Proximal alveolar bone loss in a longitudinal radiographic investigation

IV. Smoking and some other factors influencing the progress in individuals with at least 20 remaining teeth

Anders Bolin, Stig Lavstedt, Lars Frithiof and Carl O. Henrikson
Departments of Oral Radiology and Periodontology, Karolinska Institute, Stockholm, Sweden

Bolin A, Lavstedt S, Frithiof L, Henrikson CO. Proximal alveolar bone loss in a longitudinal radiographic investigation. IV. Smoking and some other factors influencing the progress in individuals with at least 20 remaining teeth. Acta Odontol Scand 1986;44:263–269. Oslo. ISSN 0001-6357.

In Sweden people in all age groups now have more remaining teeth than previously. An investigation has been made to identify some predictors of alveolar bone loss in a 10-year period in subjects with at least 20 remaining teeth. The material consisted of 349 individuals, examined radiographically, clinically, and by interview in 1970 and in 1980. These subjects, born in 1904–1952, constituted a subgroup, with regard to remaining teeth, of an unselected sample of the population of the old county of Stockholm. In the unselected sample statistically significant predictors of alveolar bone loss found in a stepwise multiple regression analysis were 1) alveolar bone loss in 1970, 2) age, 3) number of lost teeth, and 4) Russell's Periodontal Index (PI). In the subgroup the predictors were in the order 1) Russell's PI and 2) smoking. The prediction values (R^2) of further variables were marginal. The analyses showed that there was an interaction between PI and smoking, implying that the effect of smoking on alveolar bone loss was increased in individuals with high PI values. Furthermore, a tendency was found for a dose-response effect of tobacco consumption. This tendency almost disappeared when controlling for PI. □ *Epidemiology; periodontal disease; periodontal index; prognosis; radiography, dental; smoking*

Anders Bolin, Odontologiska Klinikerna, Box 4064, S-141 04 Huddinge, Sweden

Many factors influence alveolar bone loss. Some of them can be studied in longitudinal epidemiologic investigations. When factors with possible influence on the development of alveolar bone loss in an unselected population are being analyzed, some predictors seem to predominate. In a previous long-term longitudinal radiographic investigation of 406 individuals, aged 18–65 years in 1970, a stepwise multiple regression analysis with 18 predictors was performed (1). The result showed that the strongest correlations existed between the dependent variable, alveolar bone height difference between 1970 and 1980, and the following predictors: 'alveolar bone loss in 1970' ($p < 0.001$), 'age' ($p < 0.001$), 'number of lost teeth' in 1970 ($p < 0.001$), and 'Russell's Periodontal Index' (PI) in 1970 ($p < 0.01$). Inclusion of the remaining 14 predictors increased the coefficient of determination from 0.40 to 0.42.

At present Swedish people in all age groups have more remaining teeth than previously (2, 3). Therefore, it might be of interest to determine the predictors of significance for the progress of alveolar bone loss in a population with a current number of remaining teeth. In such a material predictors other than those mentioned above might be of significance. One such predictor could be smoking (4–6). The aim of the present investigation was to study how the same predictors as in the previous investigation (1) influence the progress of alveolar bone loss in a sample with a current number of remaining teeth over a period of 10 years.

Table 1. Distribution of 349 participants with at least 20 remaining teeth in different age groups

Age, 1970	No. of subjects	Percentage
18–25	109	31
26–35	92	26
36–45	73	21
46–55	51	15
56–65	24	7
18–65	349	100

Materials and methods

Of the inhabitants aged 18–65 years in 1970 (450,000 persons) in the county of Stockholm (old geographic boundaries) an unselected sample of 406 dentate persons was drawn. This material has been described in a previous paper (7). From this sample we excluded 57 individuals who had fewer teeth than the average—that is, the individuals in

Table 2. Variables with quantifications, mean values, and standard deviations (SD) used in the statistical analyses. V1–V18 refer to the 1970 investigation. Reference number in parentheses

	Variables	Units and quantifications	Mean	SD
V1	Sex	Male = 1, female = 0	0.487	0.501
V2	Age	18–65 years	34.8	12.2
V3	Social class	Upper = 1, middle = 2, working = 3	2.14	0.70
V4	Tooth-brushing frequency	Less than once a day = 0, once a day = 1, twice a day or more = 2	1.79	0.51
V5	Tooth-brushing technique	Two dummy variables: a) if horizontal strokes = 1 if other methods = 0	0.086	0.281
V6	Tooth-brushing technique	b) if vertical strokes or roll = 1 if other methods = 0	0.590	0.493
V7	Smoking, general	Smoking = 1, no smoking = 0	0.524	0.500
V8	Smoking, quantified	No smoking = 0, 1–9/cigarettes/day = 1, 10–19/cigarettes/day = 2 >19/cigarettes/day = 3. One pipe fill = 1 cigarette = 1 g tobacco in accordance with Pindborg (8)	1.11	1.19
V9	Frequency of dental treatment	At least one treatment/year = 0, more seldom = 1	0.221	0.415
V10	Number of lost teeth	0–12	5.34	3.01
V11	DMFT	0–32	21.75	5.18
V12	Partial dentures	If present = 1, if not = 0	0.023	0.150
V13	Number of periradicular destructions	Number of periradicular destructions divided by the number of remaining teeth	0.048	0.072
V14	Plaque index	DI-S in OHI-S index by Greene & Vermillion (9)	1.46	0.65
V15	Calculus index	CI-S in OHI-S index by Greene & Vermillion (9)	1.16	0.64
V16	OHI-S index	Greene & Vermillion (9)	2.63	1.23
V17	Periodontal index	PI in accordance with Russell (10)	2.14	1.54
V18	Proximal alveolar bone loss index	ABL index (7)	10.03	5.93

the subsample had at least 20 remaining teeth. Thus the material in the present investigation consisted of 349 persons (Table 1). The individuals were in 1970 and in 1980 examined radiographically, clinically, and by interview about dental care habits, smoking habits, and frequency of dental treatment. The predicting variables used in the present analyses are those examined in the 1970 investigation (5) and are presented in Table 2.

The alveolar bone loss (ABL) in 1970 was recorded in scores denoting 10% of the root length. The mean ABL value for one individual was named the 'ABL index 1970'. For evaluating the difference in alveolar bone height (ABD) between 1970 and 1980 a partial recording index, 12 m, 11 m, 33 d, 31 d, and 41 m, was used (11), and the mean alveolar bone difference for an individual was called the 'ABD index'. No substitution for the sites of the index was used. The alternative to the partial recording was total recording. The ABD index was expressed in percentage of the root length.

Table 3. Distribution of 349 participants with at least 20 remaining teeth in different ABD index groups. Mean and standard deviation of the ABD index was 4.8 ± 3.4

ABD index	No. of subjects	Percentage
0.0–1.9	42	12.0
2.0–3.9	129	37.0
4.0–5.9	91	26.1
6.0–7.9	45	12.9
8.0–9.9	19	5.4
10.0–25.5	23	6.6

The assessment procedure and the examination errors have been described in previous papers (7, 11).

In the analyses the ABD index constitutes the dependent variable. The variables in Table 2 are the predictors of alveolar bone loss over the 10-year period to be analyzed. The statistical methods used were frequency calculations, simple correlation analyses, and stepwise multiple regression analyses.

Table 4. Coefficients in the correlation between the alveolar bone difference, the ABD index, PI, smoking, general, and the predictors used in the stepwise multiple regression analysis. V1–V18 refer to the 1970 investigation. Significance limits: $r = 0.105$–0.136: $p < 0.05$; $r = 0.137$–0.173: $p < 0.01$; $r > 0.173$: $p < 0.001$; $N = 349$

	Predictor	ABD index	V17	V7
V17	PI	0.48	1.00	0.04
V18	ABL index	0.39	0.71	0.00
V16	OHI-S index	0.34	0.69	0.11
V14	Plaque index	0.33	0.63	0.11
V15	Calculus index	0.32	0.69	0.09
V8	Smoking, quantified	0.25	0.09	0.88
V10	Number of lost teeth	0.25	0.41	−0.07
V7	Smoking, general	0.23	0.04	1.00
V13	Number of periradicular destructions	0.17	0.39	−0.11
V2	Age	0.15	0.46	−0.23
V4	Tooth-brushing frequency	−0.14	−0.13	0.00
V12	Partial dentures	0.14	0.11	−0.01
V11	DMFT	0.10	0.19	−0.03
V5	Horizontal brushing technique	0.09	0.03	−0.01
V9	Frequency of dental treatment	0.06	0.07	0.17
V6	Vertical or roll brushing technique	−0.03	0.04	−0.01
V3	Social class	−0.01	−0.02	0.08
V1	Sex	0.00	0.07	0.07

Results

The mean values and standard deviations for the 18 predicting variables used in the analyses can be seen in Table 2. The mean and standard deviation of the dependent variable, the ABD index, was 4.8 ± 3.4% of the root length. The ABD indices are grouped in six classes in Table 3, and it can be seen that 49% of the individuals had an ABD index lower than 4.0—that is, an alveolar bone loss in 10 years less than 4% of the root length. Only 6.6% of the subjects had an ABD index higher than 10.0.

The simple correlation analyses showed that the correlations between the ABD index and 12 of the 18 predictors were significant ($p < 0.05$) (Table 4).

In the stepwise multiple regression analysis (Table 5) two predictors reached significance at the 1% level. The dominant predictor was PI (V17), followed by smoking, general (V7). The coefficient of determination, R^2, was 0.28. The first predictor, the PI, had an R^2 value 0.23. The regression coefficient 1.05 for PI implies that an increase in mean value of PI by one unit corresponds to an estimated average increase of the ABD index by 1.05% of the root length. The means of the ABD index in different PI intervals are given in Fig. 1.

In a previous investigation of 406 individuals with ABD index as the dependent variable four predictors were significant at the 1% level: ABL index 1970, age, number of lost teeth, and PI (1). When these predictors and smoking, general, were used in a multiple regression analysis in the present investigation, the coefficient of determination reached the value 0.30. Including all variables as predictors, irrespective of significance levels, the coefficient of determination increased to 0.33. In this analysis the predictor OHI-S index was excluded because it is a summation of plaque index and calculus index.

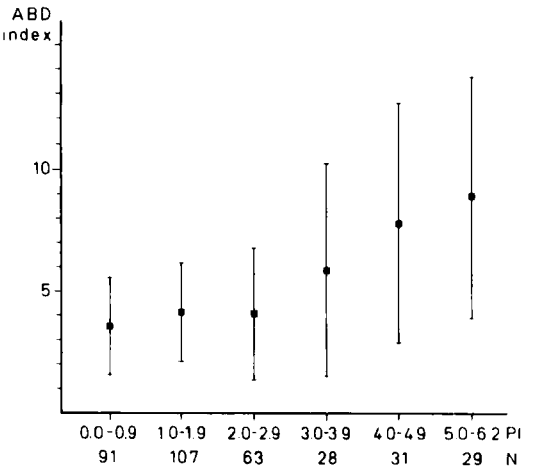

Fig. 1. The means of the ABD index for the 349 individuals in different PI intervals, with the standard deviations.

The difference between the ABD indices for smokers and non-smokers increased ($p < 0.05$) with increasing value of PI (Fig. 2). Even at low values of PI the results suggested that the smokers had a higher ABD index than non-smokers.

When the material was analyzed in terms of smoking, quantified, in 1970 versus ABD

Table 5. Stepwise multiple regression analysis with alveolar bone difference 1980–1970 (the ABD index) as the dependent variable and the V1–V18 in Table 2 as predictors. The individuals constituting the material for the analysis ($N = 349$) had at least 20 remaining teeth. The variables refer to the 1970 investigation

	Predictor	Regression coefficient		t	Significance
V17	Periodontal Index	1.05	0.10	9.99	$p < 0.001$
V7	Smoking, general	1.46	0.32	4.67	$p < 0.001$
	Intercept	1.82			

$R^2 = 0.28$.

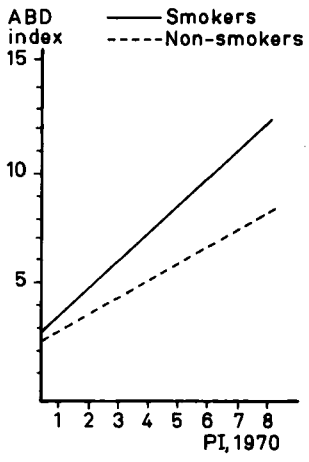

Fig. 2. The regression of the relation between smokers and non-smokers in the ABD index and the periodontal index 1970 (PI). The regression equation was ABD index = 2.34 + 0.49(V7) + 0.79(V17) + 0.44(V7)(V17).

index, a tendency to increasing ABD index was found with increasing tobacco consumption (Table 6). When controlling for PI, the dose-response effect became weaker.

Discussion

Long-term longitudinal investigations of alveolar bone loss are scarce. Since periodontitis usually progresses slowly, an investigation of progression needs a long interval between the examinations. It has therefore been an advantage to use a 10-year observation period. In spite of this long interval there is a need for a technique with high precision and minimum loss of measurable sites (11).

In the present investigation the material is selected with regard to the number of remaining teeth. The dental prophylaxis and the changed attitudes among the population have resulted in less tooth mortality. The number of remaining teeth will probably increase further in future populations. The current number of remaining teeth may be 20 or more. For that reason only individuals with at least 20 teeth are included in the analyses. This level is supported by the results in a previous paper (1). Furthermore, multiple regression analysis has been performed for subjects with at least 16 and with at least 24 remaining teeth. The predictors in significant positions were the same as in the sample with at least 20 remaining teeth.

The two variables plaque index and calculus index have a significant correlation with the ABD index (Table 4). However, Russell's PI may also be interpreted as being related to bacteriologic factors. This explains the fact that plaque index and calculus index did not attain significant positions in the stepwise multiple regression analysis. These factors have been absorbed by PI.

The correlation between smoking, general, and PI was weak ($r = 0.04$). The weak correlation might be explained partly by the fact that PI is positively correlated to age, whereas smoking, general, was negatively correlated to age. When we analyzed for age, the correlation coefficient increased to 0.17.

Table 6. Mean and standard deviations of the ABD index for non-smokers and smokers in three classes. The daily tobacco consumption is expressed as number of cigarettes or grams of tobacco. Standardization is performed by means of regression analysis, and the mean PI of the non-smokers is used as standard

Smoking quantity, 1970	No. of individuals	ABD index		Mean ABD index when standardized for PI
		Mean	SD	
Non-smokers	166	4.0	2.71	4.0
1–9	45	5.0	4.36	5.1
10–20	73	5.5	3.16	5.5
>20	65	6.1	4.11	5.6

Table 7. Multiple regression analysis to examine the internal validity of Russell's Periodontal Index. The ABD index is the regressand, and the regressors are the fractions of teeth assigned 1, 2, 6, and 8 in accordance with Russell's index

Regressor	Regression coefficient	SE
1	0.26	1.02
2	2.13	1.08
6	5.69	0.99
8	14.09	18.26

$R^2 = 0.231$.

In Russell's PI the scale 0, 1, 2, 6, 8 has been used. To investigate whether any other scale would improve the correlation with the ABD index, a multiple regression analysis with the ABD index as the dependent variable was performed. Four independent variables were introduced into the regression model: for each individual the fraction of teeth assigned 1 in accordance with the Russell system, the fraction assigned 2, the fraction assigned 6, and the fraction assigned 8. The value 0 is used as reference. The regression coefficients in Table 7 constitute the scale that maximizes the correlation with the ABD index in this material. The improvement is, however, slight, and the coefficient of determination (R^2) increased from 0.229 to 0.231. The resulting scale shows fairly good correspondence with the original one, and the internal validity of PI is consequently fairly good. It should be noted that the total fraction of PI value 8 was only 1.5‰ (that is, 8 teeth).

Fifty-two per cent of the individuals were smokers, which is the same frequency as in the unselected material (1). The smoking habits seem to be stable, as 296 of the 349 individuals had the same smoking habits in 1970 and 1980. The correlation coefficient between smoking, general, in 1970 and in 1980 was 0.71.

Over several decades several investigations have been made to ascertain whether smoking, in one way or another, has a negative influence on the dental-supporting tissues. Smoking seems to be a significant and complicating factor when the predictors are analyzed for alveolar bone loss (4). In some investigations it is shown that oral hygiene has deteriorated or the plaque index is higher in smokers (12, 13); other studies provide no support for such relations (14, 15).

In a longitudinal investigation of an unselected material of 406 persons (1) there was no significant correlation between the alveolar bone loss and smoking in a stepwise regression analysis. However, when a subgroup of the material mentioned consisting of the individuals with at least 20 remaining teeth was analyzed, smoking, general, assumed a significant level in the multivariate analysis. The different results in the investigations mentioned above can be explained by factors such as selected materials or length of the smoking period.

The tendency to a dose-response relation decreased when it was controlled for PI in a regression analysis; that is, a slight confounding influence of PI was seen.

In preventive and curative periodontal treatment it is important to inform smoking patients that smoking is a factor that accelerates alveolar bone loss. Furthermore, this effect is more pronounced the higher the PI.

References

1. Bolin A, Lavstedt S, Henrikson CO. Proximal alveolar bone loss in a longitudinal radiographic investigation. III. Some predictors with a possible influence on the progress in an unselected material. Acta Odontol Scand 1986;44:257–62.
2. Lavstedt S, Bolin A, Henrikson CO, Jonsson B. Tandtillstånd och behov av tandvård hos en normal population. En longitudinell epidemilogisk studie. Delegationen för social forskning. Rapport 1982:7.
3. Hugoson A, Koch G, Thilander H. Tandhälsotillståndet hos 1000 personer i åldrarna 3 till 70 år inom Jönköpings kommun. Tandlakartid 1974;66:1284–97.
4. Arno A, Schei O, Lövdahl A, Waerhaug J. Alveolar bone loss as a function of tobacco consumption. Acta Odontol Scand 1959;17:3–10.
5. Lavstedt S, Eklund G. Some factors of significance for proximal marginal bone loss studied on an epidemiological material. Acta Odontol Scand 1975; (suppl 67):50–89.
6. Ismail AJ, Burt BA, Eklund SA. Epidemiologic patterns of smoking and periodontal disease in the United States. J Am Dent Assoc 1983;106:617–23.

7. Lavstedt S, Bolin A, Henrikson CO. Proximal alveolar bone loss in a longitudinal radiographical investigation. II. A 10-year follow-up study of an epidemiological material. Acta Odontol Scand 1986;44:199–205.
8. Pindborg JJ. Tobacco and gingivitis. J Dent Res 1947;26:261–4.
9. Greene JC, Vermillion JR. The simplified oral hygiene index. J Am Dent Assoc 1964;68:25–31.
10. Russell AL. A system of classification and scoring for prevalence surveys of periodontal disease. J Dent Res 1956;35:350–9.
11. Lavstedt S, Bolin A, Henrikson, CO, Carstensen J. Proximal alveolar bone loss in a longitudinal radiographical investigation. I. Methods of measurement and partial recording. Acta Odontol Scand 1986;44:149–57.
12. Preber H, Kant T. Effect of tobacco-smoking on periodontal tissue of 15-year-old schoolchildren. A clinical and radiographical study. J Periodont Res 1973;8:278–83.
13. Preber H, Kant T, Bergström J. Cigarette smoking, oral hygiene and periodontal health in Swedish army conscripts. J Clin Periodontol 1980;7:106–13.
14. Swenson HM. The effect of cigarette smoking on plaque formation. J Periodontol 1979;50:146–7.
15. Bergström J. Short-term investigation on the influence of cigarette smoking upon plaque accumulation. Scand J Dent Res 1981;89:235–8.

Received for publication 14 April 1986