Proximal alveolar bone loss in a longitudinal radiographic investigation

II. A 10-year follow-up study of an epidemiologic material

Stig Lavstedt, Anders Bolin and Carl O. Henrikson
Department of Oral Radiology, School of Dentistry, Karolinska Institute, Stockholm, Sweden

Lavstedt S, Bolin A, Henrikson CO. Proximal alveolar bone loss in a longitudinal radiographic investigation. II. A 10-year follow-up study of an epidemiologic material. Acta Odontol Scand 1986;44:199–205. Oslo. ISSN 0001–6357.

Four hundred and six individuals from an unselected sample from the County of Stockholm aged 18–65 years in 1970 were examined radiographically in 1970 and 1980. The differences in proximal alveolar bone height were recorded, attention being paid to the divergences in projection between the two investigations. The mean of the alveolar bone difference was 5.5% of the mean root length, which corresponds to an average annual bone loss of 0.09 mm. Ninety per cent of the individuals had a difference in alveolar bone height of less than 10% of the root length—that is, an average bone loss of 1.6 mm or less during 10 years. By linear regression analysis it was shown that the difference in alveolar bone height is a function of the initial bone loss; that is, the greater the initial bone loss, the greater the alveolar bone loss during the 10-year period. The result of the regression analysis may facilitate predictions of alveolar bone loss. □ *Dental radiography; periodontology, clinical study*

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

In investigating the loss of alveolar bone by means of radiographs, different techniques have been used—both rotational panoramic and intraoral examinations. The intraoral techniques have been full-mouth examinations completed by the bitewing technique. To assess the alveolar bone loss on the radiographs, different reference units have been used, such as the length of the root (1–3), the length of the tooth (4–7), and the length of the crown (8–10).

For long-term longitudinal investigations it is important to choose an adequate and reproducible radiographic technique. Furthermore, the assessment of the proximal alveolar bone level has to be performed in such a manner that well-defined measuring points are selected which can be identified on the radiographs to be compared and can provide high-precision measurements with a minimum of dropouts.

Longitudinal investigations have mostly been performed on selected materials. The purpose of the present investigation was to determine the progress of alveolar bone loss assessed on intraoral radiographs in a longitudinal study of an unselected population.

Materials and methods

In 1970 the population of the County of Stockholm (old geographical boundaries) consisted of roughly 450,000 inhabitants aged 18–65 years, and from these an unselected sample of 1423 individuals was drawn. They were examined with regard to their need for medical, social, and dental care. There were 32 refusals and unavailable persons. Thus the dropout rate was 2.25%.

The sample was divided into two statistically equivalent parts, and one of them, consisting of 669 individuals, constituted the total material for a dental follow-up study in 1980. The interval between the midpoints of the two investigations was 9 years and 8 months, and in this report the interval referred to is 10 years.

In 1970 the 669 individuals were examined by at least 1 of 3 examination techniques—clinical, radiographic, or interview. At the follow-up study in 1980, 597 of the individuals could be examined by at least 1 of these techniques. The dropout (10.8%) was caused by the death of 32 persons, the emigration of 19 persons, and refusal to participate of 21 persons.

Of the 669 individuals examined in 1970, 591 were examined radiographically. Of these, 463 were re-examined radiographically in 1980; in this group 33 persons were edentate, and 24 had received such extensive dental restorations as to make measurements of alveolar bone loss impossible. The remaining 406 individuals were available for this study.

To investigate whether differences existed between the subjects who were only interviewed and the others, analyses were made concerning the pattern of interview answers, socioeconomic and demographic reports, and important clinical and radiographic results from the 1970 investigation (11). There were no significant differences between the groups with regard to social class, income, sex, or age. The mean age of the group examined in 1980 was 47.6 years, that of the interviewed group 47.8 years, and that of the dropout group 48.1 years. Nor did such variables from the 1970 investigation as 'number of remaining teeth', 'alveolar bone loss score', 'presence of complete dentures', and 'presence of fixed bridges' show significant differences between the groups. These results suggest that the material available for analysis in 1980 still represents an unselected population.

The radiographic investigation was performed as an intraoral full-mouth survey with standardized paralleling and long-cone technique and 2–4 bitewing radiographs. The same alignment principles were used in 1970 and 1980.

Assessment procedure

The radiographs from the examination performed in 1970 had been evaluated with regard to the alveolar bone loss by a method described by Schei et al. (1), without the 1-mm space in the ruler (12). The alveolar bone loss was thus expressed in scores denoting tenths of the root length. Score 1 was equal to less than 10% of the root length, score 2 was equal to 10% but less than 20%, and so on. The score at a single-root side was named MBL value, and the mean of the MBL values at all measuring sites of a subject was called the MBL index. The MBL index is linearly transformed to the ABL (alveolar bone loss) index by the formula:

$$\text{ABL index} = 10 \times \text{MBL index} - 5.$$

Thus, the ABL index is expressed in percentage of the root length.

To evaluate the difference in alveolar bone height between 1970 and 1980, the measurements were made with vernier calipers with an accuracy within 0.05 mm (Kanon Dial Caliper-50), and the values were expressed in tenths of a millimeter.

Only periapical radiographs were used. The difference between 1970 and 1980 with regard to the percentage relation between the alveolar bone height and the length of the root side for each site has been called the ABD value (alveolar bone height difference), and the mean of the ABD values in a subject has been named the ABD index.

To reduce the number of measurements from about 70,000 in the entire material to a moderate number, a method for partial recording was used (13). Thus, in individuals with at least 15 measurable sites, measurements have been made at the following tooth sides: 12 mesially, 11 mesially, 33 distally, 31 distally, and 41 mesially. When 1 or more of the sites were unmeasurable or less than 15 sites were available in an individual, a recording of all measurable tooth sides was made. The construction of this partial index is described in greater detail in a separate paper (13).

Two of the authors examined simultaneously the radiographs from 1970 and 1980 for each subject. The intraexaminer error of the ABD index was determined by duplicate assessments of 27 randomly selected subjects. The re-examinations were made 3 years after the first examination, and the correlation between the two examinations was calculated.

Furthermore, the intraexaminer variation was estimated as the standard error of an estimate of a single determination, S_d, which is related to the precision and is calculated by the formula

$$S_d = \sqrt{\frac{\Sigma d^2}{2n}},$$

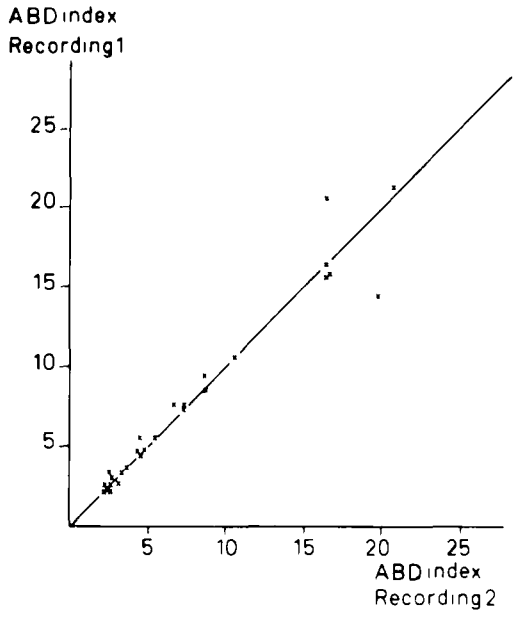

Fig. 1. Scatter diagram of the two determinations of ABD indices of 27 randomly selected full-mouth surveys ($r = 0.97$).

where d is the difference between the two recordings and n is the number of individuals.

Results

Intraexaminer error

The two determinations of the ABD index resulted in mean values and standard deviations of 7.72 ± 5.90 and 7.77 ± 5.86. The correlation coefficient between the two examinations was 0.97. The precision, expressed as the standard error of an estimate of a single determination, was 0.93. This corresponds to 12% of the mean values mentioned above. The distribution of the individual values of ABD indices from the two determinations is given in Fig. 1.

Progress of proximal alveolar bone loss

The mean and standard deviation of the ABD index was 5.5 ± 4.99. This corresponds to an average bone loss of 0.9 mm, since the mean root length was 16 mm. Table 1 shows the ABD index in different age groups. With some exceptions the ABD index increased with age. The most noteworthy divergence concerned the oldest group. Also notable was the size of the standard deviations. Men in most of the age groups had higher ABD indices than women. When the subjects were grouped by their ABD index (Table 2), 60% of them had an ABD index lower than 5.0 and 10% an index higher than 10.0.

Table 1. ABD index, mean and standard deviation (SD) (alveolar bone loss in the period 1970–1980 determined in percentage of the mean root length): age and sex distribution ($N = 406$)

Age in 1970, years	ABD index								
	Men			Women			Both sexes		
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD
18–20	15	4.2	3.06	14	4.5	2.66	29	4.3	2.83
21–25	37	4.5	3.00	44	4.2	2.01	81	4.3	2.50
26–30	28	4.3	4.18	30	4.3	1.82	58	4.3	3.16
31–35	25	6.0	4.34	15	5.2	4.11	40	5.7	4.22
36–40	25	4.9	3.17	19	6.2	3.35	44	5.5	3.27
41–45	18	5.7	3.09	21	6.5	5.92	39	6.2	4.78
46–50	21	7.1	7.91	23	4.6	3.08	44	5.8	5.97
51–55	10	7.3	5.95	17	6.7	4.82	27	6.9	5.16
56–60	12	10.9	11.36	15	8.6	11.19	27	9.7	11.11
61–65	11	6.7	6.73	6	6.5	4.38	17	6.6	5.90
18–65	202	5.7	5.37	204	5.4	4.60	406	5.5	4.99

Table 2. The distribution of the subjects by ABD index

ABD index	Subjects in the sample	
	No.	%
0.0–0.9	13	3
1.0–1.9	33	8
2.0–2.9	70	17
3.0–3.9	74	18
4.0–4.9	57	14
5.0–5.9	40	10
6.0–6.9	30	7
7.0–7.9	24	6
8.0–8.9	12	3
9.0–9.9	11	3
10.0–13.9	20	4
14.0–50.0	22	6
Total	406	99

Mean ABD index, 5.5; SEM, 0.2517.

The correlation coefficient between the ABL index in 1970 and the ABD index was 0.58, which is significant ($p < 0.001$). As can be seen in Fig. 2, however, the variation between individuals is considerable.

From the equation and the diagram it can be seen that the bone loss rate is a function of the initial bone loss, the ABL index. The group that in 1970 had an ABL index of 10% of the root length (which approximately represents the mean of the sample) is estimated to have had an average bone loss of 5.0%—that is, a bone loss of 15.0% after 10 years. The group with an estimated initial loss of 20% had, on an average, 28.7% bone loss in 1980, and the group with an estimated initial loss of 30% had, on an average, 42.4% bone loss in 1980.

The alveolar bone loss index (ABL index 1970) was evaluated on the radiographs obtained in 1970 and is given in Table 3. To study the correlation between the ABL and ABD indices, a linear regression analysis was performed. The ABD index constituted the dependent and the ABL index the independent variable. The analysis gave the following regression equation (Fig. 2):

$$\text{ABD index} = 1.323 + 0.368 \times \text{ABL index}.$$

Table 3. ABL index 1970, mean and standard deviation (SD) in age groups (the ABL index is expressed in percentage of the root length; $N = 406$)

Age in 1970, years	ABL index 1970		
	n	Mean	SD
18–20	29	5.8	1.2
21–25	81	6.1	1.5
26–30	58	6.6	2.2
31–35	40	10.8	5.6
36–40	44	12.6	6.2
41–45	39	15.0	7.9
46–50	44	16.2	9.0
51–55	27	21.4	11.9
56–60	27	20.8	10.6
61–65	17	21.7	6.9
18–65	406	12.0	8.3

Discussion

In previous longitudinal studies of proximal alveolar bone loss the material consisted of patients or students at dental schools, patients of general practitioners, or employees. All these populations might be regarded as selected. The present material, however, consists of inhabitants of the County of Stockholm. This region was composed of both urbanized areas and rural areas. The central part of Stockholm was not included. Since the unchecked dropout of the original sample was small and the remaining dropout did not significantly differ from those investigated with regard to demographic and some dental variables, the material may be regarded as representative of the 450,000 inhabitants aged 18–65 years in 1970.

The material, randomly selected for determination of the error, consisted of 20 individuals with ABD index lower than 10 and 7 individuals with ABD index higher than 10. For all individuals with the lower ABD index there was close agreement between the two determinations. In the group with higher ABD index there were two subjects with marked differences. This may be explained by the fact that in radiographic sets representing high ABD indices the choice of measurable sites and of measurement method

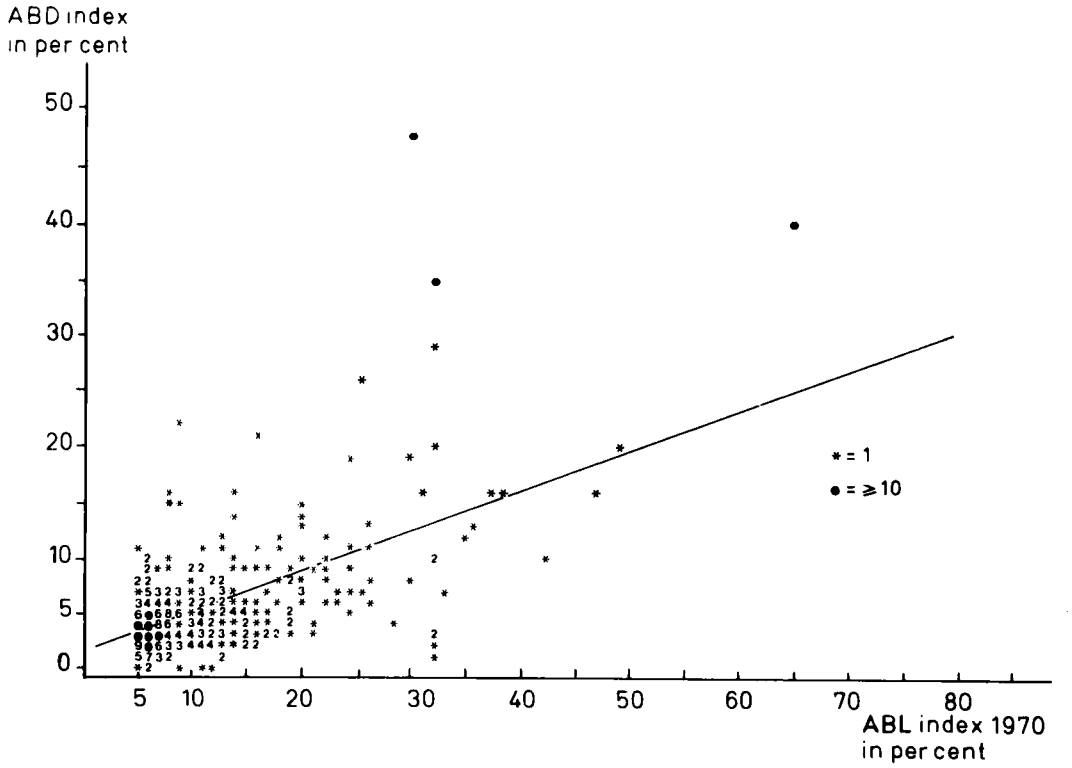

Fig. 2. Scatter diagram of the ADB indices (alveolar bone height difference 1970–1980) and the ABL indices (alveolar bone loss 1970). The scatter diagram covers 406 individuals. The regression line is determined from individuals constituting the material.

(12) may differ between the two determinations. For the whole material only 10.4% had an ABD index higher than 10.

It should be noted that the alveolar bone loss is underestimated because several teeth had been lost after severe periodontitis. Of the total 389 teeth (third molars excluded) lost in the material during the period 1970 to 1980, approximately one fourth had an alveolar bone loss of two thirds or more of the root length in 1970.

When the results of the present investigation are compared with previous ones, it is necessary to consider differences in mean age and periodontal health of the subjects and differences in radiographic methods. Furthermore, when the alveolar bone loss is expressed in absolute measures, the different degrees of magnification will influence the results. Thus panoramic radiographs involve a magnification of 20–40% (14), whereas the magnification of intraoral radiographs is about 5–10%. No correction for magnification has been made in the present investigation or in previous investigations based on intraoral radiographs from 1970.

Good correspondence was observed between the present and most of the previous radiographic studies. The average annual alveolar bone loss in the investigation in which intraoral radiographs were used ranged between 0.03 and 0.07 mm (3, 9, 15). In panoramic radiographs the value was 0.07 mm after correction for a 30% magnification (6, 7, 14). In a cross-sectional study performed by means of orthopantomograms alveolar bone loss was observed in 249 individuals aged 18–60 years. The mean annual loss was 0.06 mm (16), and this had been corrected for in the enlargement.

On the other hand, studies in which clinical probing was performed showed a more

rapid rate of loss of periodontal tissue than those with radiographic measurements. Thus, in longitudinal studies an annual increase in pocket depth of 0.20 mm or more was found (17–19). The divergence between clinical probing and radiographic investigations concerning destructive periodontitis does not seem to accord with the findings of Suomi et al. (20), who demonstrated that there was no significant difference between probing and radiographic measurements.

In the present investigation the progression of alveolar bone loss increased with age. This is in agreement with some other investigations. Björn (6) and Söderholm (7) found a tendency to increased rate of bone loss with age. The former investigation comprised a period of 6 years and the latter 9 years. In another longitudinal study (3), however, the yearly rate of bone loss was not found to be greater in older than in younger patients. However, in that study the assessment technique was coarse and the material relatively small.

As can be seen in Fig. 2, the bone loss rate during the 10-year period is dependent on the initial bone loss. Assuming that all factors constituting the periodontal conditions are unchanged compared with the period 1970–1980, a prediction of the changes in alveolar bone loss might be made. If an initial value of ABL index (ABL_0) is given, it is possible to estimate the alveolar bone loss with the aid of the regression equation after 10 (ABL_{10}), 20 (ABL_{20}), 30 (ABL_{30}), and 40 (ABL_{40}) years. The average bone loss at these times can be expressed by the following equations:

$$ABL_{10} = 1.323 + 1.368 \times ABL_0$$

$$ABL_{20} = 3.133 + 1.871 \times ABL_0$$

$$ABL_{30} = 5.609 + 2.560 \times ABL_0$$

$$ABL_{40} = 8.996 + 3.502 \times ABL_0$$

The regression lines corresponding to these equations can be seen in Fig. 3.

A prediction of the alveolar bone loss for groups of individuals with certain average levels of alveolar bone height may be based on the regression equations given (Fig. 3). This can be exemplified as follows.

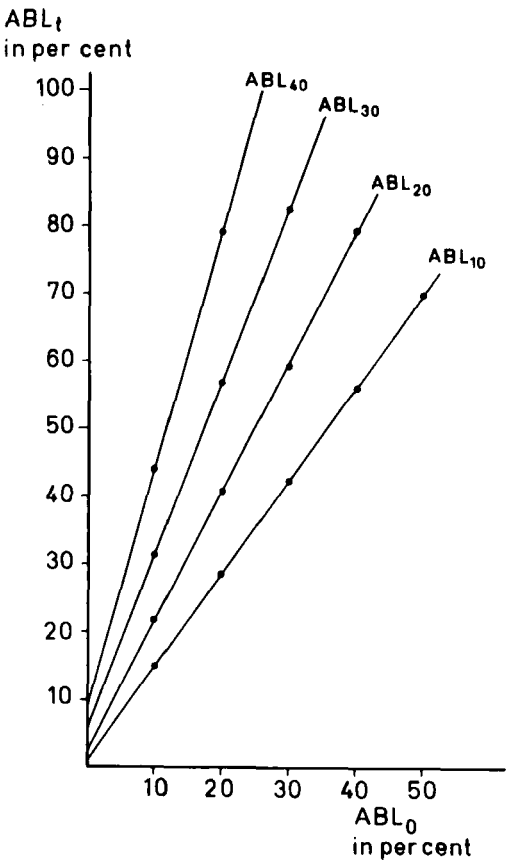

Fig. 3. Regression lines for the relation between the ABL_0 (alveolar bone loss 1970) and the predicted ABL_t after 10, 20, 30, and 40 years. The measures ABL_0 and ABL_t represent the alveolar bone loss in percentage of the root length. $N = 406$.

A group of individuals with a mean value of initial ABL_0 index of 50% will reach the same bone height after 10 years as a group with an initial ABL_0 index of 25% after 30 years. The attempt to predict the progress of periodontitis is based on the assumption that the factors influencing the bone loss are unchanged. The assumption may be supported by the fact that there is a good agreement with other radiographic investigations carried out on different populations and at different times.

In the present investigation mean values of the alveolar bone loss over time have been determined for individuals, groups of individuals, and the whole population. No atten-

tion has been paid to the bone loss at different sites, although it is well known that bone loss is irregular in many individuals (21). However, our purpose has been to evaluate mean values of the progress of destructive periodontitis, which is also of interest for estimating the need for dental treatment of a Swedish population. As is shown in Table 2, most of the subjects had a very small alveolar bone loss during the period, and only 10% had an ABD index greater than 10.0—that is, 1.6 mm average bone loss during 10 years.

Acknowledgements.—This work was supported by grants from the Karolinska Institute, and financial support has also been received from the Ministry of Social Affairs, Stockholm, Sweden.

References

1. Schei O, Waerhaug J, Lövdal A, Arno A. Alveolar bone loss as related to oral hygiene and age. J Periodontol 1959;30:7–16.
2. Lavstedt S. A methodological-roentgenological investigation on marginal alveolar bone loss. Acta Odontol Scand 1975;33(suppl 67).
3. Rohner F, Cimasoni G, Vaugnat P. Longitudinal radiographical study on the rate of alveolar bone loss in patients of a dental school. J Clin Periodontol 1983;10:643–51.
4. Engelberger A, Rateitschak KH, Marthaler TM. Zur Messung des parodontalen Knochenschwundes. Helv Odontol Acta 1963;7:34–8.
5. Björn H, Halling A, Thyberg H. Radiographic assessment of marginal bone loss. Odontol Rev 1969;20:165–79.
6. Björn A-L. Dental health in relation to age and dental care. Odontol Rev 1974;27(suppl 29).
7. Söderholm G. Effect of a dental care program on dental health conditions [Thesis]. University of Lund, Malmö, 1979.
8. Håkansson J. Dental care habits, attitudes towards dental health and dental status among 20–60 year old individuals in Sweden [Thesis]. University of Lund, Malmö, 1978.
9. Selikowitz H-S, Sheiham A, Albert D, Williams GM. Retrospective longitudinal study of the ratio of alveolar bone loss in humans using bite-wing radiographs. J Clin Periodontol 1981;8:431–8.
10. Håkansson J, Björn A-L, Jonsson B. Assessment of the proximal periodontal bone height from radiographs with partial reproduction of the teeth. Swed Dent J 1981;5:147–53.
11. Lavstedt S, Bolin A, Henrikson CO, Jonsson B. Tandtillstånd och behov av tandvård hos en normalpopulation. En longitudinell epidemiologisk studie. Stockholm: Delegationen för social forskning, 1982:7.
12. Henrikson CO, Lavstedt S. Precision and accuracy in intraoral roentgenological determination of proximal marginal bone loss. Acta Odontol Scand 1975; 33(suppl 67):26–49.
13. 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.
14. Tronje G, Welander U, McDavid WD, Morris CR. Imaging characteristics of seven rotational panoramic x-ray units. IV. Horizontal and vertical magnification. Dentomaxillofac Radiol 1985(suppl 8):29–34.
15. Soumi JD, West TD, Chang JJ, McClendon BJ. The effect of controlled oral hygiene procedures on the progression of periodontal disease in adults. Radiographic findings. J Periodontol 1971;42:562–4.
16. Markkanen H, Rajala M, Knuuttila M, Lammi S. Alveolar bone loss in relation to periodontal treatment need, socioeconomic status and dental health. J Periodontol 1981;52:99–103.
17. Becker W, Berg L, Becker BE. Untreated periodontal disease. A longitudinal study. J Periodontol 1979;50:234–44.
18. Axelsson P, Lindhe J. Effect of controlled oral hygiene procedures on caries and periodontal disease in adults. J Clin Periodontol 1981;8:239–48.
19. Lindhe J, Haffajee AD, Socransky SS. Progression of periodontal disease in adult subjects in the absence of periodontal therapy. J Clin Periodontol 1983; 10:433–42.
20. Suomi JD, Plumbo J, Barbano JP. A comparative study of radiographs and pocket measurements in periodontal disease evaluation. J Periodontol 1968;39:311–5.
21. Socransky SS, Haffajee AD, Goodson JM, Lindhe J. New concepts of destructive periodontal disease. J Clin Periodontol 1984;11:21–32.

Received for publication 29 October 1985