Incidence of Periodontal Attachment Loss over 8 to 10 Years among Iowa Elders Aged 71+ at Baseline

Fang Qian, PhD; Steven M. Levy, DDS, MPH; John J. Warren, DDS, MS; Jed S. Hand, DDS, MHSA

Abstract

Objectives: *There has been limited research on the long-term incidence of periodontal attachment loss (ALOSS) among adults aged 70 and older. This study investigated periodontal ALOSS incidence among elderly Iowans aged 71 and older over an 8- to 10-year period.* ***Methods:*** *Clinical examination data were obtained for a cohort of the Iowa 65+ Oral Health Study/Oral Lesion Detection Study in 1988 (baseline) and again in 1996-98. Periodontal measurements, including gingival recession and probing depth, were made by trained examiners at both exams for each retained tooth at buccal (B) and mesiobuccal (MB) sites. Paired-sample* t*-tests were used to determine whether significant differences existed in ALOSS between the two time points; two-sample* t*-tests were used to assess the significance between genders and age groups (81 to 85 versus 86 to 93 years at follow-up).* ***Results:*** *Of the 77 individuals examined at baseline, 35 provided longitudinal data for a total of 705 retained teeth. The data revealed that there were significant changes in ALOSS at B, MB, and combined sites during the observation period, but there were no significant differences in ALOSS by gender or age group. The mean differences in ALOSS between the two time periods were 0.57 mm (SD = 0.69, Max = 2.08) at B sites, and 0.43 mm (SD = 0.63, Max = 2.00) at MB sites. Over the period of 8 to 10 years, 2+ mm ALOSS incidence occurred at 17.6 percent of B sites and 13.9 percent of MB sites. Also, 68.6, 71.4, and 82.9 percent of the subjects experienced ALOSS incidence of 2+ mm at one or more B, MB, and B or MB sites, respectively, while 20.0, 25.7, and 31.4 percent of the subjects experienced ALOSS incidence of 4+ mm at one or more B, MB, and B or MB sites, respectively.* ***Conclusions:*** *Continuing ALOSS incidence was common in this elderly population. This study suggests that periodontal treatment continues to be important for the elderly.*

Key Words: cohort study, elders, periodontal, attachment loss, incidence, progression

Introduction

For most of the 20th century, the growth of the older population far outpaced that of the total population or the population under 65. Recent projections from the US Census Bureau show that the nation's population will grow 18 percent between 2000 and 2020 (1). However, the number of persons aged 65 and older is expected to grow 54 percent in this time period. At the same time, the percentage of older adults who have retained their natural teeth has increased steadily, resulting in improved oral function and quality of life (2). With the longer retention of teeth, older adults remain at risk for dental caries (i.e., tooth decay) and periodontal disease (3-9).

Until recently, there have been very few longitudinal follow-up studies that present data on periodontal attachment loss (ALOSS) in community-dwelling adults aged 65 years and older. Levy et al. (10) summarized studies that included periodontal probing and ALOSS assessments involving participants aged 79+ years, together with a description of study sample characteristics, methods characteristics, and characteristics of the oldest participants in each study. The Piedmont 65+ Dental Study (11) and the South Australian Dental Longitudinal Study (SADLS) for Older Adults Aged 60+ (7) were the only two studies that involved community-dwelling older populations over the age of 60 with an examination criteria comparable to the Iowa 65+ Oral Health Study (OHS) (12). The Piedmont 65+ Study of the Elderly was stratified by race and studied the functioning and the oral health status of older Blacks and Whites. The final sample of the Piedmont 65+ Dental Study consisted of 540 dentate subjects who had periodontal examinations at baseline and at least one more exam at any of four follow-up examinations at 18, 36, 60, and 84 months (5,6,13-16). The Piedmont study reported that 54 percent of the Piedmont cohort experienced ALOSS of 3+mm in 5 years. While previous ALOSS predicted

Send correspondence and reprint requests to Dr. Fang Qian, Department of Preventive and Community Dentistry, College of Dentistry, The University of Iowa, N-431 Dental Science Building, Iowa City, IA 52242-1010, USA. Tel.: 319-335-7202; Fax: 319-335-8895; e-mail: fang-qian@uiowa.edu. Fang Qian, John J. Warren, and Jed S. Hand are with the Department of Preventive and Community Dentistry, College of Dentistry, The University of Iowa. Steven M. Levy is with the Department of Preventive and Community Dentistry, College of Dentistry and the Department of Epidemiology, College of Public Health, The University of Iowa. An earlier version of this paper was presented at the annual meeting of the International/American Association for Dental Research, March 9 to 12, 2005, Baltimore, MD. This research was supported by NIH Grant #P50-DE10758. Manuscript received: 8/1/06; accepted for publication: 12/26/06.

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subsequent ALOSS at the person level, the majority of sites that experienced ALOSS had not previously displayed ALOSS (14,15). This is consistent with the concept that, although periodontitis risk is often defined at the person level, individual site characteristics determine site-level patterns of tissue destruction within the mouth. The etiologic modeling from five sequential examinations (baseline, 18-month, 36-month, 60-month, and 84-month) over a period of 7 years for incident periodontal ALOSS revealed that interventions aimed at infections, smoking, and preventive dental care utilization could be most useful in older adults (16).

The SADLS included subjects who resided in Adelaide and Mount Gambier, South Australia, as reported by Slade and Spencer (7) and Thomson et al. (17). The baseline ages (n = 801) were 60 or more, while the follow-up ages (n = 342) were 65 or more. Forty-three percent demonstrated ALOSS (defined as two or more sites with ALOSS of 3+mm) over the course of 5 years.

Hirotomi et al. (18) conducted a longitudinal study over a 2-year period from 1998 to 2000 on periodontal conditions in systemically healthy, community-dwelling elderly (n = 436) in Niigata, Japan, with subjects divided into two age groups (ages 72 and 82) at follow-up. They described the precise nature of periodontal conditions and disease progression in elderly individuals, and evaluated the intraoral factors relating to periodontal status and disease progression over the 2-year time period. They reported that 75.1 percent of the subjects and 19.0 percent of teeth experienced additional ALOSS of 3 mm or greater. It was significantly higher in males (79.8 percent) than in females (69.9 percent). In addition, the percentage of teeth with an ALOSS of 3 mm or greater was significantly higher in males (21.7 percent) than in females (15.9 percent).

These three studies have contributed valuable information to the understanding of the antecedents, yet few previous studies investigated the incidence of ALOSS at all three levels: person, tooth, and site. The purpose of this article was to present descriptive findings on the prevalence, extent, and severity of the incidence of periodontal ALOSS over a period of 8 to 10 years from 1988 to 1996-98 among elderly Iowans aged 71 years and older at baseline in the Iowa 65+ Rural Health Study (RHS) cohort.

Material and Methods

Sample. The sample studied was the surviving members of the Iowa 65+ RHS, a cohort recruited between December 1981 and July 1982, from a census of the entire population aged 65 and older in two predominantly White, rural Iowa counties (19). From the original enumeration obtained from the 1980 Census data, 3,673 (84 percent of the population aged 65+) community-dwelling senior citizens participated in a series of health interviews covering a wide range of health issues (19). In 1988, a stratified random sample of 340 dentate subjects then aged 71+ years was included from the RHS cohort to receive dental examinations, including periodontal attachment measurements, in the Iowa 65+ OHS (4). In 1996, the Oral Lesion Detection Study (OLDS) began, including oral examinations on survivors from the RHS study (9,10). From 1996 to 1998, 175 of those 340 subjects who had previously participated in the OHS study were identified. Of those 175 individuals, 77 subjects participated in the OLDS study, while 98 subjects were lost to the follow-up examinations, mainly because of illness and debilitation. Of these 77 individuals, only 35 were included in this analysis, because they had ALOSS assessments made on their retained teeth both in the 1988 OHS study and the 1996-98 follow-up OLDS study. As a result, the study sample in this longitudinal study includes 35 subjects, with a total of 749 teeth at baseline and 705 teeth at follow-up.

For this 8- to 10-year follow-up study, all procedures regarding the recruitment of subjects and their participation were approved by The University of Iowa Institutional Review Board. In addition, informed consent was obtained from each subject and/or his/her guardian.

Clinical Dental Examination Protocol and Periodontal Assessment. For both the OHS examinations in 1988 and follow-up examinations in 1996-98, the subjects were first contacted by mail and then by telephone to schedule oral exam appointments. Periodontal exams were conducted using a mouth mirror, color-coded periodontal probe, and headlamp, without radiographs or air-drying.

The 1988 examinations were conducted by five trained calibrated examiners, and the 1996-98 follow-up examinations were conducted by four different examiners who were trained and calibrated according to the same criteria used previously. Although none of the 1988 examiners conducted any of the follow-up examinations, four of the original examiners participated in planning, calibration, and coordination of the examinations. The interexaminer reliability for the 1988 examinations was assessed by the five original examiners who were calibrated prior to beginning the study, and then again part way through the study. For periodontal ALOSS (±1 mm), the pairwise interexaminer percentage agreement ranged from 89 to 94 percent, while the pairwise weighted kappa statistics ranged from 0.56 to 0.80. For the 1996-98 follow-up examinations, similar procedures were used by the four examiners, with the calibration and reliability assessments made prior to and approximately halfway through the study exam period. The pairwise percentage agreement across examiners on ALOSS (±1 mm) ranged from 80 to 91 percent, while the pairwise weighted kappa statistics ranged from 0.36 to 0.61.

For both examination periods, criteria for the periodontal examination protocol followed what was used in the national survey of adults by the National Institute of Dental Research in 1985-86 (20). The examination

was limited to the determination of gingival recession, probing pocket depth, and loss of attachment; calculus and bleeding assessments were not made. Gingival recession was measured from the cementoenamel junction to the free gingival margin. If the gingival margin was coronal to the cementoenamel junction, the distance from the cementoenamel junction to the margin was recorded as a negative measurement. Pocket depths were measured from the free gingival margin to the base of the sulcus or pocket. All measurements were made in millimeters with a probe periodontal probe at buccal (B) and mesiobuccal (MB) sites and were rounded down to the next lowest whole millimeter. ALOSS was defined by summing the amount of gingival recession from the cementoenamel junction, and the depth of the gingival sulcus or pocket, at both B and MB sites. Incidence of ALOSS for each site was computed by subtracting the baseline ALOSS from the follow-up ALOSS. At both time points, the extent of ALOSS was defined as the proportion of all sites examined that had ALOSS of 2 mm or more, and the severity was the average ALOSS (from a position 1 mm apical to the cementoenamel junction) in sites that had ALOSS of 2 mm or more.

Comparisons were made of the baseline characteristics in 1988 between the 35 subjects who participated in the 1996-98 follow-up exams and the 305 others examined in 1988, but not in 1996-98. The characteristics compared were sex, age, educational level (categories: eighth grade or less, some high school/graduate, attended college/graduate), marital status, alcohol use, tobacco use, diabetes, and hypertension.

Statistical Analysis. Analysis of the baseline periodontal status of 340 subjects who remained in the study and those who left the study was conducted, including a comparison of tooth status between the two groups. For those 35 subjects who remained in the follow-up study, their teeth at baseline were compared according to whether they were lost or retained at follow-up.

Incidence rates of ALOSS data from baseline (1988) to the subsequent follow-up (1996-98) were compared and analyzed at the site level, tooth level, and person level by gender and age. This paper presents the ALOSS incidence at B and MB sites for each tooth that was examined at both time points for those 35 subjects.

Descriptive statistics, paired-sample *t*-tests, and two-sample *t*-tests were performed to analyze the data using SAS v.9 (SAS Institute, Inc., Cary, NC), with the significance level set at $P < 0.05$. In some cases, these tests produced marginally significant results at $P \leq 0.10$.

Comparisons of baseline characteristics in 1988 between the 35 subjects who participated in the 1996-98 follow-up exams and the 305 others examined in 1988, but not in 1996-98, were conducted using chi-square, Fisher's exact, and nonparametric Wilcoxon rank-sum tests.

Results

Analysis of Baseline Data. A comparison was conducted on the baseline periodontal status of the 340 subjects, comparing those 35 subjects who participated in the 1996-98 follow-up study with those 305 subjects who did not. No statistically significant differences in selected demographic and risk factors were found between the two groups in terms of sex, educational level, marital status, history of alcohol use, history of tobacco use, diabetes, and hypertension. The only exception was that those who did not participate in the 1996-98 follow-up study were significantly older at baseline than those who participated.

People who did not participate in the follow-up had statistically significant fewer teeth than those who did (18.2 teeth per person for those lost versus 21.4 for those remaining, $P = 0.02$). Furthermore, people who left the study had significantly greater mean gingival recession, mean probing depth, and mean ALOSS at both B and MB sites, and at combined sites, compared to those who remained in the study ($P < 0.05$ in all instances). The average ALOSS was 2.56 mm (B), 2.60 mm (MB), 2.58 mm (combined sites) for those who left the study versus 1.66 mm (B), 1.66 mm (MB), 1.66 mm (combined sites) for those who remained in the study, respectively. There were significant differences in the percentage of subjects who had at least one site at baseline with 3+ mm gingival recession or 4+ mm ALOSS at MB sites between the two groups ($P = 0.02$ and $P = 0.04$, respectively). More subjects among those who left the study had at least one site at baseline with 3+ mm gingival recession (5.2 percent) or 4+ mm ALOSS (9.5 percent) at MB sites, compared with subjects who remained in the study (2.1 percent for 3+ mm gingival recession and 4.6 percent for 4+ mm ALOSS). On the other hand, no significant differences were found between the two groups at B sites and combined sites, including the 3+ mm probing depth at MB sites.

Analysis of baseline ALOSS level between teeth that were lost and teeth that were retained at follow-up for the subjects who remained in the study was also conducted at the tooth level (Table 1). During the 8- to 10-year duration of this study, of the 749 teeth that were present at baseline, 44 teeth (5.9 percent) were lost by 19 (54.3 percent) of the 35 subjects by 1996-98. There were significant differences in the average gingival recession level, average probing depth, and average ALOSS level at both B and MB sites and combined sites, between teeth lost and teeth remained at follow-up. There were significant differences between the two groups of teeth in the percentage of teeth that had 3+ mm gingival recession, 3+ mm probing depth, or 4+ mm ALOSS at both B and MB sites and combined sites. These results showed that the average gingival recession level, average probing depth, average ALOSS level, and average percentages of teeth that had 3+ mm gingival recession, 3+ mm probing depth,

Table 1
Comparison between the 705 Teeth Retained at Follow-Up and the 44 Teeth Lost after Baseline

	Retained teeth (n = 705)						Lost teeth (n = 44)					
	Buccal sites		Mesiobuccal sites		Combined buccal and mesiobuccal sites		Buccal sites		Mesiobuccal sites		Combined buccal and mesiobuccal sites	
Probing measure	Mean (SD)	Percentage at or beyond threshold	Mean (SD)	Percentage at or beyond threshold	Mean (SD)	Percentage at or beyond threshold	Mean (SD)	Percentage at or beyond threshold	Mean (SD)	Percentage at or beyond threshold	Mean (SD)	Percentage at or beyond threshold
Gingival recession of 3+mm*	0.39 (0.82)	3.74	0.14 (0.51)	0.72	0.27 (0.59)	2.23	1.35 (1.53)	20.93	0.60 (1.20)	9.30	0.98 (1.22)	15.12
Pocket depth of 3+mm†	1.12 (0.36)	0.43	1.44 (0.57)	3.02	1.28 (0.38)	1.73	1.47 (0.67)	9.30	1.84 (0.65)	13.95	1.65 (0.55)	11.63
Loss of attachment of 4+mm‡	1.51 (0.89)	5.04	1.58 (0.75)	2.30	1.55 (0.69)	3.67	2.81 (1.71)	25.58	2.44 (1.44)	11.63	2.63 (2.70)	18.60

* Significant at buccal (B) and mesiobuccal (MB) sites, and combined B and MB sites for gingival recession of 3+mm ($P < 0.05$, t-test).
† Significant at B and MB sites, and combined B and MB sites for pocket depth of 3+mm ($P < 0.05$, t-test).
‡ Significant at B and MB sites, and combined B and MB sites for attachment loss of 4+mm ($P < 0.05$, t-test).
SD, standard deviation.

or 4+mm ALOSS at both B and MB sites and combined sites were significantly greater for the teeth that were lost in the study than for those that were retained ($P < 0.05$) (Table 1).

Periodontal ALOSS data for the 35 subjects remaining in the study were also calculated. The mean (SD) gingival recession level, mean probing depth, and mean ALOSS level were 0.49 mm (0.59 mm), 1.10 mm (0.15 mm), and 1.59 mm (0.58 mm) at B sites; 0.21 mm (0.35 mm), 1.43 mm (0.29 mm), and 1.64 mm (0.46 mm) at MB sites; and 0.35 mm (0.46 mm), 1.27 mm (0.21 mm), and 1.61 mm (0.48 mm) at combined sites, respectively. The percentages of sites with 3+mm gingival recession, 3+mm probing depth, and 4+mm ALOSS were 4.99 percent (13.42 percent), 0.45 percent (1.58 percent), 6.28 percent (13.55 percent) at B sites; 0.92 percent (3.09 percent), 3.21 percent (7.24 percent), and 4.36 percent (10.92 percent) at MB sites; and 2.96 percent (8.02 percent), 1.83 percent (4.15 percent), and 5.32 percent (10.77 percent) at combined sites, respectively. There were significant differences between B and MB sites for the gingival recession and probing depth, and percentage of sites with 3+mm gingival recession and 3+mm probing depth ($P < 0.05$). However, no significant differences in ALOSS were found between B and MB sites.

Analysis of Incidence of ALOSS. Of the 35 subjects, 21 were females and 14 were males. The overall mean age of the subjects at follow-up in 1996-98 was 85.6 years, with 42.9 percent of them 86 years old or older. The mean age for females was 85.7 versus 85.5 years of age for males. The mean number of remaining teeth at follow-up among all subjects was 20.1 (range 2 to 29), the median number of teeth was 23, and 88.6 percent of the subjects had at least 10 teeth. The mean number of teeth for females in the older group was 4.7 teeth less than for younger females, and it was six to seven teeth less than the mean number of teeth for male subjects in

both age groups. There were no significant differences in the number of retained teeth between males and females or between age groups.

Table 2 presents comparisons of mean ALOSS between the two time periods at B, MB, and combined sites by age group and gender. Based on the paired-sample *t*-tests, there were statistically significant differences in ALOSS between the two time periods at B, MB, and combined sites for each gender, each age group, and for all subjects combined. However, no overall significant differences were found by gender or by age group with two-sample *t*-tests. Overall, the mean ALOSS observed at the 8- to 10-year follow-up exam was significantly greater than the mean ALOSS at baseline in 1988 in all cases.

Table 3 reports the distribution of subjects who had at least one site with ALOSS incidence of 2+mm. Note that 68.6 and 71.4 percent of the 35 subjects had the most severe ALOSS incidence of 2+mm at one or more B and MB sites, respectively, versus 82.9 percent with at least one B or MB site of such progression. ALOSS incidence of 4+mm at one or more B and MB sites was experienced by 20.0 and 25.7 percent of the subjects, respectively.

Table 4 describes the extent of ALOSS progression by gender, age group, and site. For the entire sample, the mean extent was 16.1 percent of combined B and MB sites per individual experiencing ALOSS progression of 2+mm. There were no significant differences in extent when compared by gender at B, MB, and combined sites for the younger group and for the whole sample (P = 0.29 to 0.58). For the older group, significant and marginally significant differences were observed by gender at B (P = 0.04) and combined (P = 0.06) sites, respectively. However, no significant difference was observed at MB sites for the older group. On the other hand, there were significant or marginally significant differences in extent overall when compared by age group at B, MB, and combined sites for male subjects (P= 0.01 to 0.04) and for the whole sample (P= 0.08 to 0.10), with significantly greater ALOSS progression of 2+mm in the older age group at all sites. For female subjects, however, there were no significant differences in extent when compared by age (P = 0.83 to 0.98).

Table 5 displays the severity of ALOSS progression (i.e., the mean change in ALOSS among those sites with a change of 2mm or more) by gender, age group, and site over the two time periods. Overall, the mean progression of ALOSS for the sites with 2+mm ALOSS progression was 2.57mm at B sites, 2.60mm at MB sites, and 2.59mm at combined sites, respectively. There were no significant differences in severity when compared by gender at B, MB, and combined sites for either age group or for the whole sample (P= 0.30 to 0.87). There were significant or marginally significant differences in severity when compared by age group at B, MB, and combined sites for male subjects (P = 0.03 to 0.04) and for the whole sample (P = 0.04 to 0.09), with the severity of ALOSS

Table 2
Comparison of Mean Attachment Loss (ALOSS) at Baseline and Follow-Up by Site, Age Group, and Gender

	Mean ALOSS (SD)								
	Buccal			Mesiobuccal			Combined		
	Baseline (1988)	Follow-up (1996-98)	*P*-value	Baseline (1988)	Follow-up (1996-98)	*P*-value	Baseline (1988)	Follow-up† (1996-98)	*P*-value
Age (years)									
81 to 85	1.57 (0.47)	1.95 (0.86)	<0.01*	1.52 (0.42)	1.88 (0.73)	<0.01*	1.55 (0.41)	1.92 (0.77)	<0.01*
86+	1.62 (0.71)	2.43 (0.90)	<0.01*	1.79 (0.48)	2.33 (0.70)	0.01*	1.71 (0.57)	2.38 (0.75)	<0.01*
Gender									
Female	1.66 (0.65)	2.10 (0.94)	0.01*	1.62 (0.49)	1.95 (0.71)	0.02*	1.64 (0.54)	2.03 (0.79)	0.01*
Male	1.49 (0.44)	2.24 (0.84)	0.01*	1.65 (0.42)	2.25 (0.77)	<0.01*	1.57 (0.41)	2.25 (0.79)	<0.01*
All subjects	1.59 (0.58)	2.16 (0.89)	<0.01*	1.64 (0.46)	2.07 (0.74)	<0.01*	1.62 (0.48)	2.12 (0.79)	<0.01*
Gender‡ *P*-value		0.22			0.22			0.20	
Age¶ *P*-value		0.07			0.38			0.16	

* Significant at $P < 0.05$ (*t*-test).
† Mean ALOSS for combined buccal and mesiobuccal sites.
‡ Comparison for changes in ALOSS between genders over two time periods.
¶ Comparison for changes in ALOSS between age groups over two time periods.
SD, standard deviation.

Table 3
Distribution of Subjects with at Least One Site with a Specified Level of the Most Severe Progression of Attachment Loss (ALOSS) according to Site at the Person Level

Level of most severe ALOSS progression (mm)	Buccal site *n* (%)	Mesiobuccal site *n* (%)	Buccal or mesiobuccal site* *n* (%)
2	6 (17.1)	10 (28.6)	7 (20.0)
3	11 (31.4)	6 (17.1)	11 (31.3)
4	2 (5.7)	4 (11.3)	3 (8.6)
5	2 (5.7)	1 (2.9)	2 (5.7)
6	1 (2.9)	2 (5.7)	3 (8.6)
7		1 (2.9)	1 (2.9)
8	1 (2.9)		1 (2.9)
9	1 (2.9)	1 (2.9)	1 (2.9)
Total	24 (68.6)	25 (71.4)	29 (82.9)

* The number of subjects with specified level of most severe progression of ALOSS from either the buccal and mesiobuccal sites.

Table 4
Extent of Incidence of Attachment Loss (ALOSS) by Gender, Age Group, and Site

	Extent: mean percentage of sites with an ALOSS progression of 2+mm (SE)			
	Male	Female	*P*-value for gender	Total subjects
Age group (at follow-up)				
81 to 85				
Buccal	7.92 (0.04)	16.44 (0.06)	0.29	13.03 (0.04)
Mesiobuccal	7.78 (0.04)	12.62 (0.04)	0.39	10.69 (0.03)
Combined‡	7.85 (0.04)	14.53 (0.04)	0.30	11.86 (0.03)
86+				
Buccal	37.85 (0.08)	14.86 (0.06)	0.04*	24.06 (0.06)
Mesiobuccal	27.14 (0.08)	13.91 (0.05)	0.16	19.20 (0.05)
Combined‡	32.50 (0.08)	14.38 (0.05)	0.06†	21.63 (0.05)
P-value for age group				
Buccal	0.01*	0.86		0.10†
Mesiobuccal	0.04*	0.83		0.10†
Combined‡	0.01*	0.98		0.08†
Total				
Buccal	20.75 (0.06)	15.76 (0.04)	0.47	17.76 (0.03)
Mesiobuccal	16.08 (0.05)	13.17 (0.03)	0.58	14.34 (0.03)
Combined‡	18.41 (0.05)	14.47 (0.03)	0.49	16.05 (0.03)

* Significant at $P < 0.05$ (*t*-test).
† Marginally significant at $P \leq 0.10$.
‡ Mean percentage of combined buccal and mesiobuccal sites with an ALOSS progression of 2+mm.

progression significantly greater in the older age group. For female subjects, however, there were no significant differences in severity when compared by age ($P = 0.28$ to 0.42) at B, MB, and combined sites.

Table 6 summarizes the number and percentage of retained teeth with incidence of ALOSS by measurement sites. Overall, 17.6 and 13.9 percent of teeth showed 2+mm of ALOSS progression at B and MB sites, respectively. Considered together, 24.0 percent of retained teeth experienced 2+mm of progression of ALOSS at either B or MB sites. The data also revealed that (not shown in Table 6) of the 124 B sites with 2+mm incidence of ALOSS, 56 sites (45.2 percent) showed both gingival recession and pocket depth progression, 58 (46.8 percent) experienced only gingival recession progression, and 10 (8.0 percent) experienced only pocket progression. Of the 98 MB sites with 2+mm incidence of ALOSS, 41 sites (41.8 percent) showed both gingival recession and pocket depth progression, 21 (21.4 percent) experienced only gingival recession progression, and 36 (36.8 percent) experienced only pocket depth progression. Of the total sum of ALOSS incidence for the 35 subjects in the study, 73.4 percent was from gingival recession progression and 26.6 percent from pocket depth progression at B sites; at MB sites, 45.4 percent overall was from

Table 5
Severity of Incidence of Attachment Loss (ALOSS) by Gender, Age Group, and Site with 2+mm ALOSS

	Severity: mean ALOSS progression at sites with 2+mm (SE)			
	Male	Female	*P*-value for gender	Total Subjects
Age group (at follow-up)				
81 to 85				
Buccal	2.21 (0.12)	2.31 (0.09)	0.53	2.28 (0.07)
Mesiobuccal	2.13 (0.13)	2.51 (0.24)	0.32	2.38 (0.16)
Combined‡	2.17 (0.09)	2.42 (0.13)	0.30	2.33 (0.09)
86+				
Buccal	2.77 (0.16)	2.97 (0.55)	0.53	2.87 (0.27)
Mesiobuccal	2.80 (0.20)	2.95 (0.54)	0.66	2.88 (0.29)
Combined‡	2.78 (0.12)	2.96 (0.36)	0.76	2.87 (0.20)
P-value for age group				
Buccal	0.04*	0.28		0.04*
Mesiobuccal	0.03*	0.42		0.09†
Combined‡	0.03*	0.38		0.08†
Total				
Buccal	2.55 (0.14)	2.59 (0.25)	0.87	2.57 (0.15)
Mesiobuccal	2.47 (0.16)	2.68 (0.25)	0.52	2.60 (0.16)
Combined‡	2.51 (0.10)	2.64 (0.17)	0.69	2.59 (0.11)

* Significant at $P < 0.05$ (*t*-test).
† Marginally significant at $P \leq 0.10$.
‡ Mean ALOSS at combined buccal and mesiobuccal sites with an ALOSS progression of 2+mm.

Table 6
Distribution of Number and Percentage of Retained Teeth with Incidence of Attachment Loss (ALOSS) according to Measurement Site

Incidence of ALOSS from 1988 to 1996-98 (mm)	Buccal site		Mesiobuccal site		At buccal or mesiobuccal site*	
	n	%	*n*	%	*n*	%
Progressed						
9	1	0.14	1	0.14	1	0.14
8	1	0.14	0	0.00	1	0.14
7	0	0.00	1	0.14		
6	1	0.14	2	0.28	3	0.43
5	2	0.28	2	0.28	3	0.43
4	6	0.85	10	1.42	11	1.56
3	37	5.25	18	2.55	45	6.38
2	76	10.78	64	9.08	105	14.89
1	186	26.38	221	31.35	269	38.16
No change						
0	312	44.26	260	36.88	235	33.33
Improved						
−1	76	10.78	107	15.18	30	4.26
−2	7	0.99	17	2.41	2	0.28
−3			2	0.28		
Total	705	100	705	100	705	100

* This considers both buccal and mesiobuccal site on each tooth, and the greatest incidence of ALOSS from 1988 to 1996-98 at the buccal and mesiobuccal site per tooth is scored here.

gingival recession progression and 54.6 percent from pocket depth progression. For combined sites, 60.9 percent was from gingival recession progression and 39.1 percent from pocket depth progression.

Table 7 shows the distribution of ALOSS progression of 2 mm or more by tooth type and surface. The highest rate of ALOSS progression of 2+mm occurred at B sites of maxillary molars (28.9 percent), followed by MB sites (24.4 percent), B sites of maxillary premolars (20.2 percent), and B and MB sites of mandibular molars (23.8 and 18.8 percent, respectively). In the maxillary arch, incisors experienced the lowest rate of the progression of ALOSS of 2+mm. In the mandibular arch, canines had the lowest rate of incidence of ALOSS of 2+mm at B sites, while premolars had the lowest rate of incidence of ALOSS of 2+mm at MB and combined sites.

Discussion

The results of this study showed that periodontal disease progression, as measured by incidence of ALOSS, occurred over the 8 to 10 study years among this elderly cohort, but it was not significantly related to either the gender or the age of the subject (Table 2). The findings from the distribution of incidence of ALOSS of 2+mm indicated that the ALOSS was primarily in the form of changes in gingival recession (60.9 percent), not as increased pocket depth

(39.1 percent), at combined B and MB sites. If only B sites were considered, 73.4 percent of the observed 2+mm incidence of ALOSS was contributed by progression in gingival regression, while the equivalent estimate for MB sites was 45.4 percent, or 60.9 percent for combined sites. Similar findings have been reported by the Piedmont (4,5,10,12-15) and the SADLS longitudinal studies (17). The findings from both studies revealed that, on average, the bulk of ALOSS was observed as increases in gingival regression rather than probing depth. Goodson (21) also reported that periodontitis in older adults was typically not deep pockets, but ALOSS was extremely common. Our study supports these conclusions.

This study confirms that the periodontal ALOSS is prevalent among the elderly study group, because 68.6, 71.4, and 82.9 percent of the subjects had experienced ALOSS incidence of 2+mm at one or more B, MB, and combined (B or MB) sites, respectively, while 51.4, 42.9, and 62.9 percent experienced ALOSS incidence of 3+mm at one or more B, MB, and combined (B or MB) sites, respectively (Table 3). Comparing our findings with other longitudinal studies in elderly populations, incidence levels of 3+mm at combined (B or MB) sites were similar to those observed by Thomson et al. (58.6 percent) (17), lower than those observed by Hirotomi et al. (75.1 percent) (18), and higher than those observed for the 18-month incidence for Whites in the Piedmont study (46.0 percent) (6). We note that the higher incidence observed in the Japanese study (18) might have resulted from different characteristics of the population studied and from the fact that six sites per tooth were examined, while only two sites per tooth were examined in our study and the Piedmont study. On the other hand, the lower incidence observed for Whites in the Piedmont study might have resulted from their younger ages, as well as a much shorter longitudinal time period in comparison to this study. Given the variability in the study designs and differences in populations, the overall incidence rate in this study does appear to be similar to that from other studies, such as in the South Australians study (17).

The extent of incidence of ALOSS among the older dentate adults examined in this study was not significantly related to gender, except for the older age group at B and combined sites. Female subjects 86+ years old at follow-up in 1996-98 tended to have a lower percentage (~14 percent) of sites with ALOSS progression of 2+mm than did males (27 to 38 percent) of the same age group. When only male subjects or all subjects were considered, the extent and severity of ALOSS progression appeared to be significantly or marginally significantly associated with age. For females, both an extent and severity of ALOSS of 2+mm were not significantly related to age.

The results of this study were somewhat consistent with results concerning gender and age from 18-month incidence of ALOSS among Whites in the Piedmont study (6). In that study, the overall extent and severity of ALOSS were not significantly different by gender or age, but males tended to show more extensive ALOSS. This study revealed similar results that extent and severity for male subjects showed significant correlations with age, but not for female subjects or all subjects. In particular, this study showed that male subjects of the older age group had a higher extent of ALOSS than the same age group of the females.

The strengths of this study were the study design, age of subjects, length of study period, and three levels of analysis (site, tooth, and person). The sample sizes for the site and tooth levels are adequate (n = 1,408 and n = 704, respectively). While the sample size for the analysis at the person level appears relatively small (n = 35), we conducted a comparison analysis between subjects who participated in the follow-up exams and those who did not. We observed that those subjects who left the study had fewer and less healthy teeth. For the 35 subjects who participated in the follow-up study, we analyzed their remaining and lost teeth during the 8- to 10-year study period. Remaining teeth were significantly healthier at baseline than lost teeth. These results can be regarded as a quantified description of the healthy survivor effect for the older people and their retained teeth. In fact, the average number of teeth lost at follow-up was 2.3 teeth, with 54.3 percent of the subjects losing one or more teeth. This was similar to that observed by Thomson et al. (17): 2.9 teeth, with 52.4 percent of subjects

Table 7
Distribution of Sites with an Attachment Loss (ALOSS) Progression of 2+mm according to Tooth Type and Surface

Tooth type and arch	n	Percentage (number) of sites with ALOSS progression of 2+mm (from 1988 to 1996-98)		
		Buccal site	Mesiobuccal site	Both sites*
Maxillary				
Molar	90	28.9 (26)	24.4 (22)	16.7 (15)
Premolar	84	20.2 (17)	17.9 (15)	7.1 (6)
Canine	55	14.5 (8)	10.9 (6)	3.6 (2)
Incisor	101	6.9 (7)	7.9 (8)	2.0 (2)
Mandibular				
Molar	80	23.8 (19)	18.8 (15)	6.3 (5)
Premolar	107	18.7 (20)	9.3 (10)	3.7 (4)
Canine	67	13.4 (9)	11.9 (8)	9.0 (6)
Incisor	121	14.9 (18)	11.6 (14)	10.7 (13)
Overall	705	17.6 (124)	13.9 (98)	7.5 (53)

* ALOSS progression of 2+mm at both buccal and mesiobuccal sites for a given tooth.

who lost one or more teeth. This quantified healthy survivor effect indicated that the true lifelong periodontal disease experience might be greater than the results of the present study.

Moreover, although this study was rather unique in assessing periodontal ALOSS in the elderly, there were limitations. These included a relatively small sample, bias resulting from the unavoidable loss of subjects at follow-up, different examiners at the two periods, and inevitable measurement errors, which may have affected the results. In addition, because no microbiological measures were collected in this study, comparisons on this risk factor could not be conducted.

While this study group is unique and interesting, in order to address representativeness, a comparison of selected demographic characteristics between those 35 study subjects and the 3,673 subjects who comprised 84 percent of the population of aged 65+ community-dwelling senior citizens who participated in the Iowa 65+ RHS baseline were conducted. No significant differences were found between the two groups in terms of sex, income level, educational level, and marital status. The only exception was that those who did not participate in the 1996-98 follow-up study were significantly older than those who participated.

In summary, the elderly adults in this study comprised a sample of the oldest individuals in the studies on the incidence of ALOSS for noninstitutionalized seniors, being aged 71+ at baseline and 79+ at follow-up. Findings from this study indicate that periodontal ALOSS continues throughout life (62.9 percent with 3+mm of progression at B or MB sites, Table 3) at a rate generally similar to younger cohorts in other studies (14,17). Future longitudinal population-based studies with larger, more representative samples are necessary to investigate the influence of time, systemic and oral health, nutrition, and sociodemographic factors on periodontal disease. As the size of the older cohorts in the national population continue to increase, considering the aging baby boom generation, it is important to better understand the role of periodontal disease in aging in order to provide adequate preventive and treatment services to all adults in the nation.

Conclusions

Destructive periodontal disease has been consistently associated with aging, so that many came to see it as an inevitable consequence of growing older. Early studies found a close association between age, periodontal disease, and tooth loss, but several recent investigations have shown that, although some gingival recession, pocket depth, and ALOSS are expected with age, age alone in healthy adults does not lead to a critical loss of periodontal support. The findings from this 8- to 10-year longitudinal study of very elderly subjects provide evidence that continued ALOSS incidence was prevalent, but not severe. Therefore, adequate preventive and periodontal treatment services continue to be important for the elderly.

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