

Clinical course of chronic periodontitis

III. Patterns, variations and risks of attachment loss

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Abstract

Aim: The purpose of this study was to assess the rate of attachment loss during various stages of adult life in a well-maintained middle-class population.

Material and Methods: The data originated from a 26-year longitudinal study of Norwegian males who had received regular and adequate dental care and practised daily oral home care. The initial examination in 1969 included 565 individuals aged between 16 and 34 years. Subsequent examinations took place in 1971, 1973, 1975, 1981, 1988 and 1995. Thus, the study covers the age range of 16–59 years. The rate of the annual attachment loss was calculated as the difference between the individual mean attachment loss between two examinations divided by the years between examinations. The mean annualized relative risk of attachment loss was calculated as the frequency distribution of sites with initial periodontal attachment loss (loss of attachment at the first time of occurrence ≥ 2 mm) and healthy sites (loss of attachment always < 2 mm). For comparison of significant changes in annual attachment loss rates between the age groups and mean annualized relative risks of attachment loss as they proceeded through adult life, the Wilcoxon Mann–Whitney *U*-test was used.

Results: The mean overall individual attachment loss during 44 years (between 16 and 59 years) totaled 2.44 mm (range 0.14–2.44 mm), averaging an annual mean rate of 0.05 mm/year. The highest annual rate of attachment loss occurred before 35 years of age (0.08–0.1 mm/year), after which the mean annual rate decreased to about 0.04–0.06 mm/year for the next three decades of life leading to 60 years. The mean annualized relative risk of initial attachment loss increased significantly from adolescence (1.2%) to the maximum at 30–34 years of age (6.9%). After the age of 34 years, the risk of initial attachment loss decreased again, but after the age of 40 years, another continuous increase was observed.

Conclusions: Over a 26-year period, 25% of the subjects went through adult life with healthy and stable periodontal conditions. The remaining 75% developed slight to moderately progressing periodontal disease with progression rates varying between 0.02 and 0.1 mm/year with a cumulative mean of loss of attachment of 2.44 mm as they approached 60 years of age. The annual mean rate and the mean annualized risk of initial attachment loss were highest between 16 and 34 years of age. Only 20% of the sites continued to lose further attachment during the remainder of the observation period, and less than 1% of the sites showed substantial loss of attachment (> 4 mm).

Key words: periodontal attachment loss; initial loss of attachment; age dependent; relative risk; longitudinal study

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The overall objective of these longitudinal investigations, which started in Norway (1969) and Sri Lanka (1970), was to attempt to assess, through repeated examinations, the essential pathogenic features and stages of chronic period-

ontitis in two population groups considered to represent the extremes in disease prevalence, incidence and severity.

In previous articles on the initiation and progression of chronic adult periodontitis (Løe et al. 1978b, 1992, Heitz-

Mayfield et al. 2003), it has been shown that in a randomized group of middle-class men in Norway, 50% of the 16-year-olds exhibited initial loss of attachment (ILA) on the buccal surfaces of molars and premolars of both jaws.

These lesions progressed at a relatively even and slow rate (0.1 mm/year) during the twenties and thirties. At 30 years of age, the mean individual cumulative loss of attachment was less than 1 mm. As the subjects approached 40 years of age, the mean individual loss was slightly above 1.5 mm (Løe et al. 1978b).

Comparisons between the development and the rate of progression of these periodontal lesions with those of Sri Lankan tea laborers (Løe et al. 1978b, 1986) revealed that the mean rates of progress during the same age periods were three to four times greater, and that large differences in the rate of periodontal destruction also occurred within the Sri Lankan cohort (Løe et al. 1986).

The purpose of the present study was to examine further the pattern and rates of attachment loss, the variations in the starts and stops, and risks for converting healthy periodontal sites to chronic periodontitis in a cohort of men between 16 and 59 years of age who had experienced regular and adequate professional and personal oral health care throughout their lives.

Material and Methods

Sources of data

The data upon which the analyses were made originated from a 26-year longitudinal study of a group of Norwegian middle-class males who, during their entire life, had received state-of-the-art dental care and practised oral home care on a daily basis. The initial examination in 1969 included 565 individuals aged between 16 and 34 years. Subsequent examinations took place in 1971, 1973, 1975, 1981, 1988 and 1995. At the last examination, 223 individuals partici-

pated. Thus, the study covers the age range of 16–59 years. As in most longitudinal studies of this size and length, a certain number of the population dropped out or did not participate in all examinations (Table 1).

Three subsets were used: (1) individuals who participated in all seven surveys; (2) individuals examined at least in the first and last surveys; and (3) all valid observations. For this study, there was no significant difference between all three groups and all valid observations were, therefore, used for all the calculations and evaluations.

For this analysis, the subjects were divided into nine age groups (<20, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59 years) (Table 1).

Clinical parameters

At each appointment the participants answered questions regarding personal general health and dental care. The oral cavity at large was inspected and missing teeth were recorded at each appointment. The clinical examination of the periodontal tissues and adjacent areas of the dentition included measurements and scoring of various indices, such as the plaque index, gingival index, retention index and loss of attachment (Løe et al. 1978a) on all the mesial and buccal surfaces of the teeth except third molars. From 1981 (Survey 5) onwards, the clinical examinations also included the distal and lingual surfaces. In 1973 (Survey 3) and in subsequent surveys, gingival recession was also recorded.

Loss of attachment was measured using a blunt probe with a point diameter of 0.6 mm and graded at 1, 2, 3, 4, 5, 7, 9 and 11 mm. The same probes were used at all examinations.

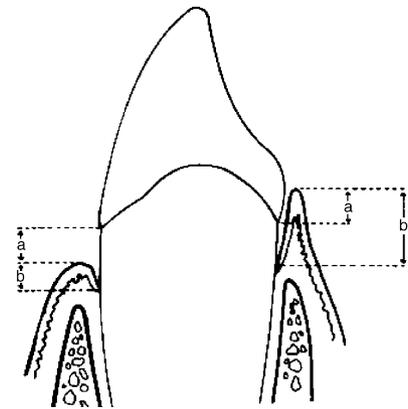


Fig. 1. Units of measurement when loss of attachment is followed by pocket formation (right) and gingival recession (left) (Løe et al. 1978b).

Loss of attachment is the distance from the cemento-enamel junction (CEJ) to the bottom of the clinical pocket. In cases where the marginal gingiva has been subject to recession (Fig. 1, left) and the CEJ is exposed, the loss of attachment equals the sum of pocket depth and the distance from the gingival margin to the CEJ: $a+b=LA$ (Løe et al. 1978b).

The mean rate of attachment loss was calculated as the difference between the individual mean attachment loss of all sites of a participant between two examinations divided by the years between examinations.

The level for "sites with periodontal attachment loss" was set at 2 mm or more. Periodontal attachment loss may be presented as only pocket formation (pocket depth ≥ 2 mm), as only recession (recession > 0 , pocket depth < 2 mm) or as combinations of the two. This analysis consisted of sites with *initial loss of attachment* (first occurrence of 2 mm or more of period-

Table 1. Number of patients examined at each age group during 26 years

Age group (years)	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Survey 7	Patients per age group
<20	143	65	0	0	0	0	0	208
20–24	224	149	117	51	0	0	0	541
25–29	161	116	102	88	45	0	0	512
30–34	36	45	65	89	92	0	0	327
35–39	1	6	8	16	74	77	0	182
40–44	0	0	0	1	17	82	30	130
45–49	0	0	0	0	0	42	104	146
50–54	0	0	0	0	0	0	66	66
55–59	0	0	0	0	0	1	23	24
patients per survey	565	381	292	245	228	202	223	2136

ontal attachment loss) and sites in which loss of attachment had been recorded in a previous examination.

“Reversed sites” were sites that already had a recorded loss of attachment at a previous survey, and had less than 2 mm of attachment loss at one of the following surveys. “Healthy sites” were sites that never passed the threshold of 2 mm attachment loss.

The mean annualized relative risk of attachment loss was calculated by the following formula:

$$\frac{\sum \text{IniLoA}}{(\sum \text{Healthy} + \sum \text{IniLoA}) * \Delta \text{ years}} = \text{Mean annualized relative risk of initial loss of attachment}$$

The mean annualized relative risk of a patient at a specific age was calculated by the sum of all sites with ILA ($\sum \text{IniLoA}$) divided by the sum of all healthy sites and the sites with ILA ($\sum \text{Healthy} + \sum \text{IniLoA}$). Finally, the sum was divided by the time between two surveys (Δ years). The results will indicate the relative risk for a tooth site to shift from a healthy state (loss of attachment <2 mm) to a site with periodontal attachment loss (≥ 2 mm).

Based on the results of Glavind & Løe (1967) reporting a measurement error of <0.5 mm for individual sites in measuring pocket depth and loss of attachment, a threshold of 1 mm was set as the criterion for a site to lose further periodontal attachment over time after initial attachment loss. Sites with attachment loss at baseline were not considered for this part of the evaluation. For these calculations, the last measured value and the time of ILA were compared:

- ILA = last measured loss of attachment value (*non-progressing (stable) sites*).
- ILA < last measured loss of attachment value (*progressed sites*).
- ILA > last measured loss of attachment value (*reversed sites*).

Sites with loss of attachment of ≥ 2 mm at baseline or with ILA at Survey 7 (1995) were not considered for this part of the evaluation.

Data analysis

The Statistical Analysis System Package (SAS Institute Inc., Cary, NC, USA) was used in order to calculate frequen-

cies, mean values, standard deviations and standard errors. For the comparison of the significant changes in the rates of attachment loss between two age groups longitudinally, the Wilcoxon Mann-Whitney *U*-test (Proc NPAR1Way, SAS/STAT[®] Software, Copyright © 2000 by SAS Institute Inc., Cary, NC, USA. All rights reserved) was used.

The level of significance was set at $\alpha = 0.05$.

Results

Patterns of loss of attachment

The mean individual cumulative attachment loss ranged from 0.14 mm at 16–19 years of age to 2.44 mm in the 55–59-year-old subjects (Table 2, Fig. 2). At 20–21 years of age, 92% of the sites had never been affected by loss of attachment (≥ 2 mm), 8% of the sites were affected by loss of attachment (≥ 2 mm) and 0.33% of the sites having exhibited ≥ 2 mm of attachment loss at a previous examination, had reversed below the 2 mm threshold (Table 3, Fig. 3). During the subsequent 10, 20 and 30 years, the proportion of healthy sites continued to decrease (72%, 50% and 31%, respectively), and that of the sites with attachment loss increased (24%, 46% and 59%, respectively); the proportion of sites that reversed also increased (3%, 4% and 11%, respectively). As the individuals approached 60 years, the percentage of healthy sites

dropped to 24%; sites with loss of attachment had increased to 69% and 7% of the sites had reversed.

Fig. 4 depicts the frequency distribution of the sites with no attachment loss, ILA, previously recorded loss of attachment of ≥ 2 mm and reversed sites for *incisors and canines*. At the age of 20–21 years, over 95% of the sites of incisors and canines had *no* loss of attachment. Only very few sites (less than 1%) showed previously recorded loss of periodontal attachment. As the years went by, the proportion of sites with no loss (<2 mm) decreased, but by the age of 55–57 years, 30% of all available sites of anterior teeth still had no attachment loss. The proportion of sites with previously recorded loss of attachment, however, increased from 0.7% at the age of 20–21 years to almost 40% at the age of 55–57 years.

Table 2. Mean loss of attachment between 16 and 59 years of age

Age group (years)	N	Mean	SE
<20	208	0.142	0.010
20–24	541	0.584	0.016
25–29	512	0.797	0.021
30–34	327	1.108	0.028
35–39	182	1.366	0.042
40–44	130	1.570	0.049
45–49	145	1.827	0.059
50–54	66	1.983	0.094
55–59	23	2.442	0.235

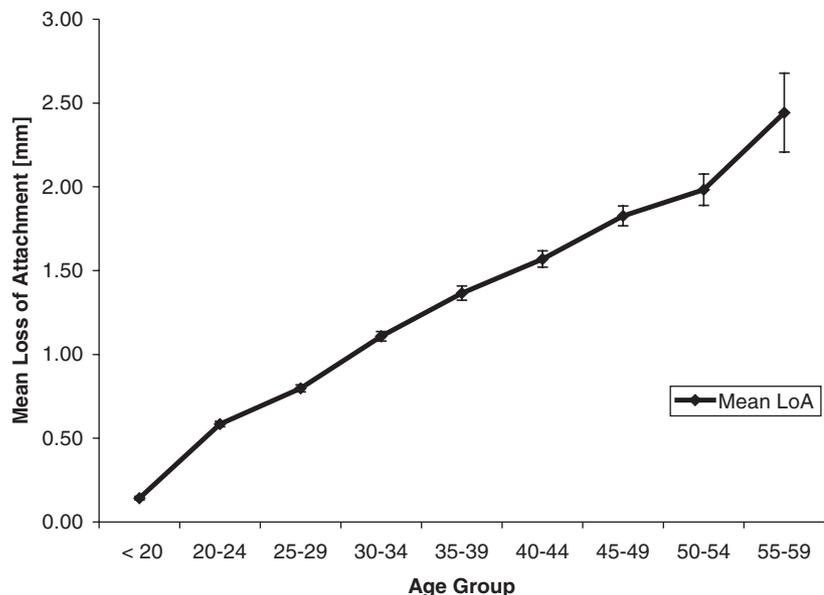


Fig. 2. Mean loss of attachment by age groups.

Table 3. Frequency of sites with no loss of attachment (LoA), LoA and reversed sites at different age levels

Age group (years)	Sites with no LoA		LoA		Reversed sites	
	N	%	N	%	N	%
20–21	3573	91.59	315	8.08	13	0.33
30–31	5371	72.37	1799	24.24	252	3.40
40–41	1879	49.79	1747	46.29	148	3.92
50–51	949	30.58	1822	58.72	332	10.70
55–57	448	23.60	1294	69.09	137	7.31

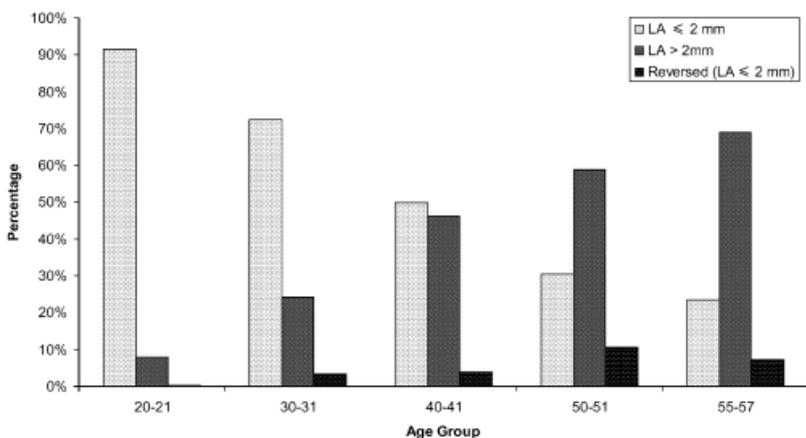


Fig. 3. Frequency of sites with no loss of attachment, loss of attachment and reversed sites by age groups.

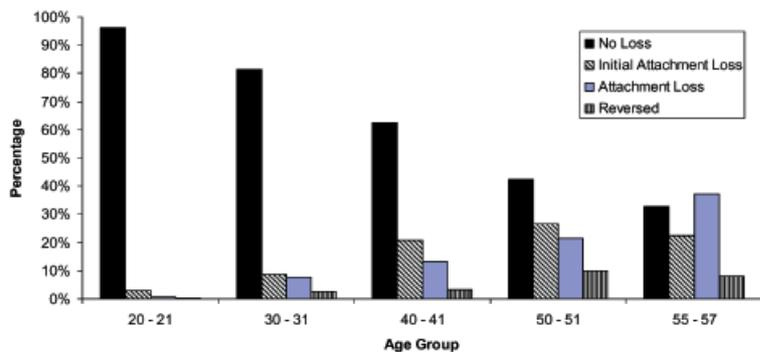


Fig. 4. Frequencies of sites with no loss, initial loss, loss of attachment and reversed sites at different age levels: for incisors and canines.

At the age of 20–21 years, already more than 3% of sites of *premolars and molars* showed previously recorded loss of attachment (Fig. 5). This proportion increased significantly more than that of the incisors and canines during the following years, so that by 55–57 years of age, 55% of the premolars and molars exhibited loss of attachment. At this stage, less than 15% of the sites had no attachment loss.

Table 4 yields the frequency distribution of sites that expressed ILA by age groups. At baseline in 1969, 61,532 sites out of 63,280 sites possible ($565 \times 28 \times 4$) were present. Four hundred and thirty-seven teeth were already missing at that observation period (Schätzle et al. 2003). Thirty-two percent (19,525) of the sites at baseline exhibited ILA. Up to the age of 24 years, there were only very few sites

($\leq 5\%$) that expressed initial attachment loss. During the following 20 years (25–44 years), the number of sites with initial attachment loss was highest and yielded percentages between 10% and 20%. In individuals 50 years and older, less than 10% of all the sites expressing initial attachment loss during the entire observation period (26 years) showed continued loss of attachment.

Table 5 shows the frequency distribution of sites with loss at attachment with different recorded characteristics: reversed sites, stable sites and progressed sites. In the 26-year observation period, 22,522 sites (19,525 sites with ILA and 2997 sites with attachment loss at baseline) expressed some further attachment loss over the years. Two thousand nine hundred and ninety-seven of the affected sites had already expressed some loss of attachment and were therefore not depicted in Table 5. In the last survey, 6135 sites exhibited ILA and, therefore, no statement about their future progression could be made. Less than 25% of all sites progressed to lose periodontal attachment; about 50% of all sites expressing ILA within the first six surveys remained stable; 30% did not exhibit any loss of attachment at the last follow-up survey.

Table 6 shows the frequency distribution of further attachment loss of progressed sites after ILA was recorded. Almost 90% of these sites lost only minor further attachment (≤ 2 mm). About 10% of the progressed sites lost 3–4 mm in the period from diagnosis to the time point at which the subjects were no longer followed. Only very few sites (50 of 13,390) that expressed ILA progressed substantially.

Table 7 shows the percentage of persons and tooth surfaces with attachment loss presented as *pocket formation only* (pocket depth ≥ 2 mm, recession = 0 mm) and the mean pocket depths at affected sites. Already at 20–24 years of age, 84% of the men exhibited one or more pockets 2 mm or deeper, and 6% of the interproximal and 13% of the buccal sites were affected. The mean pocket depth was 0.71 mm. By 35 years of age, all participants exhibited one or more sites with pockets of depth 2 mm or more. Most of the pockets were found on the interproximal and lingual aspects of the teeth. The highest values for pocket depth were located interproximally.

The percentage of buccal/lingual sites with pocket depths 2 mm and beyond

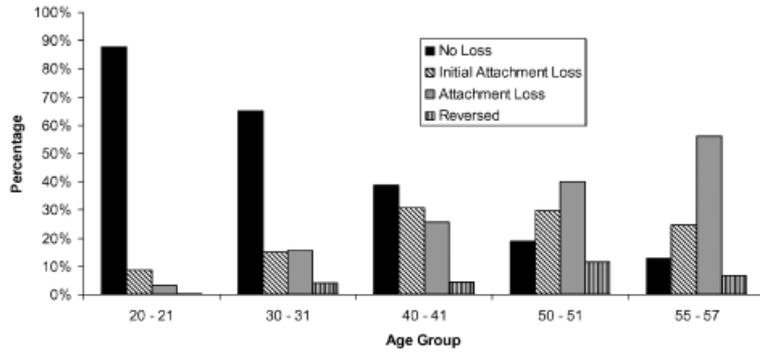


Fig. 5. Frequencies of sites with no loss, initial loss, loss of attachment and reversed sites at different age levels: for premolars and molars.

Table 4. Frequency of occurrence of sites with initial loss of attachment (IniLoA) by age groups

Age group (years)	Number of sites with IniLoA	%
<20	76	0.39
20-24	989	5.07
25-29	1976	10.12
30-34	2799	14.34
35-39	3613	18.50
40-44	3692	18.91
45-49	4138	21.19
50-54	1759	9.01
55-59	483	2.47
total	19,525 (31.73%)	100

61,532 sites present at baseline in 1969.

Table 5. Frequency distribution of sites with loss of attachment: stable sites, progressed sites, reversed sites

	N	%
reversed sites	3991	29.81
stable sites	6462	48.26
progressed sites	2937	21.93
total	13,390	100.00

Sites not considered for this evaluation:
2997 sites with initial loss of attachment at baseline (1969);
6135 sites with initial loss of attachment at Survey 7 (1995).

showed a relative decrease with age (from 62% at 20-24 years to 45% at 25-29 years), but after 35 years and through the following 25 years, the proportion of loss of attachment expressed as pocketing remained stable (60% interproximal, 40% buccal/lingual) (Table 8).

Table 6. Frequency distribution of further attachment loss of progressed sites after initial loss of attachment was recorded

LoA (mm)	N	%
1-2	2603	88.63
3-4	284	9.67
5-6	33	0.01
≥7	17	0.01
total	2937	100.00

LoA: loss of attachment.

Generally, only gingival recession (without pocket depth ≥2 mm) had occurred in 99% of the buccal and lingual sites before the age of 25 years (Table 9). Thereafter, recession was present in more than 90% of these sites. There was a small proportion of gingival recession in interproximal sites (0.23% at 20-24 years), which increased to 10% at 55-59 years of age.

Fig. 6 and Table 10 illustrate the frequency of sites with at least 2 mm attachment loss with pocket formation, gingival recession and combinations of the two. In the youngest group, 60% of the sites with periodontal attachment loss presented with pocket formation with or without gingival recession. With increasing age, attachment loss in terms of pocketing only and in combination with pocket formation and gingival recession increased to 75% in the 55-59-year-old subjects. After the age of 30 years, the total proportion of sites with gingival recession only remained stable in 20-25% of the sites. At the same time, there was a slight relative decrease in the proportions of pocket formation (from 76% to 61%) and a modest increase in the proportion of pocket-recession combinations (from 0% to 15%).

Table 7. Percent of persons and tooth surfaces with pocket formation (pocket depth (PD) ≥ 2 mm) and mean PD (in mm)

Persons	Age (years)	% with pockets	Mean PD	Mesial		Buccal		Distal		Lingual	
				Mean PD over all surfaces	% with PD affected sites	Mean PD over all surfaces	% with PD affected sites	Mean PD over all surfaces	% with PD affected sites	Mean PD over all surfaces	% with PD affected sites
<20		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20-24		83.93	0.71	0.62	13.21	2.02	2.02	NA	NA	NA	NA
25-29		93.19	0.87	0.78	21.04	2.03	2.03	NA	NA	NA	NA
30-34		98.78	1.05	0.99	28.73	2.04	2.04	23.64	2.18	0.86	9.44
35-39		100.00	1.22	1.17	43.71	2.40	2.40	26.92	2.30	0.92	13.88
40-44		100.00	1.40	1.44	54.77	2.16	2.16	35.15	2.27	1.05	24.15
45-49		100.00	1.59	1.82	55.71	2.23	2.23	44.08	2.36	1.25	39.22
50-54		100.00	1.69	2.01	54.66	2.28	2.28	46.11	2.42	1.58	60.03
55-59		100.00	1.93	2.30	65.86	2.38	2.38	46.24	2.40	1.77	71.12
								57.89	2.76	1.92	75.58

NA: not applicable.

Table 8. Frequency of occurrence of pocket formation in interproximal and buccal/lingual sites by age group

Age group (years)	Only pocket formation (LoA \geq 2 mm)			
	Buccal and lingual		Interproximal	
	N	%	N	%
< 20	NA	NA	NA	NA
20–24	416	62.37	251	37.63
25–29	977	49.32	1004	50.68
30–34	1549	44.78	1910	55.22
35–39	1901	41.94	2632	58.06
40–44	2028	42.89	2700	57.11
45–49	2361	41.31	3354	58.69
50–54	1017	39.93	1530	60.07
55–59	359	39.58	548	60.42

NA: not applicable.

LoA: loss of attachment.

Table 9. Frequency of occurrence of gingival recession in interproximal and buccal/lingual sites by age group

Age group (years)	Only gingival recession (pocket depth < 2 mm)			
	Buccal and lingual		Interproximal	
	N	%	N	%
< 20	NA	NA	NA	NA
20–24	439	99.77	1	0.23
25–29	913	98.60	13	1.40
30–34	1070	98.08	21	1.92
35–39	1142	93.30	82	6.70
40–44	1088	92.83	84	7.17
45–49	1556	91.96	136	8.04
50–54	784	92.34	65	7.66
55–59	323	90.22	35	9.78

NA: not applicable.

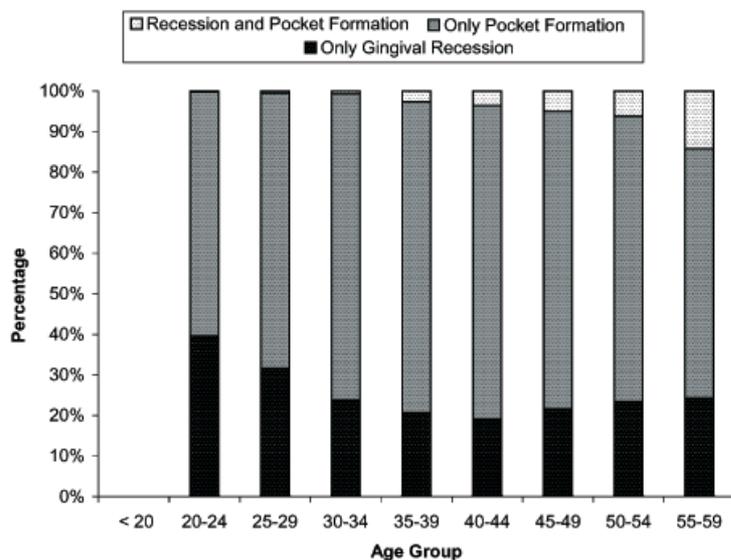


Fig. 6. Frequency of occurrence of gingival recession, pocket formation and the combination thereof contributing to loss of attachment in various age groups.

Progression of attachment loss

The mean rate of annualized loss of attachment before 20 years of age was 0.09 mm/year. As the subjects approached 30 years, the rate fluctuated between 0.07 and 0.10 mm/year, after which a statistically significant decrease to 0.05 mm occurred. This rate of loss of attachment per year remained stable for the following 20 years. During the fifties and on approaching 60 years of age, a trend towards an increased rate of loss took place. However, this was not statistically significant (Table 11, Fig. 7).

Frequency analyses (Table 12, Fig. 8) showed that before 20 years of age, 14% of the individuals experienced a mean annual rate of attachment loss below 0.02 mm, 29% had an annual rate between 0.02 and 0.06 mm, and in 57% of the subjects loss of attachment progressed at a mean annual rate of 0.06 mm to 0.1 mm. By 30–40 years and during the fourth and fifth decades of life, this rate of progression fell and comprised between 26% and 36% of the participants. As they approached 60 years of age, 50% of the men, again, exhibited an annual progression rate of 0.06 mm to 0.1 mm.

Risk of progression

As shown in Table 13 and Fig. 9, the risk of converting a healthy site to a site with loss of periodontal support appeared to be small before 20 years of age (1%). The risk then steadily increased with age and reached a peak of 7% at the age of 35 years, following which the relative risk seemed to stabilize at 4–5% before reaching another peak (6%) at the age of 55–59 years. The changes in mean annualized risk reached statistical significance at age groups younger than 40 years old and from the age of 40–44 years to 45–49 years.

Discussion

The purpose of these analyses was to further determine the pattern and variations of periodontal destruction during 45 years of adult life of well-educated middle-class Norwegian men aged between 16 and 59 years. For details about the study design, randomization, methods of measurements and method errors, baseline data, etc., the reader is referred to earlier publications in this series (Løe

Table 10. Frequency of occurrence of gingival recession, pocket formation and combinations by age group

Age group (years)	Only gingival recession		Only pocket formation		Combinations	
	N	%	N	%	N	%
<20	NA	NA	NA	NA	NA	NA
20-24	440	39.64	667	60.09	3	0.27
25-29	926	31.69	1981	67.80	15	0.51
30-34	1091	23.80	3459	75.46	34	0.74
35-39	1224	20.70	4533	76.67	155	2.62
40-44	1172	19.15	4728	77.25	220	3.59
45-49	1692	21.70	5715	73.31	389	4.99
50-54	849	23.43	2547	70.30	227	6.27
55-59	358	24.29	907	61.53	209	14.18

NA: not applicable.

Table 11. Mean annualized rates of periodontal attachment loss

Age group (years)	N	Mean	SE	Prob > T
<20	65	0.0863	0.0100	0.1997
20-24	317	0.1023	0.0079	0.0064*
25-29	351	0.0721	0.0080	0.2288
30-34	291	0.0911	0.0069	0.0001*
35-39	181	0.0474	0.0055	0.5948
40-44	128	0.0455	0.0044	0.506
45-49	140	0.0519	0.0042	0.2235
50-54	61	0.0408	0.0053	0.0939
55-59	23	0.0612	0.0135	

*Significant differences ($p < 0.05$).

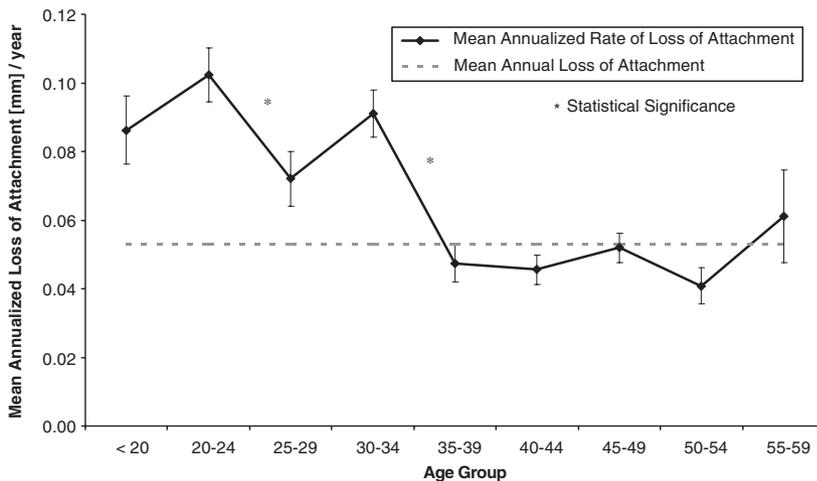


Fig. 7. Mean annualized rate of loss of attachment by age groups.

et al. 1978a, b, c, 1986, Ånerud et al. 1979, 1991).

Patterns of periodontal attachment loss

The current analyses have demonstrated, again, that this cohort started

their adult life with an essentially healthy periodontium. Although all subjects at the age of 16-20 years had one or more sites with inflamed gingiva, more than 90% of all sites did not exhibit bleeding on probing ($GI \geq 2$), and loss of attachment was extremely rare.

During the early twenties, less than 10% of sites lost periodontal attachment and most of it was due to gingival recession. For the next 30 years, more sites were affected, and as the participants approached 60 years of age, approximately 75% of the sites showed an attachment loss of 2 mm or more.

ILA occurred first on the buccal sites of both anterior and posterior teeth, and mainly in combination with gingival recession. As shown in an earlier paper (Løe et al. 1992) only a small percentage (<1%) of sites with recession was seen in the interproximal areas of young adults in their twenties, and the proportions of sites with gingival recession alone increased only slightly over the next 30-40 years. As the participants approached 60 years of age, approximately 10% of all sites presented with gingival recession only, most of which amounted to <3 mm.

Pocket formation occurred sporadically in the youngest age groups, but by 35 years all participants showed one or more sites with pockets 2 mm or deeper. Those sites then were mostly located in the interproximal areas. With increasing age, pocket formation alone or in combination with gingival recession accounted for the attachment loss.

This study has demonstrated that only 20% of the sites that expressed ILA during the observation period continued to lose further periodontal support. The major proportion remained stable. Less than 1% of all the sites progressed substantially ($LA > 4$ mm).

Variations in loss of attachment rates

During adult life this cohort experienced a cumulative mean loss of attachment of 2.30 mm (range 0.14-2.44 mm). This corresponds to an annualized decrease of periodontal support of 0.05 mm. This rate is comparable to that reported for the North-Americans of Tecumseh, MI (Ismail et al. 1990), but represents a considerably smaller rate than that reported for the adult tea plantation workers in Sri Lanka (Løe et al. 1978b, 1986), a group of adults in Sweden (Axelson & Lindhe 1978) and in the People's Republic of China (Baelum et al. 1997). The annual rate of loss encountered in the present population also compares reasonably well with another Scandinavian group (Lindhe et al. 1989) (Table 14).

The Norwegian group displayed great differences in individual rates over time.

Table 12. Frequency of annualized loss of attachment (LoA) rates by age groups

Age group (years)	LoA ≤ 0.02 mm/year		0.02 < LoA ≤ 0.06 mm/year		LoA > 0.06 mm/year	
	N	%	N	%	N	%
<20	9	13.85	19	29.23	37	56.92
20–24	87	27.44	31	9.78	199	62.78
25–29	124	35.33	38	10.83	189	53.85
30–34	77	26.46	54	18.56	160	54.98
35–39	61	33.70	54	29.83	66	36.46
40–44	33	25.78	50	39.06	45	35.16
45–49	33	23.57	56	40.00	51	36.43
50–54	17	27.87	28	45.90	16	26.23
55–59	5	21.74	7	30.43	11	47.83

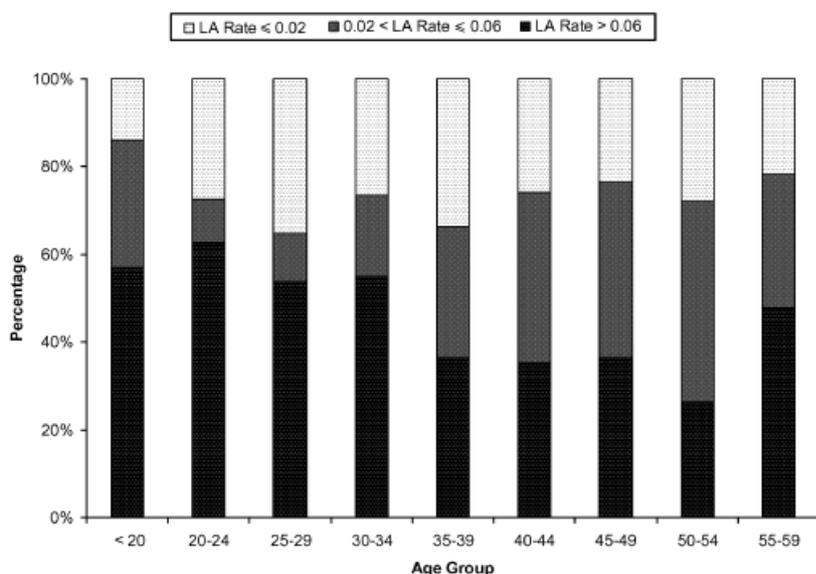


Fig. 8. Frequency of annualized loss of attachment rates by age groups.

Table 13. Mean annualized relative risk of initial attachment loss of a tooth site by age groups

Age group (years)	N	Mean relative risk of IniLoA	SE	Prob > T
<20	65	0.012	0.022	0.0001*
20–24	317	0.032	0.039	0.0001*
25–29	351	0.044	0.049	0.0001*
30–34	291	0.069	0.080	0.0097*
35–39	181	0.054	0.069	0.6504
40–44	130	0.042	0.028	0.0014*
45–49	145	0.050	0.029	0.2533
50–54	65	0.057	0.031	0.5246
55–59	23	0.063	0.035	

*Significant differences ($p < 0.05$).
IniLoA: initial loss of attachment.

Approximately 25% of the participants never exceeded an annual loss rate of 0.02 mm, and essentially went through adult life with the periodontal health intact. The rest, 75% of the men, exhibited variations in the annual attachment loss rate between 0.02 and 0.06 mm. Before 35 years of age, the

majority of this group had an annual loss of attachment rate of 0.06 to 0.1 mm. During the forties and fifties, however, both the mean annual rate (Fig. 3) and the frequency of the rates decreased (Fig. 4). As the group approached 60 years of age, the annual rate appeared to slightly rise again.

In a previous publication (Løe et al. 1986), three different subpopulations were identified in the Sri Lankan cohort on the basis of annual rates of attachment loss: (1) 8% of the cohort showing rapidly progressing destruction of the periodontium; (2) 80% showing moderate progression (0.05–0.10 mm/year); and (3) 12% exhibiting no progression of chronic periodontal disease beyond gingivitis.

As shown in the current analysis the Norwegian cohort also included a group (25% of the men) who, during their entire 60 years of life, did not develop chronic periodontal disease beyond gingivitis, and basically went through adult life with a healthy periodontium. In the remaining 75%, the rate of attachment loss resembled that of the “moderately progressing” group in the Sri Lanka cohort, i.e. an annual rate of loss < 0.1 mm. Anything comparable to the Sri Lankan tea workers with a high annual progression rate of 0.1–1.0 mm was not found among these Norwegian men.

The present study has also established that in a population who had received regular and adequate professional and personal health care throughout 60 years of life, there are significant differences in the pattern and rates of attachment loss before and after 35 years. Initial attachment loss occurred early in adult life, and mostly in combination with gingival recession in buccal surfaces of anterior and posterior teeth. Gingival recession, occurring as initial lesions of attachment loss, may have been caused by trauma inflicted by toothbrushing (Hirschfeld 1931, Gorman 1967, O’Leary et al. 1968, Sangnes 1976, Løe et al. 1992, Khocht et al. 1993), and appeared to come to a temporary halt before 35 years of age.

Certainly, initial attachment loss in combination with pocket formation may be seen before 35 years of age primarily in interproximal areas and also often in combination with pocket formation and gingival recession. Pocket formation increases slowly by deepening of the initial lesions and the addition of new sites during the following decades. This gingival recession in combination with pocketing may, as indicated before (Løe et al. 1992), be caused by factors inherent in the pathogenesis of periodontal destruction, other than iatrogenic insults.

Furthermore, this study has demonstrated that only a minute proportion

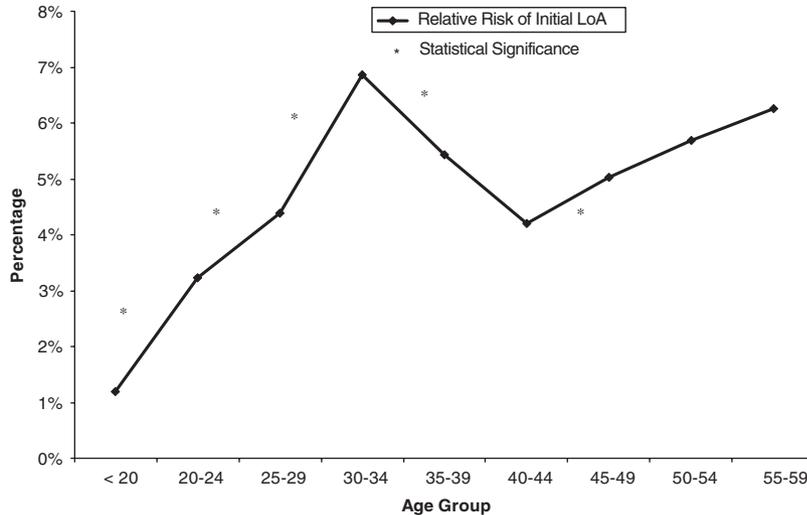


Fig. 9. Mean annualized relative risk of initial attachment loss of a tooth site by age groups.

Table 14. Mean annual rate of periodontal attachment loss in different populations

Publications	Mean annual rate (mm/year)
Löe et al. (1978b) (Sri Lankan cohort)	0.18–0.29
Axelsson & Lindhe (1978)	0.17–0.3
Löe et al. (1986) (Sri Lankan cohort)	0.05–1.00
Lindhe et al. (1989)	0.07–0.14
Ismail et al. (1990)	0.04
Baelum et al. (1997)	0.15–0.19
Schätzle et al. (2001)	0.04–0.10

(<1%) of the sites with initial attachment loss as defined ($LoA \geq 2$ mm) progressed substantially during the observation period in this well-maintained middle class patient cohort. The slight increase in attachment loss seen as individuals are approaching 60 years was not statistically significant, but still deserves further investigation in order to ascertain the factual progression rates as the cohort advances into old age.

In conclusion, repeated clinical examinations over a 26-year period (covering an age span of 16 to 59 years) of a cohort of well educated men, who throughout their lives received regular dental care and practiced good oral home care, have demonstrated that 25% of the men went through adult life with healthy and stable periodontal conditions. The remaining 75% developed slight to moderately progressing periodontal disease with progression rates varying between 0.02 and 0.1 mm/year with a cumulative mean of loss of attachment of 2.44 mm as they approached 60 years of age. Initial loss of attachment before 35 years of age

occurred mostly as gingival recession in buccal surfaces, although at this age, occasional pocketing was found in interproximal areas. Only 20% of the sites continued to lose further attachment during the remainder of the observation period, and less than 1% of the sites showed substantial loss of attachment (>4 mm).

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Zusammenfassung

Der klinische Verlauf chronischer Parodontitis: III. Muster, Variationen und Risiken für Attachmentverlust.

Zielsetzung: Feststellung der Attachmentverluste während verschiedener Phasen des Erwachsenenlebens einer gut betreuten Population der Mittelklasse.

Material & Methoden: Die Daten stammen aus einer über 26 Jahre laufenden longitudinalen Studie bei Norwegischen Männern, die

tägliche häusliche Mundhygiene betrieben und nach aktuellen Maßstäben zahnärztlich versorgt wurden. Die Erstuntersuchung 1969 umfasste 565 Personen im Alter zwischen 16 und 34 Jahren. Anschließend Untersuchungen fanden 1971, 1973, 1975, 1981, 1988 und 1995 statt. Somit deckt die Studie ein Altersspektrum von 16 bis 59 Jahren ab. Die Rate des jährlichen Attachmentverlustes wurde als Differenz der mittleren Attachmentverluste einer Person zwischen 2 Untersuchungen dividiert durch die Zahl der Jahre zwischen beiden Untersuchungen berechnet. Das mittlere relative Risiko für Attachmentverlust auf ein Jahr wurde als Häufigkeitsverteilung von Stellen mit initialem parodontalen Attachmentverlust (LoA beim ersten Auftreten ≥ 2 mm) und gesunden Stellen (LoA immer < 2 mm) berechnet. Für den Vergleich signifikanter Veränderungen der jährlichen Attachmentverlusten zwischen den Altersgruppen und den mittleren auf ein Jahr berechneten relativen Risiken für Attachmentverlust wie sie während des Lebens voranschritten wurde der Wilcoxon Mann-Whitney U -Test verwendet.

Ergebnisse: Der mittlere individuelle Gesamttachmentverlust in 44 Jahren betrug (zwischen 16 und 59) 2.44 mm (Intervall 0.14–2.44 mm), mit einer mittleren jährlichen Verlustrate von 0.05 mm/Jahr. Die höchste jährliche Attachmentverluste wurde vor dem 35. Lebensjahr verzeichnet (0.08–0.1 mm/Jahr). Danach reduzierte sich die mittlere jährliche Attachmentverluste auf etwa 0.04–0.06 mm/Jahr für die nächsten 3 Lebensdekaden bis zum 60. Lebensjahr. Das mittlere relative Risiko für initialen Attachmentverlust auf ein Jahr vergrößerte sich signifikant vom Jugendlichenalter (1.2%) auf ein Maximum zwischen 30 und 34 Jahren (6.9%). Nach dem Alter von 34 Jahren reduzierte sich das relative Risiko wieder, aber ab dem Alter von 40 wurde ein erneuter Anstieg beobachtet.

Schlussfolgerungen: Diese Studie hat gezeigt, dass die mittlere jährliche Attachmentverluste und das mittlere relative Risiko für parodontalen Attachmentverlust auf ein Jahr während des Lebens variieren. Ihr Maximum erreichten sie zwischen dem 16. und 34. Lebensjahr.

Résumé

L'évolution clinique de la parodontite chronique. III. Tendances, variations et risques de perte d'attache

But: Cette étude se propose de mettre en évidence le taux de perte d'attache lors de divers étapes de la vie adulte dans une population de classe moyenne bien maintenue.

Matériel & Méthodes: Les données proviennent d'une étude longitudinale sur 26 ans concernant des norvégiens de sexe masculin qui recevaient de bons soins dentaires réguliers et pratiquaient chaque jour des manoeuvres d'hygiène orale. L'examen initial en 1969 comprenait 565 individus entre 16 et 34 ans., qui furent réexaminés en 1971, 1973, 1975, 1981, 1988 et 1995. Ainsi, cette étude couvre

un intervalle d'âge de 16 à 59 ans. Le taux de perte d'attache annuel fut calculé comme étant la différence entre la moyenne des pertes d'attache individuelle entre deux examens, divisée par les années écoulées entre ces deux examens.

Le risque relatif moyen annualisé de perte d'attache fut calculé comme étant la fréquence de distribution des sites avec une perte d'attache initiale (LoA lors de la première visite ≥ 2 mm) et les sites sains (LoA toujours < 2 mm).

Pour la comparaison des changements significatifs annuels des taux de perte d'attache entre les groupe d'âge, et les risques relatifs annualisés de perte d'attache telle qu'elle se produit lors de la vie adulte, nous avons utilisé le test Wilcoxon Mann-Whitney.

Résultats: La perte d'attache globale individuelle pendant 44 ans (entre 16 et 59 ans) était de 2.44 mm (de 0.14 à 2.44 mm), ce qui représente une moyenne annuelle de 0.05 mm/an. Le plus fort taux annuel de perte d'attache se produisait avant 35 ans (0.08–0.1 mm/an) et ensuite, ce taux moyen annuel diminuait vers 0.04–0.06 mm/an pour les 3 décades ultérieures jusqu'à 60 ans.

Le risque moyen relatif annualisé de perte d'attache initiale augmentait significativement de l'adolescence (1.2%) jusqu'à un maximum vers 30–34 ans (6.9%). Ensuite, ce risque de perte d'attache initiale diminuait de nouveau, mais après 40 ans, on observait une nouvelle augmentation continue.

Conclusions: Cette étude a montré que les taux annuels et les risques annualisés de perte d'attache parodontale varient tout le temps. Le taux moyen annuel et le risque moyen annualisé de perte d'attache initial étaient plus importants entre 16 et 34 ans.

References

- Axelsson, P. & Lindhe, J. (1978) Effect of controlled oral hygiene procedures on caries and periodontal disease in adults. *Journal of Clinical Periodontology* **5**, 133–151.
- Ånerud, Å., Løe, H., Boysen, H. & Smith, M. (1979) The natural history of periodontal disease in man. Changes in gingival health and oral hygiene before 40 years of age. *Journal of Periodontal Research* **14**, 526–540.
- Ånerud, Å., Løe, H. & Boysen, H. (1991) The natural history and clinical course of calculus formation in man. *Journal of Clinical Periodontology* **18**, 160–170.
- Baelum, V., Luan, W., Chen, X. & Fejerskov, O. (1997) A 10 year study of the progression of destructive periodontal disease in adult and elderly Chinese. *Journal of Periodontology* **68**, 1033–1042.
- Glavind, L. & Løe, H. (1967) Errors in the clinical assessment of periodontal destruction. *Journal of Periodontal Research* **2**, 180–184.
- Gorman, W. J. (1967) Prevalence and etiology of gingival recession. *Journal of Periodontology* **38**, 318–322.
- Heitz-Mayfield, L., Schätzle, M., Løe, H., Ånerud, Å., Boysen, H., Lang, N. P. & Bürgin, W. (2003) Clinical course of chronic periodontitis. II. Incidence, characteristics and time of occurrence of the initial periodontal lesions. *Journal of Clinical Periodontology* **30**, 902–908.
- Hirschfeld, I. (1931) Tooth-brush trauma recession: a clinical study. *Journal of Dental Research* **11**, 61–63.
- Ismail, A. I., Morrison, E. C., Burt, B. A., Caffesse, R. G. & Kavanagh, M. T. (1990) Natural history of periodontal disease in adults: findings from Tecmuseh Periodontal Study, 1959–87. *Journal of Dental Research* **62**, 430–435.
- Khocht, A., Simon, G., Person, P. & Denepitiya, J. (1993) Gingival recession in relation to history of hard toothbrush use. *Journal of Periodontology* **64**, 900–905.
- Lindhe, J., Okamoto, H., Yoneyama, T., Haffajee, A. & Socransky, S. S. (1989) Longitudinal changes in periodontal disease in untreated subjects. *Journal of Clinical Periodontology* **16**, 662–670.
- Løe, H., Ånerud, Å., Boysen, H. & Smith, M. (1978a) The natural history of periodontal disease in man: Study design and baseline data. *Journal of Periodontal Research* **13**, 550–562.
- Løe, H., Ånerud, Å., Boysen, H. & Smith, M. (1978b) The natural history of periodontal disease in man: the rate of periodontal destruction before 40 years of age. *Journal of Periodontology* **49**, 607–620.
- Løe, H., Ånerud, Å., Boysen, H. & Smith, H. (1978c) The natural history of periodontal disease in man: Tooth mortality rates before 40 years of age. *Journal of Periodontal Research* **13**, 563–572.
- Løe, H., Ånerud, Å., Boysen, H. & Morrison, E. (1986) Natural history of periodontal disease in man. Rapid, moderate and no loss of attachment in Sri Lankan labourers 14–46 years of age. *Journal of Clinical Periodontology* **13**, 431–440.
- Løe, H., Ånerud, Å. & Boysen, H. (1992) The natural history of periodontal disease in man: prevalence, severity and extent of gingival recession. *Journal of Periodontology* **63**, 489–495.
- O'Leary, T. J., Drake, R. B., Jividen, G. F. & Allen, M. F. (1968) The incidence of recession in young males: relationship to gingival and plaque scores. *Periodontics* **6**, 109–111.
- Sangnes, G. (1976) Traumatization of teeth and gingiva related to habitual tooth cleaning procedures. *Journal of Clinical Periodontology* **3**, 94–103.
- Schätzle, M., Lang, N. P., Ånerud, Å., Boysen, H., Bürgin, W. & Løe, H. (2001) The influence of margins of restorations on the periodontal tissues over 26 years. *Journal of Clinical Periodontology* **28**, 57–64.
- Schätzle, M., Løe, H., Lang, N. P., Bürgin, W., Ånerud, Å. & Boysen, H. (in press) The clinical course of chronic periodontitis. IV. Gingival inflammation as a risk factor for tooth mortality. *Journal of Clinical Periodontology*.

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