150 individuals, respectively, were randomly selected for the baseline study from the official register of inhabitants in the municipality of Gothenburg. They constituted approximately 3% of the inhabitants in the corresponding age groups. Edentulous people were not included in the examination and 88, 72 and 48 participated in the respective age groups (Table 1). Of the 208 individuals examined at baseline 102 (53 men and 49 women) participated in the 10-year follow-up examination; 56, 37 and nine persons, respectively, in the age groups of 65, 75 and 85 years. For the purpose of time-trend comparisons, a new random sample of 150 individuals in the 55-year-old age group was selected and 98 (51 men and 47 women) individuals having natural teeth agreed to participate in the study. Informed consent was obtained prior to the start of the study, which had been approved by the Ethics Committee at Gothenburg University, Dnr: H027-97.

Clinical Examination

The clinical examination was carried out at the Department of Cariology, Gothenburg University, by one dentist (SF), using the same technique as at baseline (Fure and Zickert, 1990). The numbers of remaining teeth and the wearing of dentures were recorded. The participants were interviewed about their drug consumption including the use of antimicrobial treatment, i.e. chlorhexidine, penicillin and their equivalents, during the previous two months. The subjects were also asked about whether they experienced dryness in the mouth, either constantly or only at rest when they had been asleep.

Saliva Sampling Procedure

Most collections were made in the mid-morning and at least one hour after a meal. Dentures were in situ during the saliva collection. The subjects were allowed to relax for a while and drink a glass of water prior to sampling. During the collection of unstimulated saliva, the participants were asked to

sit with their head bent forward, to allow the saliva to pool in their mouth, and not to swallow. They were instructed to expectorate into a graduated test tube when they felt the need to spit and the procedure continued for 10 min. Stimulated whole saliva, using the spitting method, was then collected in a chilled graduated test tube. A piece of paraffin wax was chewed for a while and the saliva was swallowed. Saliva was then collected continuously, while chewing on the bolus of paraffin wax for a minimum of 2 min or until a volume of 2 ml was collected. The cylinder of stimulated saliva was sealed with Parafilm and kept chilled until it was processed at the laboratory within 2 h.

Saliva Secretion Rate and Buffer Capacity

The secretion rate for unstimulated and stimulated whole saliva was estimated in ml/min. The buffer capacity of stimulated saliva, expressed as the final pH, was determined according to the method described by Ericsson (1959).

The cut-off points for hyposalivation were set to <0.1 ml/min for unstimulated saliva and <0.7 ml/min for stimulated saliva (Ericsson and Hardwick, 1978).

Microbiological Procedures

One ml of the stimulated saliva sample was dispersed on a Whirlimixer and diluted in 10-fold stages in 0.05 M potassium phosphate buffer containing 0.4% KCl. Aliquots of 25 µl of the appropriate dilutions were placed in duplicate on mitis-salivarius-bacitracin (MSB) agar (Gold et al, 1973) to grow mutans streptococci and on Rogosa SL agar to grow lactobacilli. The MSB agar plates were incubated for 2 d at 37°C in an atmosphere of 95% N_2 and 5% CO_2. The Rogosa SL agar plates were incubated aerobically at 37°C for 3 d. Counts were made of colonies with the typical morphology characteristics of *Streptococcus mutans* and *Streptococcus sobrinus* on MSB agar (Emilson, 1983) and of lactobacilli in Rogosa SL agar and the number of colony forming units (CFU) in these micro-organisms per ml of stimulated saliva was determined. A number of representative and atypical colonies on MSB agar were isolated and identified using both specific fluorescent antisera and immunofluorescent procedures (Bratthall, 1972).

Statistical Methods

In the analyses, bacterial counts were transformed to $\log_{10}$ values in order to normalize their distribution. Differences between mean values of the studied variables were analyzed using a one- or two-factor analysis of variance (ANOVA). Paired t-tests and correlation coefficients (r) were calculated to compare individual values of different variables. A stepwise multiple linear regression analysis of the variable remaining teeth in relation to salivary rates and microbial counts was performed. The level of significance was set at $P<0.05$.

RESULTS

Drop-outs

Of the 208 persons examined at baseline 102 (49%) participated in the 10-year follow-up examination (Table 1). Of the 106 non-participants in the follow-up examination, 33 had died during the 10-year period (1%, 18% and 40%, in the respective age groups of 65, 75 and 85 years). Telephone interviews revealed that two persons had lost all their teeth and 36 persons were too ill for a dental examination. Further 16 persons had a shortage of time and 19 had moved from the district. No statistically significant differences between the mean values for the baseline data of the studied variables were found in one-factor ANOVA in terms of participants and non-participants in the follow-up examination.

In the new randomly selected sample of 150 individuals aged 55 years, 98 (65%) participated (Table 1). Five per cent, four men and four women reported that they were edentulous and 5% were too ill for a dental examination. Other reasons for not participating were: moved from the district (3%), a shortage of time (14%), or lack of interest (7%).

Teeth

The mean numbers of remaining teeth were 24, 23, 17 and 14, respectively, in the age groups of 55, 65, 75 and 85 years (Table 1). Removable dentures in one or both arches were found in seven, four, nine and four subjects in the respective age groups. The remaining 176 had only natural teeth or natural teeth in combination with fixed prostheses or implants.

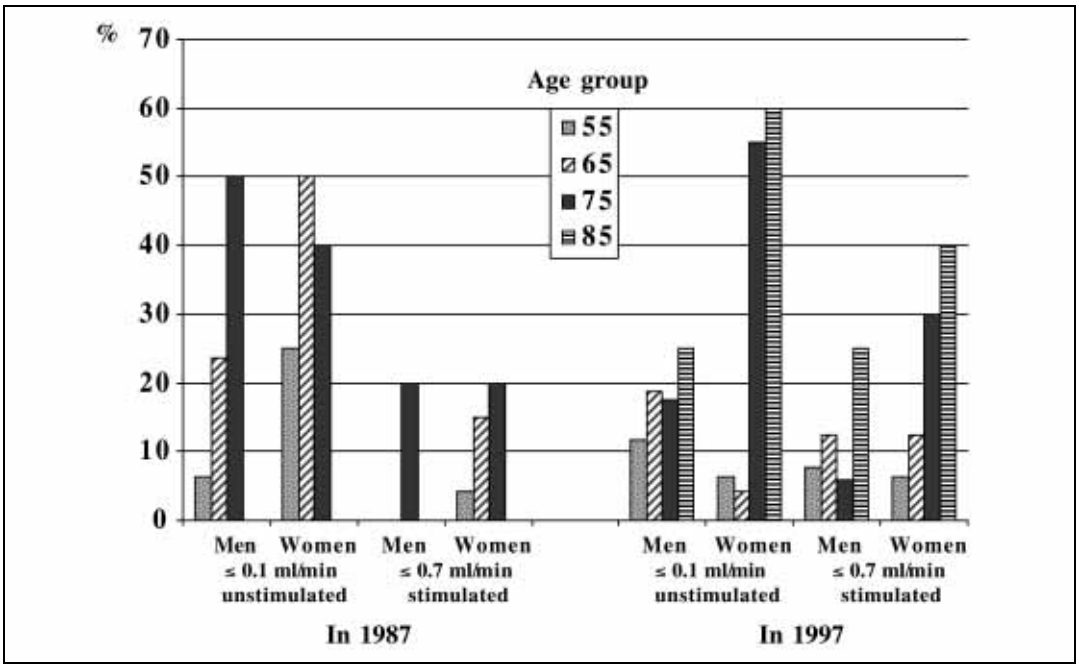

Fig 1 Frequency distribution by age group of low levels of saliva secretion rates of unstimulated saliva in men and woman.

Drugs

One hundred individuals (50%), 43 men and 57 women, were taking medication that could have xerostomic side-effects (Sreebny and Schwartz, 1997). Antihypertensives (48 persons), long-term analgesics (29 persons), antipsychotics (25 persons), antiasthmatics (22 persons) and diuretics (20 persons) were most frequently used. Other drugs included antidepressants, vasodilators, anticholinergics, antacids, antidiabetics, thyroid hormones, glucocorticoids, drugs for Parkinson's disease and systemic antihistamines. Of the 200 participants, 16% had a daily intake of ≥4 prescribed medications, this figure was 37% in people aged 75 and over (Table 1).

Saliva

Cross-sectional comparisons: The percentages of individuals with an unstimulated saliva secretion rate of 0.1 ml/min or less increased with age (Fig 1). They were found to be 9%, 13%, 38% and 44%, respectively, in the age groups of 55, 65, 75 and 85 years in 1997. Among the people who participated in the follow-up examination, the percentages of those with an unstimulated secretion rate of 0.1 ml/min or less were 14%, 38% and 44%, respectively, for the 55-, 65- and 75-year-olds in 1987. Accordingly, when comparing the same age groups, the percentages of people with hyposalivation were higher at baseline than at the follow-up. A stimulated secretion rate of 0.7 ml/min or less was found in 7%, 13%, 19% and 33%, respectively, of the 55-, 65-, 75- and 85-year-olds in 1997.

In two-factor ANOVA (age group and medication), no statistically significant differences in mean values were found between subjects using prescribed medications, which may cause hyposalivation and those who were not, in the case of either unstimulated or stimulated saliva. However, persons with a daily intake of four or more drugs had a lower unstimulated ($P<0.001$) and stimulated ($P<0.01$) secretion rate than those taking fewer than four drugs among people aged 65 and over.

Men had significantly higher secretion rates than women (Table 2). The mean secretion rates decreased with age and were found to be 0.4, 0.4, 0.3 and 0.2 ml/min, respectively, in the 55-, 65-, 75- and 85-year-olds in terms of unstimulated saliva in 1997. The corresponding values for stim-

Table 2 Mean ± SD of secretion rate (ml/min) for unstimulated and stimulated whole saliva at baseline in 1987 and at follow-up in 1997 by age group and gender

Age group (n m/w)	Secretion rates in 1987				age group (n m/w)	Secretion rates in 1997			
	unstimulated		stimulated			unstimulated		stimulated	
	men	women	men	women		men	women	men	women
					55(51/47)	0.4±0.3	0.3±0.2	2.4±1.3	2.2±1.1
55(32/24)	0.4±0.2	0.3±0.2	2.1±0.9	1.9±0.8	65(32/24)	0.4±0.2	0.3±0.2	2.1±1.2	1.9±1.0
65(17/20)	0.3±0.3	0.2±0.2	2.0±0.6	1.5±0.8	75(17/20)	0.3±0.3	0.2±0.1	1.9±1.4	1.1±0.8
75(4/5)	0.2±0.2	0.2±0.1	1.5±0.9	1.4±0.5	85(4/5)	0.2±0.2	0.1±0.1	1.5±0.8	1.0±0.3
(53/49)	0.4±0.2	0.3±0.2	2.0±0.8	1.7±0.8	(104/96)	0.4±0.3	0.3±0.2	2.2±1.2	1.8±1.1

Cross-sectional: In two-factor ANOVA (age group and gender), the differences between the mean secretion rate values were found to be statistically significant in terms of age group for unstimulated saliva in 1987 and in 1997 ($P<0.01$, for both) and for stimulated saliva in 1997 ($P<0.01$); in terms of gender for unstimulated saliva in 1997 ($P<0.01$) and for stimulated saliva in 1987 and 1997 ($P<0.05$, for both).
Longitudinal: In paired t-test no significant differences in secretion rates were found between 1987 and 1997 within the same cohort.

ulated saliva were 2.3, 2.0, 1.5 and 1.3 ml/min. When the effect of gender was accounted for in two-factor ANOVA the differences between the mean values were found to be significant in terms of age groups for unstimulated and stimulated saliva.

Longitudinal comparisons: In the 102 individuals who participated in the baseline and follow-up examinations, the secretion rates had not decreased significantly, however, during the 10-year period (paired t-test).

When comparing the same age groups, the mean secretion rate values were actually somewhat higher in 1997 than in 1987 (Table 2), but not found statistically significant in one-factor ANOVA. There was a high correlation coefficient between the unstimulated and stimulated salivary rates of r=0.6.

Dryness of the Mouth

Subjective dryness of the mouth was reported by 45 persons, 19 of whom experienced dryness constantly, while 26 only experienced it when they had been asleep. The mean secretion rates for unstimulated and stimulated saliva differed significantly between the three groups of persons who either experienced constant dryness or only experienced dryness after sleep or did not complain of oral dryness. The corresponding mean secretion rates were 0.1, 0.2 and 0.4 ml/min for unstimulated saliva ($P<0.05$), respectively, for the three groups and 0.7, 1.7 and 2.2 ml/min for stimulated saliva ($P<0.05$). A statistically significant difference was also found between the mean values for the number of drugs consumed in terms of subjective dryness ($P<0.0001$). The mean numbers of drugs were 3.6, 1.8 and 1.0, respectively, for the three groups.

Final pH of Buffer Capacity

Cross-sectional comparisons: No significant differences between mean values of buffer capacity in terms of age group were found in two-factor ANOVA (age group and gender), either 1987 or 1997 (Table 3).

Longitudinal comparisons: The salivary buffer capacity had, however, increased on average in the 10-year period among the 102 participants in the follow-up examination ($P<0.001$, paired t-test) (Table 3). This was especially notable in the 75-year age group, where the mean value for the final pH was found to be 5.6±1.5 in 1997 com-

pared with 4.4±1.5 in 1987. When comparing the same age groups the mean values were higher in 1997 than in 1987 (P<0.0001, one-factor ANOVA).

There were high correlations between the buffer capacity and the unstimulated and stimulated salivary rates of r=0.3 and r=0.5, respectively.

Table 3 Mean values ± SD for final pH of buffer capacity of stimulated whole saliva at baseline in 1987 and at follow-up in 1997 by age group

Age group(n)	in 1987	Age group(n)	in 1997
		55(98)	5.8±1.5
55(56)	5.1±1.7	65(56)	5.3±1.5
65(37)	4.4±1.5	75(37)	5.6±1.5
75(9)	4.6±1.4	85(9)	4.8±1.0
(102)	4.8±1.6	(200)	5.5±1.5

Cross-sectional: In two-factor ANOVA on age groups and gender, no significant differences between the mean values for final pH were found in 1987 and 1997.
Longitudinal: In paired t-test the values for final pH were found significantly higher in 1997 than in 1987 (P<0.001).

Microbiological Findings

In the microbiological investigations, five subjects in 1987 and six subjects in 1997 were excluded owing to antimicrobial treatment within the two months preceding the examinations. Mutans streptococci were not detected in 2% of the saliva samples of the 55- and 65-year-olds in 1987 and 1997, while the bacteria were detected in all the saliva samples from the 75- and 85-year-olds.

Cross-sectional comparisons: The percentage of people with a high number of mutans streptococci, i.e. $\geq 10^6$ or more CFU/ml saliva increased with age. This high number was found in 14%, 21%, 43% and 50%, respectively, in the 55-, 65-, 75- and 85-year age groups in 1997 (Fig 1). Corresponding percentages were found for the equivalent age groups in 1987.

S. sobrinus was only detected in subjects with detectable *S. mutans*. Among these subjects, the percentage of *S. sobrinus* accounted for 9%, 15%, 16% and 46%, respectively, of the total amount of mutans streptococci in the 55-, 65-, 75- and 85-year-olds in 1997. The corresponding figures were 5%, 19% and 20% for the 55-, 65- and 75-year age groups in 1987. The salivary counts of *S. mutans* and lactobacilli were significantly higher in the 74 subjects who carried *S. sobrinus* than in those who did not.

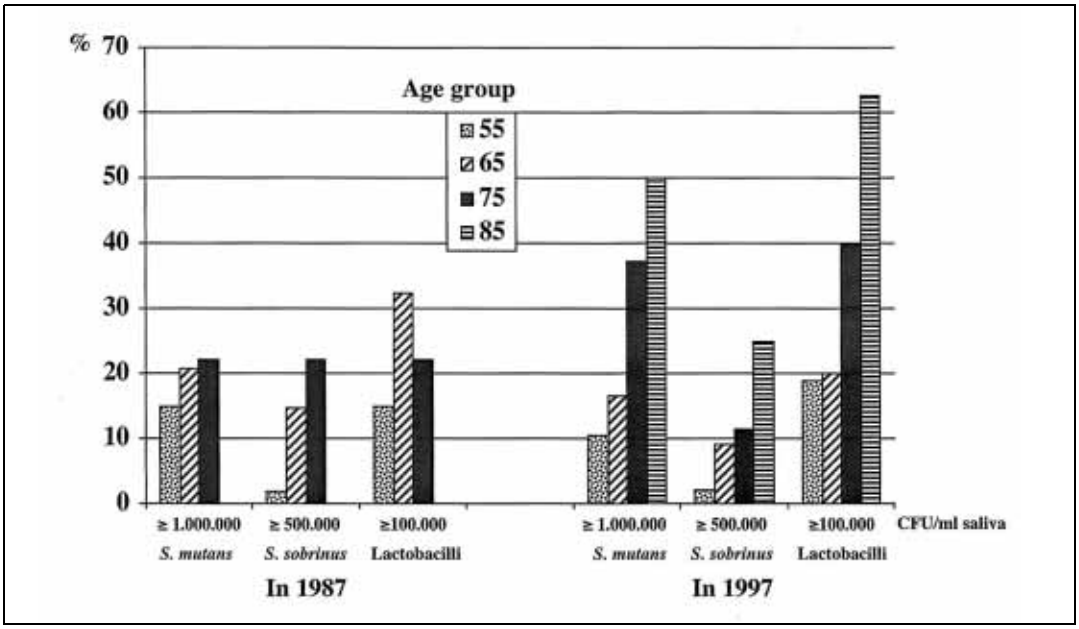

Fig 2 Frequency distribution by age group of high levels of *S. mutans*, *S. sobrinus* and lactobacilli in stimulated saliva.

Table 4 Mean ±SD x10^5 CFU of *S. mutans*, *S. sobrinus* and lactobacilli per milliliter of saliva at baseline in 1987 and at follow-up in 1997 by age group and gender for the lactobacilli

Age group (n m/w)	Microbial counts in 1987				Age group (n m/w)	Microbial counts in 1997			
	Streptococcus		Lactobacilli			*Streptococcus*		Lactobacilli	
	mutans	*sobrinus*	Men	Women		*mutans*	*sobrinus*	Men	Women
					55(50/46)	4.5±9.7	0.4±1.7	3.9±14.4	0.4±1.2
55(31/23)	4.7±7.4	0.2±0.9	0.4±0.6	0.4±0.9	65(31/24)	5.2±8.1	0.9±2.6	1.9±4.6	1.8±6.1
65(17/17)	7.6±9.9	1.8±3.6	2.9±4.3	1.7±2.8	75(17/18)	24.3±1.5	4.7±16.5	11.8±29.5	4.5±11.8
75(4/5)	6.7±9.4	1.6±2.8	5.7±6.6	0.1±0.1	85(3/5)	17.1±18.3	14.5±34.8	42.6±59.8	3.9±4.9
(52/44)	6.0±8.7	0.9±2.6	1.6±3.3	0.9±2.0	(101/93)	8.7±24.5	1.9±10.1	6.0±20.3	1.8±6.4

Cross-sectional: In two-factor ANOVA (age group and gender) the differences between the mean $\log_{10}$ values of microbial counts were found statistically significant in terms of age groups for lactobacilli (P<0.05) and *S. sobrinus* (P<0.0001) in 1987, for lactobacilli (p<0.0001), *S. sobrinus* and *S. mutans* (P<0.05 for both) in 1997, in terms of gender for lactobacilli (P<0.01) in 1997.
Longitudinal: In paired t-test the lactobacilli counts were significantly higher in 1997 than in 1987 (p<0.001).

Table 5 Stepwise regression analysis of the dependent variable of remaining teeth in 1997, in terms of baseline data of salivary rates and microbial counts, R^2 = 0.15

Independent variables	Coefficient	F value	*P* value	Partial corr.
Intercept	25.5			
1. Lactobacilli	-0.8	7.3	0.008	-0.26
2. Unstimulated secretion	6.4	5.6	0.004	0.25
3. Mutans streptococci	-1.1	4.8	0.004	-0.24
4. Buffer capacity	0.6	3.9	0.006	0.20
5. Stimulated secretion	-0.9	3.3	0.009	0.12

Men harbored more lactobacilli than women and the percentage of people with a high number of ≥10^5 CFU/ml saliva of lactobacilli in 1997 was 32% for men compared with 16% for women. The percentage of people with high levels increased with age from 19% in the 55-year-olds to 63% in the 85-year-olds (Fig 1).

In Table 4, it can be seen that the mean numbers of mutans streptococci per ml saliva were higher in the oldest age group than in the youngest. The mean values for *S. sobrinus* in 1997 increased from 0.4 x 10^5 CFU/ml saliva in the 55-year-olds to 14.5 x 10^5 in the 85-year-olds. The mean values for lactobacilli increased also with age from 2.2 x 10^5 CFU/ml saliva in the 55-year-olds to 21.1 x 10^5 in the 85-year-olds.

Longitudinal comparisons: Within the same individual, the *S. mutans* and *S. sobrinus* counts had increased in overall terms during the 10-year period, but this was not significant in the paired t-test (Table 4). The lactobacilli counts within the same individual had, however, increased significantly during the 10-year period (P<0.001, paired t-test).

Higher counts of lactobacilli and *S. sobrinus* in saliva were found in persons wearing removable dentures than in those without dentures (P<0.05, one-factor ANOVA). There was a high correlation between the number of lactobacilli and the number of mutans streptococci of r=0.4. A negative correlation was found between the stimulated salivary rate and the number of mutans streptococci and lactobacilli of r=0.3 and r=0.2, respectively.

In the stepwise regression analysis, the variation of the dependent variable remaining teeth was only explained at 15% by the baseline data of salivary rates and microbial counts (Table 5). Lactobacilli and mutans streptococci counts and salivary rates of unstimulated saliva emerged as the best explanation of the variation in number of teeth.

DISCUSSION

The 10-year cross-sectional and follow-up study revealed that the mean secretion rates of unstimulated and stimulated saliva decreased with increasing age and that the secretion rates were lower for women than for men. The salivary counts of lactobacilli and mutans streptococci increased with age and higher counts of lactobacilli and *S. sobrinus* were found in persons wearing removable dentures. These findings are in accordance with the results of the baseline and the five-year follow-up studies (Fure and Zickert, 1990; Fure, 1998). Several other studies of elderly people have produced corresponding results, while some findings are contradictory. There could be many possible explanations for the conflicting results.

Drop-outs are inevitable in a 10-year longitudinal study, particularly when very old people are involved. When comparing data recorded in 1987 between the persons who participated and those who were unable to participate in the follow-up examination, no significant differences were found in terms of salivary rates and microbial counts. However, when studying the group of individuals who had died, were too ill for an examination or had lost all their teeth individually, significantly lower salivary secretion rates and higher microbial counts were found. Corresponding results were found in the five-year follow-up study (Fure, 1998). It is therefore reasonable to assume that unfavorable salivary and microbial conditions are associated with a deterioration in general health. As the percentage of disabled persons will naturally increase with age, this could be one explanation for the findings of lower secretion rates and higher counts of acidogenic bacteria in the oldest subjects. The small sample sizes of the oldest age groups have certainly also influenced the results.

Both the unstimulated and the stimulated salivary flow were significantly higher in men than in women, which is in line with the results of most other recent studies of corresponding age groups (Thorselius et al, 1988; Österberg et al, 1992; Meurman and Rantonen, 1994; Percival et al, 1994; Lundgren et al, 1996; Pajukoski et al, 1997; Bergdahl, 2000). When it comes to age-related secretion rates, there is, however, less consistency in the findings. Some studies have revealed a reduction with age in the secretion rate of unstimulated saliva (Meurman and Rantonen, 1994; Percival et al, 1994; Sivarajasingam et al, 1995), particularly among females (Billings et al, 1996; Bergdahl, 2000). In the case of stimulated flow rate, some recent studies have also revealed a decrease with age, particularly among women (Meurman and Rantonen, 1994; Billings et al, 1996; Närhi et al, 1999), while other authors have not found any age-related reduction (Österberg et al, 1992; Pajukoski et al, 1997; Bergdahl, 2000). There could be several reasons for this variation in the results. In this study, generally within the same individual, the secretion rates had not decreased significantly during the 10-year period. The significant age-related differences in secretion rate were found in the same examination, between age groups of at least 20 years. This suggests that a prerequisite for revealing an age-related reduction in secretion rates is a study sample, which includes very elderly individuals with an age-range of at least 20 years.

The use of medication with hyposalivatory side-effect is naturally an important factor when it comes to the disparity in the results from different studies. One reason is that the effect of the drugs influences individuals very differently, another is the difficulty involved in obtaining accurate information about drug consumption. In this study, no significant differences in secretion rates were found between persons using prescribed drugs and those who did not, when the variation in age was taken into consideration. However, those with a daily intake of four or more drugs had lower secretion rates and the number of drugs taken was associated with xerostomia. Other studies have also found a negative correlation between the salivary secretion rate and the number of xerostomic drugs (Kreher et al, 1987; Thorselius et al, 1988; Meurman and Rantonen, 1994; Bardow et al, 2001). A strong relationship between subjects who report dry mouth symptoms and the number of drugs has also been confirmed by other authors (Österberg et al, 1992; Gilbert et al, 1993; Nederfors et al, 1997; Bardow et al, 2001). Most studies suggest that the number of daily drugs is a decisive factor in the relation to the salivary flow.

When comparing the same age groups between the baseline and the 10-year follow-up examinations, some interesting results were obtained from this study. The secretion rates were higher in 1997 compared with 1987 and the percentages of those subjects with very low secretion rates were lower in 1997. This may indicate that, on average, elderly people had better oral health in 1997 compared with 1987. Another explanation is that those who are well in health will be selected out in a longitudinal study. A plausible contributory cause is a greater consciousness nowadays of the xerogenic side-effect of some drugs, which may have resulted in the development of and the prescription of less hyposalivatory medicines.

No significant age-related differences were found in terms of the mean buffer capacity values. In overall terms, within the same individual, the capacity had increased during the 10-year period. A tendency towards an increase in the final pH of buffer capacity with age has also been shown in other studies (Thorselius et al, 1988; Lundgren et al, 1996; Närhi et al, 1999).

Regarding the caries-related acidogenic micro-organisms, this study revealed that the salivary counts of lactobacilli and mutans streptococci, especially *S. sobrinus*, increased with age. It was also found that denture-wearing had a significant effect on these microorganisms. These findings are in line with those of other studies of elderly people, where higher counts of lactobacilli, mutans streptococci and/or yeasts have been found in persons wearing removable dentures than in those with only natural teeth (Emilson and Thorselius, 1988; Beighton et al, 1990; Köhler and Persson, 1991; Marsh et al, 1992; Lundgren et al, 1996; Fure, 1998; Närhi et al, 1999). One reason for the change towards a more acidogenic oral flora in the elderly may therefore be associated with the increased use of dentures. In this study, however, in agreement with another study, there was also an age-related increase in the number of acidogenic micro-organisms among individuals without dentures (Marsh et al, 1992). Another reason for the change towards a more caries-related acidogenic microflora with age is the reduction in salivary flow. In accordance with other recent studies, an association was found between a low saliva secretion rate and high counts of mutans streptococci, lactobacilli and/or yeasts (Fure and Zickert, 1990; Köhler and Persson, 1991; Meurman and Rantonen, 1994; Dens et al, 1996).

The regression analysis revealed an association between few remaining teeth and low salivary flow rate and high counts of mutans streptococci and lactobacilli. This indicates that these factors are important regarding the maintaining of oral health.

In conclusion, this study indicates an overall reduction in salivary flow and an increase in salivary counts of acidogenic micro-organisms by age. This suggests that it is important to monitor these conditions in elderly people, in order to identify at an early stage individuals, who need measures for preserving good oral health.

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REFERENCES

1. Bardow A, Nyvad B, Nauntofte B. Relationships between medication intake, complaints of dry mouth, salivary flow rate and composition, and the rate of tooth demineralization in situ. Arch Oral Biol 2001;46:413-423.
2. Beighton D, Hellyer PH, Heath MR. Associations between salivary levels of mutans streptococci, lactobacilli, yeasts and black-pigmented *Bacteroides* spp. and dental variables in elderly dental patients. Arch Oral Biol 1990;35:173-175.
3. Bergdahl M. Salivary flow and oral complaints in adult dental patients. Community Dent Oral Epidemiol 2000;28:59-66.
4. Billings RJ, Proskin HM, Moss ME. Xerostomia and associated factors in a community-dwelling adult population. Community Dent Oral Epidemiol 1996;24:312-316.
5. Bratthall D. Immunofluorescent identification of Streptococcus mutans. Odontol Revy 1972;23:181-196.
6. Dens F, Boogaerts M, Boute P, Declerc D, Demuynck H, Vinckier F. Caries-related salivary microorganisms and salivary flow rate in bone marrow recipients. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996;81:38-43.
7. Emilson CG. Prevalence of *Streptococcus mutans* with different colonial morphologies in human plaque and saliva. Scand J Dent Res 1983;91:26-32.
8. Emilson CG, Thorselius I. Prevalence of mutans streptococci and lactobacilli in elderly Swedish individuals. Scand J Dent Res 1988;96:14-21.
9. Ericsson Y. Clinical investigations of the salivary buffering action. Acta Odontol Scand 1959;17:131-165.
10. Ericsson Y, Hardwick L. Individual diagnosis, prognosis and counseling for caries prevention. Caries Res 1978;12: 94-102.
11. Fure S, Zickert I. Prevalence of root surface caries in 55, 65, and 75-year-old Swedish individuals. Community Dent Oral Epidemiol 1990;18:100-105.

12. Fure S, Zickert I. Salivary conditions and cariogenic microorganisms in 55, 65 and 75-year-old Swedish individuals. Scand J Dent Res 1990;98:197-210.
13. Fure S. Five-year incidence of caries, salivary and microbial conditions in 60-, 70-, and 80-year-old Swedish individuals. Caries Res 1998;32:166-174.
14. Gilbert GH, Heft MW, Duncan RP. Mouth dryness as reported by older Floridans. Community Dent Oral Epidemiol 1993;21: 390-397.
15. Gold OG, Jordan HV, van Houte J. A selective medium for *Streptococcus mutans*. Arch Oral Biol 1973;18:1357-1364.
16. Köhler B, Persson M. Salivary levels of mutans streptococci and lactobacilli in dentate 80- and 85-year-old Swedish men and women. Community Dent Oral Epidemiol 1991;19: 352-356.
17. Kreher JM, Graser GN, Handelman SL. The relationship of drug use to denture function and saliva flow rate in a geriatric population. J Prosthet Dent 1987;57:631-638.
18. Lundgren M, Emilson CG, Österberg T. Caries prevalence and salivary and microbial conditions in 88-year-old Swedish dentate people. Acta Odontol Scand 1996;54:193-199.
19. Marsh PD, Percival RS, Challacombe SJ. The influence of denture-wearing and age on the oral microflora. J Dent Res 1992; 71:1374-1381.
20. Meurman JH, Rantonen P. Salivary flow rate, buffering capacity, and yeast counts in 187 consecutive adult patients from Kuopio, Finland. Scand J Dent Res 1994;102:229-234.
21. Närhi TO, Kurki N, Ainamo A. Saliva, salivary micro-organisms, and oral health in the home-dwelling old elderly – A five-year longitudinal study. J Dent Res 1999;78:1640-1646.
22. Nederfors T, Isaksson R, Mörnstad H, Dahlöf C. Prevalence of perceived symptoms of dry mouth in an adult Swedish population – relation to age, sex and pharmacotherapy. Community Dent Oral Epidemiol 1997;25:211-216.
23. Österberg T, Birkhed D, Johansson C, Svanborg A. Longitudinal study of stimulated whole saliva in an elderly population. Scand J Dent Res 1992;100:340-345.
24. Pajukoski H, Meurman JH, Snellman-Gröhn S, Keinänen S, Sulkava R. Salivary flow and composition in elderly patients referred to an acute care geriatric ward. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;84:265-271.
25. Percival RS, Challacombe SJ, Marsh PD. Flow rates of resting whole and stimulated parotid saliva in relation to age and gender. J Dent Res 1994;173:1416-1420.
26. Sivarajasingam V, Drummond JR. Measurements of human minor salivary gland secretions from different oral sites. Arch Oral Biol 1995;40:723-729.
27. Sreebny LM, Schwartz SS. A reference guide to drugs and dry mouth – 2nd edition. Gerodontology 1997;14:33-47.
28. Thorselius I, Emilson CG, Österberg T. Salivary conditions and drug consumption in older age groups of elderly Swedish individuals. Gerodontics 1988;4:66-70.