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A three-year prospective study of adult subjects with gingivitis. I: clinical periodontal parameters

Anna Bogren[1], Ricardo Teles[2], Gay Torresyap[2], Anne D. Haffajee[2], Sigmund S. Socransky[2], Jan Lindhe[1] and Jan L. Wennström[1]

[1]Department of Periodontology, Institute of Odontology, The Sahlgrenska Academy at Göteborg University, Göteborg, Sweden; [2]The Forsyth Institute, Boston, MA, USA

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Abstract

Aim: The objective of this study was to monitor prospectively clinical parameters in subjects without signs of destructive periodontal disease who were involved in a primary prevention programme, and to determine the changes that occurred between yearly examinations over a 3-year period.

Material and Methods: One hundred and twenty-six subjects aged at least 20 years with a maximum of two tooth sites with probing pocket depth (PPD) >4 mm and no proximal sites with clinical attachment loss participated in the study. Primary prevention was provided at baseline of the study and then every 6 months. Plaque, bleeding on probing (BoP) and PPD were scored at baseline, 1, 2 and 3 years.

Results: There were no significant changes in the plaque score over the 3 years. After year 1, the BoP score was significantly improved with 5.6%, while no further improvement in BoP was found at years 2 and 3. The mean PPD decreased from 2.3 to 2.1 mm over the 3 years ($p<0.05$).

Conclusion: Although some individuals exhibiting minor signs of periodontal pathology may have benefited from the primary prevention, the overall clinical improvement was limited for such subjects in the present 3-year study.

Key words: clinical trial; gingivitis; periodontology; plaque; primary prevention

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Evidence suggests that the accumulation of microbial plaque on teeth is a direct cause of gingivitis (Theilade et al. 1966, Lindhe & Rylander 1975, Brecx et al. 1987) and that gingivitis may precede periodontitis (Lindhe et al. 1973, 1975, Löe & Morrison 1986, Kornman et al. 1997, Schätzle et al. 2003, 2004). Löe et al. (1965) and Lindhe et al. (1978) demonstrated that the removal of plaque from sites with clinical gingivitis resulted in the resolution of the soft tissue inflammation. Further, there are publications demonstrating that self-performed plaque control may be an essential component in the prevention of periodontal disease (Axelsson & Lindhe 1978, Löe 1994). However, based on the outcome of a recent systematic review, Hujoel et al. (2005) concluded that there is currently insufficient evidence from randomized-controlled trials to determine whether chronic periodontitis can be entirely prevented by means of improved personal and supportive oral hygiene procedures.

In industrialized countries, most individuals claim to brush their teeth once or twice daily (Hugoson et al. 2005, Lang et al. 1994 and for a review, see Sheiham & Netuveli 2002). Despite this fact, the prevalence of gingivitis and chronic periodontitis remains high in most populations (Albandar & Rams 2002). This indicates that the establishment of an effective level of plaque removal by means of self-performed, conventional oral hygiene procedures is difficult in most subjects. Supportive periodontal treatment (SPT) offered on a regular basis may therefore be required to maintain sufficient levels of infection control (Lövdal et al. 1961, Suomi et al. 1971, Axelsson & Lindhe 1978, 1981, Axelsson et al. 2004). Regularly scheduled SPTs may not only provide thorough cleaning of the dentition but also encourage the subject to establish and maintain a high level of self-performed oral hygiene.

Investigators have studied clinical, microbiological and various host parameters that are characteristic of chronic and aggressive forms of periodontitis. Far less emphasis has been placed on examining changes in periodontal parameters that may occur over time in subjects who are periodontally healthy or exhibit signs of gingivitis. The current publication is the first in a series aimed at describing the clinical and microbial features over time in periodontally healthy adult subjects who received regular primary prevention. The objective of this study was to monitor prospectively clinical parameters in such subjects and determine the changes that occurred between yearly examinations over a 3-year period. The changes

observed in the periodontal microbiota are reported in a companion paper (Teles et al. 2006).

Material and Methods

Subject sample

A total of 160 subjects without signs of destructive periodontal disease were enrolled in the study. Equal numbers of participants were recruited from (1) the patient pool at a Public Dental Service clinic in the city of Landskrona, Sweden, and (2) The Forsyth Institute, Boston, USA. All subjects were informed about the design of the trial, as well as the potential risks and benefits of participation. The Ethics Committee at the Göteborg University and the Institutional Review Board at The Forsyth Institute approved the study protocol, and all subjects signed informed consents before they were entered into the study.

To be included in the study, the subjects had to (i) be $\geqslant 20$ years of age, (ii) have at least 24 natural teeth, (iii) have $\leqslant 2$ tooth sites with probing pocket depth (PPD) > 4 mm and (iv) have no proximal sites with clinical attachment loss. Subjects were excluded if they had a systemic condition or were on medications that could be expected to influence the initiation of periodontal disease, or would require antibiotic prophylaxis for routine dental procedures.

Primary prevention

All subjects received primary prevention including supragingival scaling and polishing, performed by a dental hygienist, as well as instructions in and reinforcement of proper homecare procedures at the beginning of the study and subsequently every 6 months for 3 years. A self-performed plaque removal programme was introduced that included $2\times$ a day brushing using a manual/powered toothbrush and fluoride-containing dentifrice (Protection Caries® or Total®, Colgate, Piscataway, NJ, USA). Inter-dental cleaning with dental floss and/or toothpick was part of this programme. Fresh supplies for the self-performed tooth cleaning efforts were provided at each 6-month recall.

Clinical Assessments

Clinical examinations were performed before primary prevention at baseline, and at 1, 2 and 3 years. Recordings were taken at six sites per tooth (mesiobuccal, buccal, distobuccal, mesiolingual, lingual and distolingual); the distal surface of the second molars and the third molars were excluded. Plaque and bleeding on probing (BoP) were scored as being absent or present (0 or 1). Plaque was scored positive if visible at the time of probing and BoP was scored positive if a site bled after pocket probing within the time interval used for the buccal or lingual measurements of a quadrant. The PPD was measured and recorded in millimetre twice at each visit using a manual UNC 15 probe (Hu-Friedy®, Chicago, IL, USA). The PPD values were rounded to the nearest upper millimetre, and averaged for the pair of recordings. All clinical measurements were recorded on data sheets and scanned into a computer.

Before the start of the study, the two examiners were trained to levels of accuracy and reproducibility for the various clinical parameters to be used. For both inter- and intra-examiner reproducibility, the standard deviation for PPD measurements had to reach a level of < 0.5 mm, with an agreement within ± 1 mm of at least 99% of sites examined.

Data analysis

For the purpose of the present study, the data analyses were based on the subjects who were examined at all four visits ($n = 126$). BoP and PPD were considered primary outcome variables. The plaque score was regarded as a descriptor.

Plaque and BoP were expressed as percentage positive sites for each subject. The mean PPD was calculated for each subject and then averaged across subjects for the different examination time intervals. Significant differences over time were determined using repeated measures ANOVA and the Scheffe test for post-hoc analysis. The unpaired *t*-test was used to seek differences between various subgroups in the sample. The Spearman rank correlation coefficient was used to evaluate relationships between BoP and PPD values and the changes over time in each subject.

Results

The mean age of the 126 subjects at study entry was 38 (24–73) years. Sixty-four per cent were females, 82% were Caucasian and 14% were current smokers. During the 3-year study interval none of the participants had been on any antibiotic or anti-inflammatory drug therapy for a period exceeding 10 days.

Plaque scores

The mean plaque score at baseline and annual changes are described in Table 1. No statistically significant changes in plaque scores were observed between the various examinations.

BoP scores

The mean BoP score at baseline and the annual changes in BoP over the 3-year period are described in Table 1. At baseline, the mean BoP value was 21.4% (95% CI 18.5–24.3) and a statistically significant decrease of 5.6% (3.2–7.9) was observed at the 1-year examination, while the annual change at 2 and 3 years was not significant (1.2% increase and 0.9% decrease, respectively). Figure 1 presents the change in BoP% between baseline and 1 year for each subject. Seventy-seven subjects (61%) showed a decrease in mean BoP% between baseline and 1 year, while 41 subjects (32%) exhibited an increase. There was a significant correlation between the baseline BoP score and the change between baseline and 1 year in a subject ($r = -0.692$, $p < 0.01$). Individual subject changes in BoP between years 1 and 3 (Fig. 2) indicated that 61 subjects (48%) and 55 subjects (44%), respectively, exhibited decreases and increases in mean BoP. The correlation between the mean BoP at year 1 and the change between 1 and 3 years was not statistically significant ($r = -0.035$, $p > 0.05$).

Subjects were subset into those who exhibited an increase ($n = 37$) or a decrease ($n = 80$) in the percentage of sites with BoP between baseline and 3 years. Four of thirty-seven subjects with an increase and 7/80 with a decrease in BoP showed this trend at each monitoring visit. The baseline plaque, BoP and PPD values as well as the changes in mean plaque score and PPD at 3 years in the two groups are described in Table 2. There was no statistically significant difference between the groups regarding their baseline values. The PPD reduction at 3 years was significantly greater in the BoP-decrease than in the BoP-increase group ($p < 0.01$), while no difference was found in plaque change between the two groups. The difference

Table 1. Plaque, BoP and PPD at baseline and annual changes

($n = 126$)	Plaque (%)	BoP (%)	PPD (mm)
Baseline	28.5 (25.2–31.8)	21.4 (18.5–24.3)	2.3 (2.28–2.37)
Annual change			
Year 1	– 1.94 (– 4.85/0.96)	– 5.6 (– 7.9/ – 3.2)	– 0.1 (– 0.14/ – 0.06)
Year 2	– 2.44 (– 4.90/0.02)	1.2 (– 0.8/3.1)	– 0.1 (– 0.10/ – 0.02)
Year 3	1.14 (– 1.51/3.79)	– 0.9 (– 2.5/0.6)	– 0.1 (– 0.11/ – 0.04)

Mean values (95% confidence interval).
BoP, bleeding on probing; PPD, probing pocket depth.

in BoP change between the two groups at 3 years was about 20%.

In the total sample, 55.5% of sites that were BoP-negative at baseline remained healthy throughout the 3 years of monitoring (Fig. 3). Only 1.4% of the sites that exhibited BoP at baseline were BoP-positive at all examinations.

PPD

The mean PPD value at baseline and annual changes in PPD over the 3-year period are presented in Table 1. The mean PPD at baseline was 2.3 mm (95% CI 2.3–2.4) and decreased annually with about 0.1 mm during the 3 years. The change in PPD between baseline and 1 year for each subject is described in Fig. 4. Eighty-one subjects (64%) exhibited a decrease, while 42 subjects (33%) demonstrated an increase in the mean PPD at 1 year. The correlation between the mean baseline PPD and change between baseline and 1 year in a subject was statistically significant ($r = -0.412$; $p < 0.01$). The data for PPD change between years 1 and 3 (Fig. 5) indicated that 85 subjects (68%) exhibited a decrease, while 39 subjects (31%) demonstrated an increase in mean PPD. The correlation between the individual mean PPD at year 1 and the change between 1 and 3 years was statistically significant ($r = -0.177$; $p < 0.05$).

Table 3 describes the baseline plaque, BoP and PPD values and the 3-year changes in plaque and BoP scores for subjects that showed either an increase in PPD ($n = 22$, 5/22 with PPD increase at all re-examinations) or a decrease in PPD ($n = 102$, 23/102 with PPD decrease at all re-examinations). The difference in PPD change between the two groups at 3 years was about 0.5 mm. No statistically significant difference between the two groups was found regarding the baseline plaque and BoP values, while the difference in PPD at baseline between the two groups was statistically significant ($p < 0.05$). The difference between the two groups regarding the plaque and BoP change during the 3-year interval was not statistically significant.

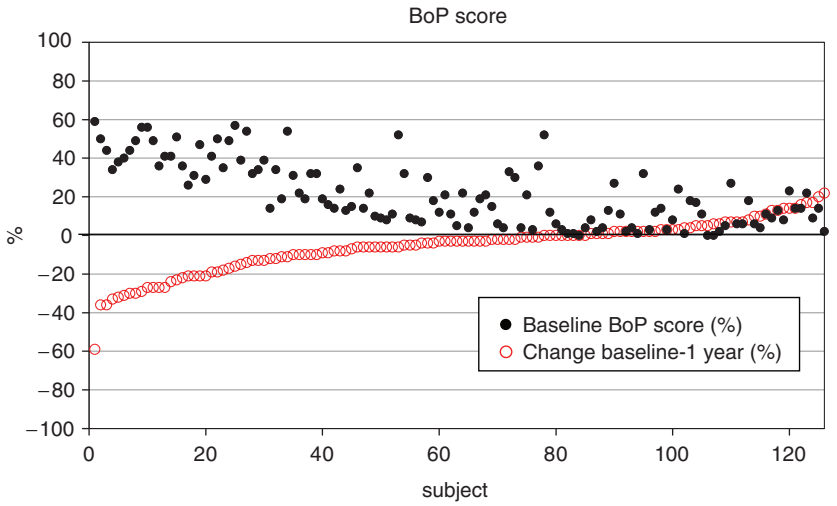

Fig. 1. Mean baseline bleeding on probing (BoP) score (%) for each subject ($n = 126$) and a cumulative plot of the mean BoP change that had occurred between baseline and 1 year for the respective subject.

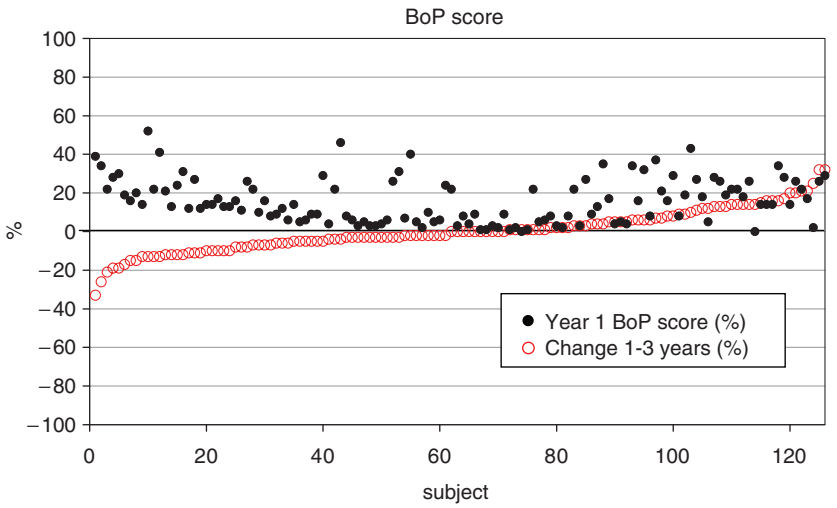

Fig. 2. Mean 1-year bleeding on probing (BoP) score (%) for each subject ($n = 126$) and a cumulative plot of the mean BoP change that had occurred from 1 to 3 years for the respective subject.

Discussion

The results of the present investigation showed that subjects exhibiting minor signs of periodontal pathology and involved in a primary preventive programme based on self-performed plaque control measures and professionally delivered mechanical tooth cleaning every 6 months may demonstrate a reduction of gingivitis and PPD. These findings are in agreement with data previously published regarding the outcome of preventive programmes based on regularly repeated mechanical self-performed and professionally delivered plaque removal (Axelsson & Lindhe 1978, 1981). On the other hand, in a systematic review (Needleman et al. 2005) it was concluded that provision of professional tooth cleaning without instruction in self-performed oral hygiene was of little value.

Table 2. Baseline characteristics and 3-year plaque and PPD change for subjects who exhibited an increased BoP (BoP-increase group) or decreased BoP (BoP-decrease group) between baseline and 3 years

	BoP increase ($n = 37$)	BoP decrease ($n = 80$)	Significance between groups*
Baseline			
Plaque (%)	31.2 (25.1–37.4)	27.5 (23.2–31.7)	NS
BoP (%)	18.6 (13.8–23.3)	24.1 (20.2–27.9)	NS
PPD (mm)	2.3 (2.16–2.36)	2.4 (2.30–2.41)	NS
Change at 3 years			
Plaque (%)	− 0.3 (− 6.3/6.9)	− 4.5 (− 9.2/0.2)	NS
PPD (mm)	− 0.1 (− 0.21/ − 0.04)	− 0.3 (− 0.34/ − 0.22)	< 0.01

*Unpaired *t*-test.
Mean values (95% confidence interval).
BoP, bleeding on probing; PPD, probing pocket depth.

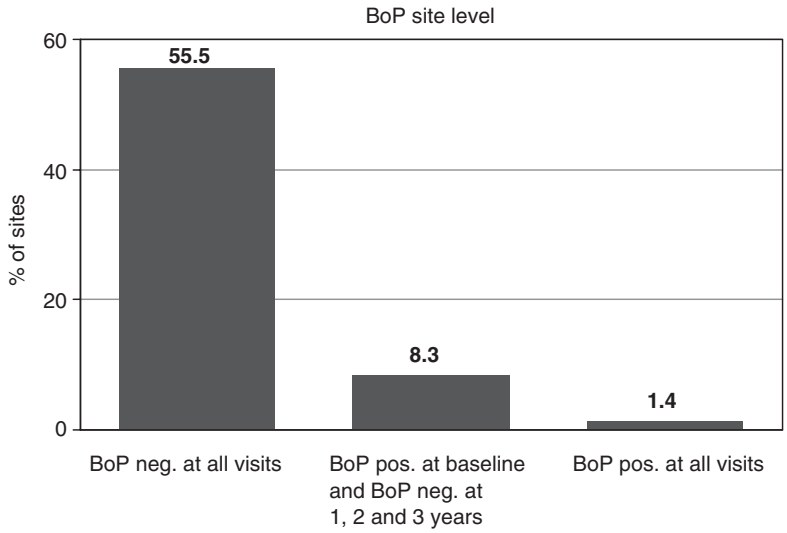

Fig. 3. Frequency (%) of sites that (i) were healthy [bleeding on probing (BoP) negative] at baseline and remained healthy at all re-examinations, (ii) were BoP positive at baseline but healthy at all subsequent examinations and (iii) were BoP positive at all four examinations.

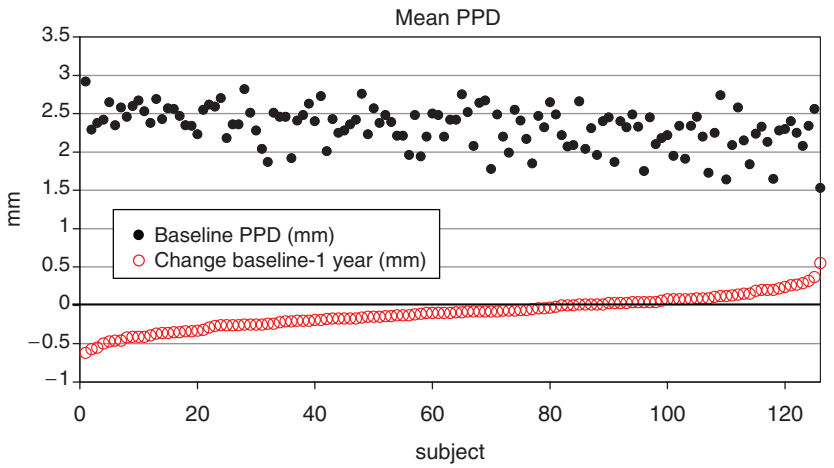

Fig. 4. Mean baseline probing pocket depth (PPD, mm) for each subject ($n = 126$) and a cumulative plot of the mean PPD change that had occurred from baseline to 1 year for the respective subject.

The subjects enrolled in the trial were selected to represent subjects with no obvious signs of destructive periodontal disease, i.e. subjects with low susceptibility to periodontitis. Based on data from epidemiological studies, it could be argued that in the young individuals in this sample (subjects that were < 30–40 years of age), the gingival lesions may not yet have reached the attachment apparatus. On the other hand, subjects in the sample who were > 50 years of age and did not exhibit any proximal site with periodontal tissue breakdown were likely to be non-susceptible to periodontitis.

In the present study, most of the improvement in gingivitis occurred during the first 12 months of the prevention programme while subsequent changes were more modest. This finding is consistent with previously published data (Axelsson & Lindhe 1977) that suggested that after 12 months of preventive therapy (first re-examination interval), the gingival conditions were close to ''ideal'' in the subjects and that further improvement in gingivitis levels was difficult to accomplish. The validity of this conclusion is supported by the fact that only 16% of all sites examined were BoP positive at the year 1 re-examination in the current study. However, whether the improvement in gingivitis was an effect of the primary preventive programme or can be ascribed to the Hawthorne effect is not possible to determine as no control group was included.

Although there was an overall improvement in BoP scores during the course of this 3-year study, there were individual subject variations in the response to the preventive programme. For example, 32% of subjects exhibited an increase in BoP scores from baseline to 1 year and 44% of subjects exhibited an increase in this parameter from 1 to 3 years. However, only four subjects had – in comparison with baseline – increased mean BoP values at all three re-examinations. 1.4% of all sites in the sample remained inflamed (BoP positive) at all examinations, while 55.5% of sites were healthy at all examination intervals. Although the majority ($n = 80$) of the 126 subjects exhibited reduced incidence of gingivitis after 3 years of preventive measures, 37 subjects presented with a larger number of sites with gingivitis at the final examination. At baseline, these 37 subjects had plaque, BoP and PPD values similar to the

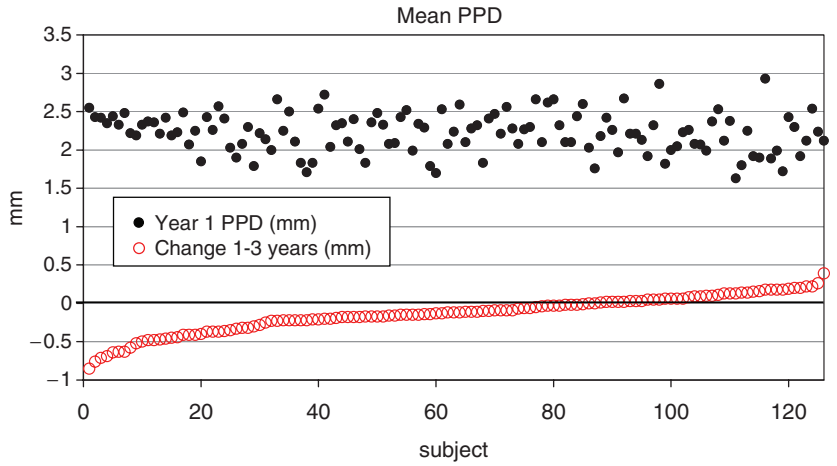

Fig. 5. Mean 1-year probing pocket depth (PPD, mm) for each subject ($n = 126$) and a cumulative plot of the mean PPD change that had occurred from 1 to 3 years for the respective subject.

Table 3. Baseline characteristics and 3-year plaque and BoP change for subjects who exhibited an increased PPD (PPD-increase group) or decreased PPD (PPD-decrease group) between baseline and 3 years

	PPD increase ($n = 22$)	PPD decrease ($n = 102$)	Significance between groups*
Baseline			
Plaque (%)	24.3 (14.8–33.8)	28.9 (25.4–32.5)	NS
BoP (%)	16.4 (10.6–22.2)	22.8 (19.5–26.1)	NS
PPD (mm)	2.2 (2.03–2.34)	2.4 (2.31–2.40)	<0.05
Change at 3 years			
Plaque (%)	1.2 (– 10.5/8.2)	– 4.4 (– 8.5/ – 2.8)	NS
BoP (%)	0 (– 6.5/6.6)	– 6.6 (– 9.0/ – 4.2)	NS

*Unpaired *t*-test.

Mean values (95% confidence interval).

Bop, bleeding on probing; PPD, probing pocket depth.

80 subjects whose BoP scores were reduced during the study period. However, at 3 –years, there was a significant difference between the two groups with respect to longitudinal change of the PPD values. The 37 deteriorating subjects had about 20% higher BoP values and 0.2 mm greater PPD values than the 80 remaining subjects at 3 years.

The mean PPD for the 126 subjects at baseline was 2.3 mm. This PPD value is quite small and it was conceivable that the preventive measures introduced in the current study would not markedly influence and further reduce the baseline PPD value. Nonetheless, 102 of the subjects in the sample exhibited a decrease in mean PPD between baseline and 3 years, while only 22 subjects experienced an increase. It is noteworthy that subjects who exhibited longitudinal PPD decrease had a higher mean PPD at baseline than subjects who displayed a longitudinal increase in the PPD value (2.4 *versus* 2.2 mm; $p < 0.05$). Hence, the observed decrease may partly be explained by regression towards the mean.

In the present subject sample, the percentage of tooth surfaces that harboured plaque at baseline (about 28%) remained almost unchanged during the 3 years of monitoring. This suggests that the preventive measures introduced may have failed to change the participants' ability and/or willingness to improve their self-performed oral hygiene measures, i.e. attitude to oral hygiene performance. In this context, however, it should be realized that the number of tooth surfaces that harboured plaque in the current sample is almost identical to that found in a group of patients who were carefully monitored by oral hygiene instruction and professional debridement for 30 years (Axelsson et al. 2004).

In conclusion, although some individuals exhibiting minor signs of periodontal pathology may have benefited from the primary prevention, the overall changes in clinical parameters were limited in the present 3-year study.

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Address:
Anna Bogren
Department of Periodontology
The Sahlgrenska Academy at Göteborg University
Box 450
SE 405 30, Göteborg
Sweden
E-mail: Anna.Bogren@odontologi.gu.se

Clinical relevance

Scientific rationale: Comparatively little information is available regarding changes in periodontal parameters that may occur over time in subjects who are periodontally healthy or exhibit signs of gingivitis only.

Principal findings: Except for a 26% reduction in gingivitis after the first year, no clinically significant alterations in periodontal parameters were found in this 3-year prevention study.

Practical implications: Adult individuals without signs of periodontitis may, over a 3-year period, show minimal alterations in clinical parameters.