Changes of Marginal Bone Level in Patients with "Progressive Bone Loss" at Brånemark System® Implants: A Radiographic Follow-Up Study over an Average of 9 Years

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ABSTRACT

Background: Patients have in many studies been identified with progressive bone loss and peri-implantitis problems, but few studies are available where these groups of patients have been followed up.

Purpose: The purpose of this paper is to study further progression of bone loss in a cohort of 182 patients that have been reported to suffer from "progressive" bone loss and peri-implantitis.

Materials and Methods: Altogether, 182 patients that have earlier been identified to suffer from "progressive" bone loss formed the present study group. Data from patients' files have been retrieved, and intraoral radiographs have been analyzed for further bone level changes. Bone loss has been measured from time of inclusion into the present group to last available radiographs. Within each patient, one or several implants were diagnosed to suffer from "progressive" bone loss (affected), whereas others are not (unaffected).

Results: Altogether, 145 patients (80%) were radiographically followed up on an average of 9.1 years (SD 3.77) after inclusion. Twenty-four implants (3.1%) were lost in 16 patients (11%). Marginal bone loss was on an average 0.3 mm (SD 0.75) at stable implants with only small differences between "affected" and "unaffected" implants. In total, 67 implants (8.6%) presented an annual bone loss of >0.2 mm. Oral hygienist treatment and/or peri-implantitis surgery did not neither reduce implant failure rate nor marginal bone loss in 88 treated patients as compared with untreated patients.

Conclusions: Less than one-third of the patients identified with "progressive bone loss" showed one or more implants as failures or with high annual bone loss (>0.2 mm) during follow-up (11.6% of implants). Treated patients (oral hygienist and/or surgery) did not perform better than untreated patients with regard to bone loss or implant failure.

KEY WORDS: bone loss, complication, dental implant, failure, follow-up, intraoral radiography, prediction, peri-implantitis

INTRODUCTION

Several factors have been shown to affect the outcome of dental implant treatment. Esposito and colleagues[1] classified implant failures as biological, mechanical, iatrogenic, and functional. The biological failures were considered being due to endogenous (systemic or local) and exogenous (operator- or biomaterial-related) factors. Progressive peri-implant inflammation is, in most cases, the reason for biologically induced complications.[2] Most likely, implant failures have a multifactorial background.[3,4] Efficient prevention of peri-implantitis problems and, should it occur, efficacious

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treatment modalities is of interest to patients, cost bearers, and the dental profession.[5,6]

Today, it is debated whether the osseointegration technique can be regarded as a safe and reliable treatment alternative or if implant-treated patients should be regarded as potential risk patients for peri-implantitis. Over the years, many have tried to define criteria for long-term success of oral implants. According to Albrektsson & Isidor,[7] a bone loss during the first year in service can be up to 1.5 mm and still be considered to be successful. There are, however, different opinions on the extent of marginal bone loss after the first year in service. Most studies demonstrate minor bone loss in general with a steady state after a couple of years.[8–11] Wennström & Palmer[12] argued that a bone loss <2 mm during the first 5 years should be required for an implant treatment to be considered successful.

Lately, studies have been published demonstrating continuous bone loss in higher frequencies than earlier demonstrated.[13–17] Fransson and colleagues[14] found that 12% of implants (Brånemark System®, Nobel Biocare AB, Göteborg, Sweden) in 28% of the patients exhibited a "progressive" bone loss, that is, one or more implants ("affected") presented a marginal bone level apically to greater than or equal to three implant threads at the last examination (5–20 years after loading) and a more coronal marginal bone level (less than three implant threads) at the 1-year follow-up. In a following study, Fransson and colleagues[18] found that bleeding on probing, probing pocket depth >5 mm, and suppuration following probing were more frequent at implants with than without "progressive" bone loss and reported that all 182 patients suffered from peri-implantitis.[18]

In studies evaluating marginal bone loss around implants, different starting points have been used. Fransson and colleagues[14] and Roos-Jansåker and colleagues[15] used radiographic data from a 1-year follow-up, whereas Snauwaert and colleagues[19] used data from the time of abutment connection. Most studies, however, have used the time of prosthesis insertion as a starting point. One reason behind the decision to choose 1-year data as a starting point might be that the bone loss during the first year in function has been regarded as part of a remodeling phase.

The aim of this follow-up study was to report further change of the marginal bone level at implants with and without "progressive" bone loss in the cohort of 182 patients evaluated by Fransson and coworkers[14,18] on an average 9 years earlier.

MATERIALS AND METHODS

Patients and Clinical Protocol

All patients had been treated with implant-supported (Brånemark System) prostheses at a specialist clinic (Brånemark Clinic, Public Dental Health Service, Göteborg, Sweden) after which the referring dentist became responsible for the maintenance phase.[20] However, all patients were invited to participate in a standardized clinical and radiographic follow-up program at the clinic. Clinical examinations were scheduled for all patients (level 1) one, 5 and thereafter every 5 years following prosthesis insertion. If indicated, patients were recalled for additional checkups (level 2). In addition, all patients were encouraged to contact the clinic whenever experiencing prosthesis or implant related problems (level 3). Intraoral radiographs were taken at the time of the clinical examinations (level 1) or, when clinically indicated, with closer intervals.

The present patients were identified from data lists covering patients that had been coded as charged for "annual clinical checkup" (level 1 and 2) at the clinic during 1999 (Figure 1). Those with radiographs showing marginal bone levels at or below the third thread at one or more implants 5 years or more after prosthesis placement but with less bone loss at the first year in function were classified as patients with "progressive" bone loss.[14] Later on, some of the patients were clinically examined to identify signs of inflammation in the mucosa to verify the clinical diagnosis of peri-implantitis.[18]

Data were retrieved regarding time of implant and prosthesis placements and radiographic examinations. It was noted when the patients were radiographically examined for inclusion in the study and later on when they were clinically examined for the mucosal health within the research program.[14,18] It was also noted whether patients had been referred to an oral hygienist or not, and if peri-implantitis surgery had been performed. Information on how many visits at the hygienists or specific information on peri-implantitis surgical technique was not available.

Figure 1 shows a flowchart describing the patient sample from 1999 to May 2004. Out of a total of 1,716 patients recorded as "checkup" patients at the clinic in

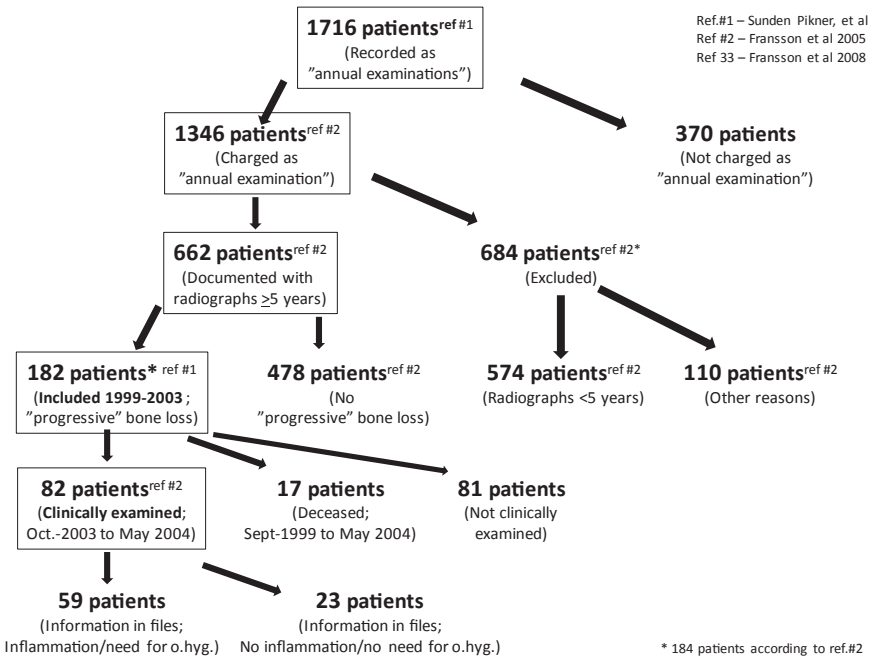

Figure 1 Inclusion and follow-up of patients.

year 1999 (level 1 and 2), 1,346 patients had been charged for "annual checkup examination." Among these patients, 182 were diagnosed to have "progressive" bone loss.[14] One hundred thirty-two of these patients (72.5%) had been followed up for 5 years or more already in 1999, whereas the remaining 50 patients were consecutively included up to 4 years later when all 182 patients had reached a follow-up time of at least 5 years.

Of the 182 patients with "progressive" bone loss, 82 patients (45.1%) were clinically examined from October 2003 to May 2004 (Figure 1) with regard to mucosal health at "affected" and "not affected" implants.[18] In 59 (72%) of these patients, the patient records indicated inflamed soft tissue, bleeding on probing and/or deep pockets at one or more of the implants, and a need of oral hygienist treatment. For the remaining 23 patients, no such comments were found in the files, (i.e., good clinical health was registered).

Present Study Group

The present study group consists of 182 patients (79 men) with a mean age of 57.6 years (SD 11.94, range 20–83 years) at implant placement surgery. Distribution of the 182 patients, representing 195 jaws, with regard to year of prosthesis placement is presented in Figure 2. The majority of the treated jaws had been edentulous (62 upper, 70 lower jaws). A total of 1,029 turned Brånemark System implants were placed according to standard two-stage surgical protocol between 1979 and 1998.[21] Fixed, screw-retained prostheses were placed 1 to 2 months after abutment connection surgery and then followed up as accounted for above. Occasionally, patients failed to show up as exemplified by the observation that 1-year radiographs were missing for 12 patients (Table 1).

Radiographic Evaluation

Intraoral radiographs obtained at the clinical examination that was the endpoint for inclusion into this group after at least 5 years of follow-up and the following last radiographic examination available (termination of the

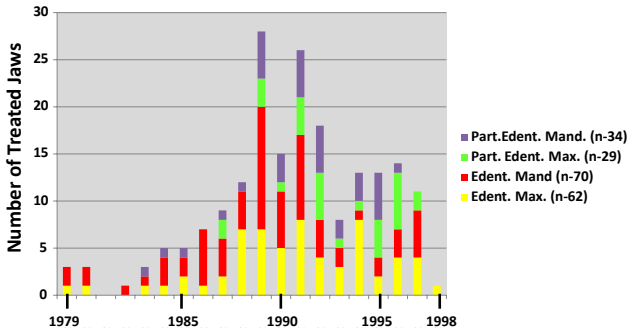

Figure 2 Distribution of included jaws ($n = 195$) in relation to year of treatment.

TABLE 1 Measured Patient (Jaw) and Implant Bone Levels (in Millimeters) at Different Time Periods

	Abutment	Prosthesis	1 Year	Inclusion	Follow-Up
Mean follow-up (years)	0		1	7.8	9.1
SD follow-up				2.95	3.77
Jaws, measured	184	186	183	195	154
Jaws, missing	11	9	12	0	41
Patients, measured	171	173	170	182	145
Patients, missing	11	9	12	0	37
		Mean Patient Bone Level			
Mean bone level	0.4	1.4	2.0	2.6	2.9
SD	0.37	0.65	0.58	0.78	0.99
		Implants			
Measured	954	970	946	990	754
Missing	57	51	72	0	215
Nonreadable	14	3	5	13	10
Removed (earlier period)		4	5	6	26
Removed (period)	4	1	1	20	24
Total implants	1029	1029	1029	1029	1029
Bone level (mm)			Number of Implants (%)		
0–1.8	919 (96)	726 (75)	475 (50)	265 (27)	183 (24)
1.9–2.4	24 (3)	156 (16)	285 (30)	277 (28)	177 (23)
2.5–3.0	3 (0)	54 (6)	107 (11)	182 (18)	129 (17)
3.1–3.6	4 (0)	18 (2)	51 (5)	126 (13)	116 (15)
3.7–4.2	1 (0)	10 (1)	21 (2)	77 (8)	51 (7)
4.3–4.8	2 (0)	4 (0)	5 (0)	29 (3)	38 (5)
4.9–5.4	1 (0)	1 (0)	2 (0)	16 (2)	24 (3)
>5.5	0	1 (0)	0	18 (2)	36 (5)

Mean value based on patients.

study in July 2012) were analyzed by two oral radiologists. Up to September 2005, the examinations were carried out with an analogue technique, later on by different digital ones. When reading the analogue images, a magnifying lens (×7) with a measuring scale divided in 0.1 mm was used, and when reading the digital ones, the inbuilt measuring function of the PACS (Sectra Imtec AB, Linköping, Sweden) corrected for any magnification. If an implant was displayed in more than one image, measurements were taken in the one showing the largest distance between the reference point (abutment/implant junction; AIJ) and the marginal bone level. Measurements were performed on each implant at mesial and distal surfaces. Only originally placed implants were evaluated. In an earlier publication[22] covering the original radiographic material, high interobserver agreement with a mean difference between the two oral radiologists of 0.25 mm (SD 0.66) was reported.

Statistics

Descriptive statistics are utilised in the present study. Differences between groups of patients were tested by means of *t*-test for independent comparisons. Overall statistical significance was set to 5%, and statistical comparisons were only performed on the patient level.

RESULTS

Of the originally included patients, 37 (20%) were excluded as no follow-up radiographs had been taken. For eight of them, no clinical visits had been done, whereas the remaining 29 patients had been clinically followed-up for an average of 5.0 years (SD 3.82, range 1–12 years). Thus, the remaining study group comprises 145 patients (60 men) and 154 treated jaws (Figure 3).

Up to July 2012, 73 patients (40%) were deceased. Of the deceased patients, 17 had died between September 1999 and May 2004 (Figure 1).

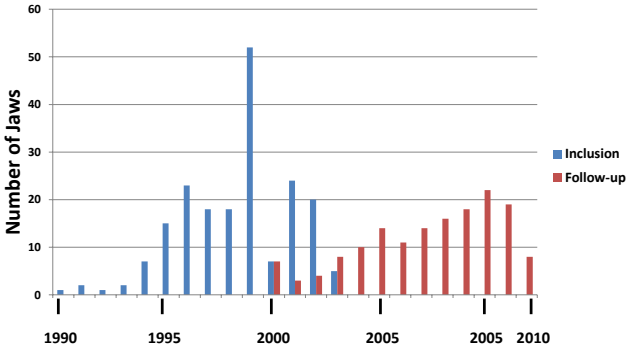

Figure 3 Distributions of jaws with regard to year of the radiographic examination at inclusion ($n = 195$) and at follow-up ($n = 154$).

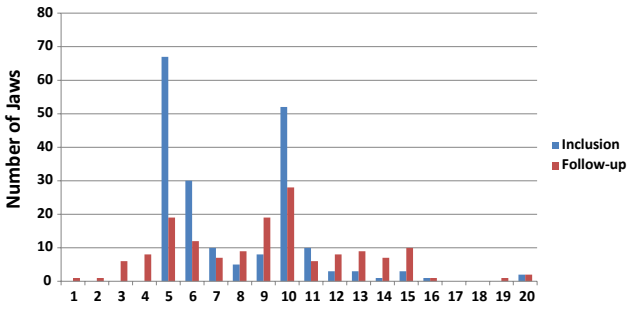

Figure 4 Distribution of jaws with regard to years of follow-up from prosthesis placement to inclusion (inclusion; $n = 195$) and from inclusion to end of study (follow-up; $n = 154$).

In 47 of the original group of 182 patients, inclusion radiographs (5 years or more of follow-up) had been obtained during 1999. In 79 patients, they had been taken before 1999, and in 56, they were taken after 1999. Figure 3 shows the distribution of jaws with regard to when the inclusion radiographic follow-up was made, at which one or more implants with "progressive" bone loss were identified and included in the study by Fransson and colleagues.[14] Figure 3 also shows when the present later follow-ups were made. The mean time from prosthesis placement to being first included was 7.8 years (SD 2.95) with a range of 5 to 20 years (Figure 4). The presently studied 145 patients (154 jaws) were radiographic followed up an average of 9.1 years (SD 3.77) up to July 2012 (Table 1).

Of originally placed 1,029 implants, 50 (4.9%) were recorded as failures, 26 (2.5%) before first inclusion, and 24 (2.3%) after first inclusion up to the end of the study (Table 1). Accordingly, in the present study group, the 24 implant failures were recorded in 16 patients (11.0 %). Among the failed implants, 15 had been described as having "progressive" bone loss ("affected") by Fransson and colleagues,[14] whereas nine did not (Table 2).

No prosthesis was lost, but in three patients provided with altogether 21 implants, the original prosthesis had to be shortened because of implant failures. Total follow-up time was on an average 16.5 years (SD 4.82) from original prosthesis placement to July 2012.

Mean marginal bone level and mean marginal bone loss are presented in Tables 1 and 3. Mean patient marginal bone loss for the present follow-up period was 0.3 mm (SD 0.75) with a small clinical but statistically significant difference ($p < .05$) between "affected" and "unaffected" implants.

Calculated marginal bone loss per year of follow-up is presented in Tables 2 and 4. Altogether, 8.6% of the implants had an annual bone loss of >0.2 mm per year, both observed for "affected" and "not affected" implants. Considering implants with the most severe problems during follow-up (Table 2), 91 implants (11.7%) were either lost or showed a marginal bone loss of >0.2 mm per year in 48 patients (33%). Figure 5 shows the distribution of "affected" and "unaffected" implants with regard to mean annual bone loss during the follow-up period (mean 9.1 years, SD 3.77).

Deceased patients showed a mean bone loss of 0.5 mm (SD 0.76) for 49 followed up jaws. Bone loss

TABLE 2 Distribution of Number of Lost Implants and Implants with Calculated Annual Bone Loss of >0.2 mm during the Follow-Up Period

	Lost Implants		>0.2 mm Bone Loss/Year		Total
Implants	Jaws	Implants	Jaws	Implants	Implants
Affected	10*	15 (4.7%)	28†	44 (13.9%)	59 (18.6%)
Unaffected	7*	9 (2.0%)	17†	23 (5.0%)	32 (7.0%)
Total	16 (11.0%)	24 (3.1%)	38 (24.7%)	67 (8.6%)	91 (11.7%)

*One jaw with both "affected" ($n = 2$) and "unaffected" implants ($n = 1$).
†Seven jaws with both "affected" ($n = 14$) and "unaffected" implants ($n = 10$).
Reported implants were placed in 51 jaws (49 patients) out of 154 followed up jaws (145 patients).

TABLE 3 Patient and Implant-Based Bone Loss in Millimeters for "Affected" and "Unaffected" Implants at Inclusion ($n = 170$) and Follow-Up for the Study Group ($n = 145$)

	Bone Loss at Different Follow-Up Periods					
	First Year to Inclusion (6.8 years)			Follow-Up after Inclusion (9.1 years)		
	Affected	Unaffected	Total	Affected	Unaffected	Total
Patients			170			145
Jaws	180	171[†]	183	146	142[†]	154
Implants	380	539	919	302	450	752
	Mean Patient Bone Loss in mm					
Mean	1.2	0.3	0.7	0.4[‡]	0.2[‡]	0.3
SD	0.85	0.56	0.60	1.06	0.68	0.75
Bone loss (mm)	Number of Implants (%)					
<0.0*	28 (7)	133 (25)	161 (17)	104 (34)	163 (36)	267 (36)
0.0	9 (2)	72 (13)	81 (9)	18 (6)	70 (16)	88 (12)
0.1–0.6	83 (22)	207 (38)	290 (32)	71 (24)	145 (32)	216 (29)
0.7–1.2	127 (33)	85 (16)	212 (23)	49 (16)	44 (10)	93 (12)
1.3–1.8	56 (15)	30 (6)	86 (9)	25 (8)	14 (3)	39 (5)
1.9–2.4	37 (10)	6 (1)	43 (5)	17 (6)	8 (2)	25 (3)
2.5–2.9	20 (5)	4 (1)	24 (3)	8 (3)	2 (0)	10 (1)
3.0–3.5	11 (3)	1 (0)	12 (1)	3 (1)	0 (0)	3 (0)
3.6–4.2	3 (1)	0 (0)	3 (0)	3 (1)	1 (0)	4 (1)
>4.2	6 (2)	1 (0)	7 (1)	4 (1)	3 (1)	7 (1)

*Increased bone level.
[†]11 jaws with only "affected" implants.
[‡]Significant difference ($p < .05$).

reached an average of 0.7 mm (SD 1.01) and 0.3 mm (SD 0.60) for "affected" and "unaffected" implants, respectively.

Mean bone level for lost implants during the present follow-up ($n = 24$) was 3.5 mm (SD 1.37) at the time of inclusion in 1999 to 2003. Five implants presented a bone level of <1.8 mm from the reference point (up to first implant thread), nine between 1.9 and 3.6 mm (up to fourth implant thread), and at the remaining 10, the bone level was >3.7 mm from the reference point and up to more than the fourth implant thread, respectively.

Altogether, 88 patients (61%) had been referred to oral hygienists and/or surgery treated for peri-implantitis. Sixty-five patients (45%) in the study group had been referred to an oral hygienist, whereas 80 were not. Mean marginal bone loss in these groups during follow-up was 0.5 mm (SD 0.80) and 0.1 mm (SD 0.62), respectively ($p < .05$).

Among the follow-up patients, 39 (27%) had been surgically treated for peri-implantitis. Five of them (12.8%) had implants ($n = 7$) that failed during the follow-up period. In patients with no history of surgery ($n = 106$), 11 patients (10.4%) had a total of 17 implant failures during the same period. Mean patient bone level for the two different groups at inclusion was 2.6 mm (SD 0.97) and 2.6 mm (SD 0.92), respectively. Corresponding patient mean marginal bone loss during the follow-up period was 0.5 mm (SD 0.92) and 0.2 mm (SD 0.66), respectively ($p < .05$).

DISCUSSION

The present group was formed with the aim to study the prevalence of patients with "progressive" bone loss and peri-implantitis at the Brånemark Clinic.[14,18] As prevalence is defined as the "total number of patients with a disease in a population at a given time,"[23] both numbers of "affected patients" as well as the "total number" of the patients in the population have to be under control at a "given time." During the present analyses of the patient data, information was revealed that raised questions on whether the study group can be used on a strict scientific basis to calculate prevalence of "progressive" bone loss and peri-implantitis or not. Accordingly, control of "total numbers of patients" can be challenged as a high

TABLE 4 Calculated Marginal Bone Loss in Millimeters per Year of Follow-Up from 1 Year to Inclusion ($n = 170$) and during Follow-Up ($n = 145$)

	Follow-Up Periods					
	First Year to Inclusion (6.8 Years)			Follow-Up after Inclusion (9.1 Years)		
	Affected	Unaffected	Total	Affected	Unaffected	Total
Patients			170			145
Jaws	180	171	183	146	142	154
Implants	380	539	919	302	450	752
	Calculated Mean Patient Bone Loss per Year of Follow-Up (mm)					
Mean	0.18	0.05	0.10	0.05	0.03	0.04
SD	0.17	0.09	0.10	0.17	0.11	0.13
Bone loss mm/year	Number of Implants (%)					
<0.00*	32 (8)	133 (25)	165 (18)	104 (34)	163 (36)	267 (36)
0.00	9 (2)	72 (13)	81 (9)	18 (6)	70 (16)	88 (12)
0.01–0.05	37 (10)	123 (23)	160 (17)	58 (19)	117 (26)	175 (23)
0.06–0-10	61 (16)	90 (17)	151 (16)	38 (13)	50 (11)	88 (12)
0.11–0.15	59 (16)	45 (8)	104 (11)	24 (8)	20 (4)	44 (6)
0.16–0.20	49 (13)	32 (6)	81 (9)	24 (8)	10 (2)	34 (5)
0.21–025	45 (12)	18 (3)	63 (7)	12 (4)	5 (1)	17 (2)
0.26–0.30	29 (8)	13 (2)	42 (5)	4 (1)	3 (1)	7 (1)
0.31–0.35	15 (4)	6 (1)	21 (2)	5 (2)	5 (1)	10 (1)
0.36–0.40	13 (3)	6 (1)	19 (2)	2 (1)	1 (0)	3 (0)
>0.40	31 (8)	1 (0)	32 (4)	13 (4)	6 (1)	19 (3)

*Increase of bone level.

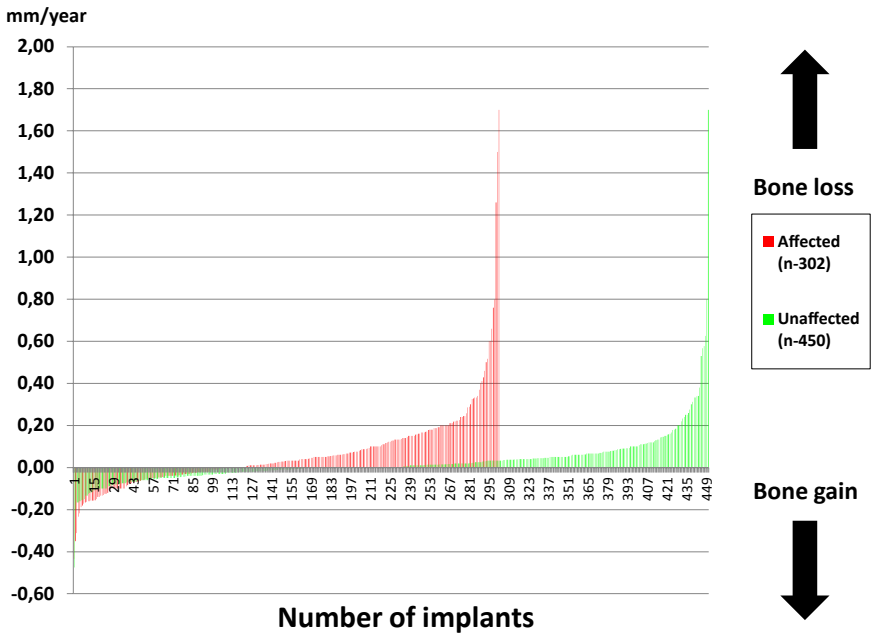

Figure 5 Distribution of "affected" and "unaffected" implants with regard to calculated mean annual bone loss during follow-up.

number of patients deceased during inclusion ($n = 17$ patients; Figure 1); further, not all patients were examined with radiographs at first annual checkup ($n = 12$ patients; 7%; Table 1) or were not clinically examined for peri-implant mucosal health after radiographic inclusion ($n = 81$ patients; 45%; Figure 1). It was also observed that notes in the files indicated a variation in the health of the mucosa in different patients (28% reported no maintenance/mucosal problems). Furthermore, it was noticed that 43% of the total number of examined patients in 1999 was excluded because of missing 5-year radiographs ($n = 574$ patients; Figure 1), even though basically all patients should have passed 5 years in function at the end of inclusion in November 2003. No information is available on whether excluded patients ($n = 574$) really were checked for available 5-year radiographs at the end of the inclusion period or not. After also considering the extended period of time for inclusion (January 1999 to November 2003) as "given time," it must be questioned if reported 28% of prevalence of peri-implantitis[18] is reporting a correct level in the population at a given time of observation in the clinic.

Irrespective of whether the present study group can be used for calculation of prevalence of peri-implantitis or not, the present group of patients represents a common protocol for identifying patients with inflammatory complications and bone loss at the implants. Even though not clinically and radiographically examined at the same time, the inclusion of these patients is based on the basic definition for peri-implantitis with clinical signs of mucosal inflammation in combination with progressive marginal bone loss at the integrated implant.[7] When measuring bone loss, different starting points as well as different periods of follow-up have been used in different studies for inclusion of peri-implantitis patients.[13–19] Also, different levels of bone loss for "affected" and "not affected" implants have been used as well, but always with the protocol that implants/patients with mucosal inflammation and a history of more bone loss are denoted "affected," and those with less bone loss are denoted "not affected."[13–19] Accordingly, the inclusion of patients with peri-implantitis is based on an assumption on linearity of bone loss, where patients with a *history* of more bone loss are assumed to be at a higher risk for *future* bone loss or loss of osseointegration than others. However, there is no strong evidence available for historic bone loss to be a predictor for future bone loss and increased risk for failure in larger populations,[20,24] even though it may be possible to find associations between early and late bone loss in selected populations based on *only* "affected" peri-implantitis patients.[25] Because both implants with no bone loss at inclusion as well as implants with obvious bone loss were lost and removed during follow-up, the present results confirm the problem to identify "affected" implants to have a higher risk for future failure. The prediction of future bone loss at the implants was poor in the present study, here shown as a low prevalence of obvious bone loss at implants (>0.2 mm/year) with a comparable distribution between "affected" and "not affected" implants (Table 2 and Figure 5). Accordingly, only one-third of the included peri-implantitis patients[14,18] exhibited during follow-up one or more implants with excessive bone loss/failure, whereas the remaining two-thirds of the population had no severe problem at all. The present observation challenges the claim that *all patients* identified with peri-implantitis should undergo surgical treatment.[26] Following this recommendation, it may involve an obvious risk of overtreatment as many here included, but untreated, patients with diagnosed peri-implantitis did not show any progression of bone levels at all during follow-up (Figure 5).

The present study population was selected to assess the number of patients with "progressive" bone loss (i.e., >3 mm) at implants with a function time of at least 5 years; hence, it is not surprising to find a mean patient bone level at the end of the follow-up period (mean 9.1 years after the inclusion year) of 2.9 mm (SD 0.99). At inclusion, 266 out of 990 implants (27%) showed a bone level relative to the AIJ >3 mm. The corresponding values at the end of the follow-up period (on an average 9 years later) were 265 out of 754 implants (35%).

A clinically small but statistically significant difference in bone loss between "affected" and "unaffected" implants was noted: 0.4 mm (SD 1.06) versus 0.2 mm (SD 0.68). For the "affected" implants, 3.3% showed a bone loss >3 mm from inclusion of the present study to the end of the follow-up (mean 9.1 years). The corresponding value for "unaffected" implants was 0.9%. Accordingly, a difference in calculated annual bone loss can be expected for "affected" and "unaffected" implants. Albrektsson and Isidor[7] as well as Smith and Zarb[27] proposed a mean bone loss <0.2 mm annually

following the implant's first year in service to meet the success criteria of crestal bone loss. In our patient material, 36 out of the 302 "affected" implants (11.9%) showed an annual bone loss >0.2 mm, whereas the corresponding values for "unaffected" implants were 20 out of 450 implants (4.4%). Still, annual bone loss for this group of patients included on a history of "progressive" bone loss must be considered low (Figure 5).

The observations regarding comparison between untreated patients and patients treated by oral hygienists and those who have experienced peri-implant surgery are difficult to interpret. As this follow-up study focuses on progression of bone loss, no information is available on the clinical oral health, and hence, no results of peri-implantitis treatment. Still, radiographic data indicate a slightly less favorable bone loss at implants in patients who have been treated as compared with untreated patients. In the 65 patients treated by oral hygienists, the mean patient bone loss was found to be 0.5 mm (SD 0.80) as compared with 0.1 mm (SD 0.62) for the untreated 80 patients. A larger mean patient bone loss was also found for patients ($n = 39$) with peri-implant surgery (mean 0.5 mm, SD 0.80) compared with those who ($n = 106$) did not undergo peri-implant surgery (mean 0.2 mm, SD 0.66). The former group lost seven implants (13%), whereas the latter lost 17 implants (10%). Hence, no clear evidence of bone preservation could be observed after treatment by oral hygienists or as a result of peri-implant surgery, even though this does not preclude that a clinically better situation may be at hand with a healthier mucosa. This observation needs further investigations.

Based on the earlier discussed problems with inclusion of the study group, it could be assumed that the present patients have been included with a wide variation of problems from very light to severe signs of inflammation at the implants. Accordingly, some patients have probably shown clear signs of problems, whereas others have shown small if any sign, and it can be assumed that the patients with most problems were more frequently referred to hygienists and later on to surgery. This again indicates that the present study group is not consistent. Present observations further emphasize the need for a better definition of peri-implantitis problems more focused on prediction and future risk of severe complications.

CONCLUSIONS

The following conclusions could be made based on radiographic data from 145 patients of originally 182 "progressive bone loss" patients (80%) followed-up on an average 9.1 years after inclusion:

- Altogether, 91 implants (11.7%) presented severe complications as implant failure or bone loss of >0.2 mm/year in 48 patients (31%) during follow-up. The remaining 97 "peri-implantitis" patients (69%) showed little or no problems with their implants during follow-up.
- Patient mean bone loss was 0.2 and 0.4 mm for "affected" and "unaffected" implants during follow-up ($p < .05$).
- Altogether, 91.4% of followed-up implants showed no or smaller annual bone loss than <0.2 mm during follow-up.
- Patients treated by oral hygienists and/or had experienced peri-implantitis surgery did not show any more favorable progression of bone loss as compared with nontreated patients. However, no data were available on type of treatment or clinical health, and this observation needs to be further analyzed.
- The present study group lacks scientific stringency to be used for calculations of prevalence of peri-implantitis in a population.

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