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# Nine- to fourteen-year follow-up of implant treatment. Part II: presence of peri-implant lesions

**Ann-Marie Roos-Jansåker[1,2], Christel Lindahl[1,2], Helena Renvert[1] and Stefan Renvert[1]**

[1]Department of Health Sciences, Kristianstad University, Kristianstad, Sweden;
[2]Department of Periodontology, Public Dental Health Service, Kristianstad, Sweden

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***Abstract***

**Objectives:** The aim of this study was to analyse the proportions of peri-implant lesions at implants after 9–14 years of function.

**Material and Methods:** Two hundred and ninety-four patients underwent implant therapy during the years 1988–1992 in Kristianstad County. These individuals were recalled to the speciality clinic 1 and 5 years after placement of the suprastructure. Between 2000 and 2002, 218 patients with 999 implants were examined clinically and radiographically.

**Results:** Forty-eight per cent of the implants had probing depth $\geqslant 4$ mm and bleeding on probing (peri-implant mucositis). In 20.4% of the implants, the bone level was located 3.1 mm apical to the implant shoulder. Progressive bone loss ($\geqslant 1.8$ mm) during the observation period was found in 7.7% of the implants. Peri-implantitis defined as bone loss $\geqslant 1.8$ mm compared with 1-year data (the apical border of the bony defect located at or apical to the third thread, i.e. a minimum of 3.1 mm apical to the implant shoulder), combined with bleeding on probing and or pus, were diagnosed among 16% of the patients and 6.6% of the implants.

**Conclusion:** After 10 years in use without systematic supportive treatment, peri-implant lesions is a common clinical entity adjacent to titanium implants.

Key words: bone loss; dental implants; long-term follow-up; mucositis; peri-implantitis; peri-implant lesions; success rate

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Over the last decades, dental implants have become a commonly used treatment alternative to removable and conventional fixed partial dentures. The prognosis of implant treatment is often reported as survival rates (i.e. the implant is still present in the mouth). In a previous publication on the material included in this paper, a survival rate of 95.7% was reported (Roos-Jansåker et al. 2006), which is in concordance with other long-term studies (for a review, see Esposito et al. 1998a, Berglundh et al. 2002). However, in order to describe the outcome of implant treatment more accurately, the clinical condition of the remaining implants needs to be considered (Mombelli et al. 1987, Mombelli & Lang 1998, Leonhardt et al. 1999, Roos-Jansåker et al. 2003). Infections adjacent to implants do occur and the term peri-implant mucositis was proposed for reversible inflammation of the soft tissues surrounding implants. If such an inflammation is combined with loss of bone, it is referred to as peri-implantitis (Albrektsson & Isidor 1994). Peri-implantitis, if not successfully treated, may lead to complete disintegration and implant loss (Esposito et al. 1998b, Quirynen et al. 2002, Leonhardt et al. 2003).

The prevalence of peri-implant mucositis has been reported in the range of 8–44% (Adell et al. 1986, Lekholm et al. 1986, 1999, Spörlein & Stein 1987, Smedberg et al. 1993, van Steenberghe et al. 1993, Bengazi et al. 1996, Jepsen et al. 1996, Behneke et al. 1997), while the prevalence of peri-implantitis has been reported in the range of 0–14.4% (for a review, see Berglundh et al. 2002). The wide ranges reported may partly be owing to differences in defining the two entities, and different lengths of the studies cited.

Periodontal destruction around the teeth is a relatively uncommon phenomenon during their first 20–30 years of function (Hugoson et al. 1998). Although peri-implant disease is a different entity and may not completely mirror periodontal disease progression, there seem to be several similarities (George et al. 1994, Bullon et al. 2004). Therefore, it seems reasonable to anticipate that the frequency of peri-implant lesions will increase as a result of increasing years of function. As of now, limited long-term data exist on

the presence of peri-implantitis (for a review, see Berglundh et al. 2002).

The aim of the present study was to determine the prevalence of peri-implant lesions around titanium implants in function 9–14 years after placement.

## Material and Methods

This study was approved by the Institutional Review Board, University of Lund, Sweden. All participating individuals signed an informed consent. The study reports on patients treated with titanium implants (Brånemark, System®, Nobelpharma, Göteborg, Sweden) at the Public Dental Health Service in Kristianstad, Sweden, from January 1988 to December 1992. During this interval, a total of 294 patients were provided with implant-supported fixed or removable restorations at the Department of Prosthodontics by two prostodontists. 29.4% of the individuals were edentulous before implant placement. The two-step implant surgery procedures were performed either at the Department of Oral Surgery (three oral surgeons) or the Department of Periodontology (three periodontists).

Systemic antibiotics were prescribed to all patients for 10 days starting the day before implant installation. Twice-daily chlorhexidine rinses were recommended until the sutures were removed after 7 days. Submerged implant healing was allowed for a minimum of 3 months. Then, the surgical abutment connection was made, and shortly thereafter, the supra structure was placed. All patients were instructed on how to maintain proper oral hygiene around the implants and the remaining teeth. Subsequently, the patients were referred back to their general dentist for supportive periodontal care and follow-up.

One and 5 years after placement of the suprastructure, the patients were seen at the Department of Prosthodontics for clinical examination, and new sets of intra-oral radiographs using the long-cone technique were obtained. Between January 2000 and December 2002, the patients were recalled for a clinical and long-cone radiographic examination. This final examination was performed 9–14 years after implant placement at the dental clinic of the University of Kristianstad by one and the same examiner (author C. L.). An update of the medical and dental history was made on all patients attending this examination, which included the following recordings under analysis in the present report:

- number of implants;
- implant positioning [(maxillary; mandibulary; anterior (incisor/cuspid region); posterior (pre-molar–molar region)];
- probing-depth measured at four sites (mesial, buccal, distal and lingual) of each implant to the nearest millimetre using a plastic probe with 0.25 N force (Hawe Click-Probe®, KerrHawe SA, Bioggio, Switzerland);
- bleeding on probing, presence or absence, following probing-depth measurement
- suppuration, if apparent, following probing;
- number of implant threads and millimetre not supported by bone at the mesial and distal aspects of the implant on the radiographs (the implant coller measure 1.3 mm and the distance between the threads 0.6 mm).

### Radiographic Examination

Radiographs at the 9–14-years examination were obtained at implant areas using the long-cone technique. The radiographs were analysed for bone-to-implant contact by one and the same examiner (author A.-M. R. J.) using a magnifying viewer (Mattsson viewer, X-produkter, Malmö, Sweden). This examiner also recorded bone-level changes from radiographs obtained of the implant areas 1 year after placement of the suprastructure. Threads not supported by bone, on both the 1- and 9–14-year radiographs, were counted at the mesial and distal site of each implant. The site with the most pronounced bone loss was chosen to represent the implant when calculating implant data.

Bone loss occurring between 1-year radiographic examination and the radiographs, obtained after 9–14 years, were calculated. Radiographs from 10% of the patients were selected for a second analysis of the marginal bone-level adjacent to the implant to assess intra- and inter-examiner variability (authors A.-M., R. J. and S. R.). The radiographs were chosen using a table of random numbers.

### Data analyses

Descriptive statistics on prevalence were calculated and tabulated. SPSS 11.0 statistical software program for PC (SPSS Inc., Chicago, IL, USA) was used for statistical calculation.

## Results

Out of the 294 patients who were provided with implants during the period 1988–1992, 76 patients did not attend the final examination. Twenty-two patients had died, and 54 patients did not wish to participate or were unable to attend because of health reasons. Thus, this report includes a study group of 218 individuals with 1057 implants from whom final 9–14-year data were gathered. Out of the 1057 implants placed, 12 implants in 10 patients were not used in the suprastructure, mostly owing to improper placement of the implant. These implants were considered ''sleeping implants'' and were excluded from analysis. In addition, 46 implants in 22 patients were lost before placement of the suprastructure or during the follow-up period. Thus, 999 implants were available for analysis. The distribution of these implants with respect to location in the oral cavity is presented in Table 1.

Table 2 presents the study population with respect to the length of the observation period. Sixty-five per cent of the patients and 60% of the implants had a follow-up of 11 years or more following implant placement, and 85% of the patients and 80% of the implants had a follow-up of 10 years or more.

The intra- and interexaminer analysis of the selected radiographs demonstrated a complete concordance in 86.2% and 83.5%, respectively (Table 3).

*Table 1.* Implant distribution within subjects ($N = 999$)

| | | Implant per subject | | | Anterior location* | | Posterior location† | |
|---|---|---|---|---|---|---|---|---|
| | no. | % | mean | range | no. | % | no. | % |
| Maxilla | 490 | 49.0 | 3.8 | 1–7 | 312 | 63.7 | 178 | 36.3 |
| Mandible | 509 | 51.0 | 4.3 | 1–6 | 320 | 62.9 | 189 | 37.1 |

*Cuspid-to-cuspid region.
†Pre-molar/molar region.

Table 4 presents the percentages of implants with different degrees of bone loss at the 1-year and at the final radiographic examination. Radiographs from 216 patients were available. Two patients with 12 implants did not agree for radiographic examination leaving 987 implants available for the study. At 21% of the implants the bone level was located at or apical to the third thread (equals ⩾3.1 mm) at the final radiographic examination as compared with 12% at the 1-year examination. Among the drop-outs, 40 patients with 193 inserted implants had 5-year radiographs. Fifteen implants were lost and resulted in 178 implants still in function at 5-year follow-up. Percentages of implants with different degrees of bone levels are presented in Table 5.

The prevalence of peri-implant lesions focusing on probing depth and bleeding only, on patient and implant bases, is presented in Table 6. Clinical measurements were performed on four sites (mesial, buccal, distal and lingual) at 994 implants in 218 patients. Five implants were not measurable, owing to the design of the suprastructure, and were not included in the analysis. Forty-eight per cent of the implants and 76.6% of the patients demonstrated probing depths ⩾4 mm with bleeding on probing, and 7% of the implants and 18.3% of the patients had probing depths ⩾6 mm with bleeding on probing.

The prevalence of peri-implantitis lesions by degree of bone levels, probing depths and bleeding on probing is presented in Table 7. It was observed that 16.0% of the implants and 48% of the patients had pockets ⩾4 mm and bleeding on probing but no concomitant bone loss. Furthermore, 10.4% of the implants with bleeding on probing and 42.1% of the patients had a bone level in the range of three to four threads (3.1–3.7 mm). Twenty-four per cent of the patients and 5.6% of the implants with bleeding on probing had a bone level at ⩾5 (4.3 mm) threads.

If peri-implantitis is defined as bone loss ⩾3 threads (a minimum bone loss of 1.8 mm) following the first year in function combined with bleeding and or pus on probing, 16% of the patients and 6.6% of the implants would be diagnosed to have peri-implantitis after 9–14 years (Table 8). In all cases diagnosed as having peri-implantitis, the apical border of the bony defect was located at or apical to the third thread (i.e. the bone level located a minimum of 3.1 mm apical to the implant shoulder). 7.7% of the implants had progressive bone loss (⩾3 threads) over the period. However, at 1.1% this bone loss was not combined with bleeding and/or pus, and therefore was not diagnosed as peri-implantitis. At 10.7% of the implants, a radiographic peri-implant gain of bone from year 1 to final examination was registered. Bleeding was concomitant in 8.4% of these sites.

*Table 2*. Years of follow-up by patient and implant

| Years of follow-up | Patients ($N = 218$) | Implants* ($N = 999$) |
|---|---|---|
| 9 | 34 (16%) | 196 (20%) |
| 10 | 44 (20%) | 204 (20%) |
| 11 | 64 (29%) | 272 (27%) |
| 12 | 45 (21%) | 197 (20%) |
| 13 | 21 (10%) | 87 (9%) |
| 14 | 10 (5%) | 43 (4%) |

*Number of initially placed implants ($N = 1057$) minus 'sleeping implants' ($N = 12$) and lost implants ($N = 46$).

*Table 3*. Intra- and inter-examiner analysis (% concordance) of the radiographic measurements on the mesial and distal sites of the implants in 26 sampled patients (10% of the population) with a total of 224 sites available for study

| | Intra-sites (%) | Inter-sites (%) |
|---|---|---|
| ± 0 thread | 86.2 | 83.5 |
| ± 1 thread | 12.5 | 9.3 |
| ± 2 threads | 1.3 | 7.2 |

*Table 4*. Prevalence (%) of implants in the study material based on bone levels only, described as threads (mm) not supported by bone at the mesial and/or distal aspect at 1-year examination ($N = 999$) and 9–14-year examination ($N = 987$)

| Threads (mm) | 0 (0–1.3) | 1 (1.9) | 2 (2.5) | 3 (3.1) | 4 (3.7) | ⩾5 (⩾4.3) |
|---|---|---|---|---|---|---|
| 1 year | 53 | 20 | 15 | 8 | 2 | 2 |
| 9–14 years | 40 | 20 | 19 | 9 | 5 | 7 |

*Table 5*. Prevalence (%) of implants in the drop-out group based on bone levels only, described as threads (mm) not supported by bone at the mesial and/or distal aspect at 1-year examination ($N = 178$) and 5-year examination ($N = 178$)

| Threads (mm) | 0 (0–1.3) | 1 (1.9) | 2 (2.5) | 3 (3.1) | 4 (3.7) | ⩾5 (⩾4.3) |
|---|---|---|---|---|---|---|
| 1 year | 47 | 26 | 15 | 7 | 3 | 2 |
| 5 years | 30 | 33 | 22 | 7 | 5 | 3 |

*Table 6*. Prevalence (%) of probing depth (PD) (without attention to presence of bone levels) measured at four sites of the implant, and bleeding/suppuration on patient ($N = 218$) and implant ($N = 994$) basis

| | PPD ⩾4 mm | | PD⩾5 mm | | PPD⩾6 mm | |
|---|---|---|---|---|---|---|
| | bleeding | no bleeding | bleeding | no bleeding | bleeding | no bleeding |
| Patients | 76.6 | 11.0 | 40.8 | 2.3 | 18.3 | 0.9 |
| Implants | 48.1 | 12.3 | 19.0 | 3.4 | 7.0 | 0.9 |

PPD, pocket probing depth.

## Discussion

The patients included in this study were surgically treated with Brånemark implants with a machined surface by specialists in either periodontology or oral surgery. The surgical procedure as well as the initial follow-up were standardized for all individuals. Thereafter, supportive therapy was based on the risk assessments made by the referring general dentist. Available records did not allow any meaningful analyses of the nature and quality of supportive therapy.

Although the mean number of dental visits during the observation period was high (15.3), the range was wide (from 0 to 60 visits). Several of the patients with frequent visits to the dentist, visited the dental clinic owing to mechanical problems related to the implant treatment and not in order to receive suppor-

*Table 7.* Prevalence (%) of peri-implant lesions evidenced by different bone levels in addition to pocket depths and bleeding/suppuration on patient ($N = 216$) and implant ($N = 987$) basis measured at the mesial and distal sites of the implant

| | PPD ⩽ 3 mm | | PPD ⩾ 4 mm | | PPD ⩾ 5 mm | | PPD ⩾ 6 mm | |
|---|---|---|---|---|---|---|---|---|
| | bleeding | no bleeding | bleeding | no bleeding | bleeding | no bleeding | bleeding | no bleeding |
| *Bone level implant shoulder* | | | | | | | | |
| Patients | 35.0 | 15.0 | 48.0 | 20.4 | 16.0 | 3.7 | 3.7 | 1.4 |
| Implants | 14.1 | 4.8 | 16.0 | 5.6 | 4.4 | 0.9 | 1.0 | 0.3 |
| *Bone level one or two threads* | | | | | | | | |
| Patients | 49.0 | 21.3 | 53.7 | 21.3 | 21.8 | 6.0 | 9.7 | 1.4 |
| Implants | 13.6 | 6.0 | 13.7 | 5.7 | 5.2 | 1.4 | 2.2 | 0.3 |
| *Bone level three or four threads* | | | | | | | | |
| Patients | 13.4 | 6.5 | 28.7 | 7.0 | 12.5 | 2.8 | 3.7 | 1.4 |
| Implants | 3.4 | 1.4 | 7.0 | 1.5 | 2.9 | 0.5 | 0.9 | 0.2 |
| *Bone level ⩾5 threads* | | | | | | | | |
| Patients | 5.5 | 2.3 | 18.5 | 4.6 | 8.3 | 2.8 | 3.2 | 0.9 |
| Implants | 1.3 | 0.4 | 4.3 | 1.1 | 1.9 | 0.6 | 0.8 | 0.2 |

*Table 8.* Prevalence (%) of bone level changes evidenced by different amounts of bone loss or gain and bleeding/suppuration on patient ($N = 216$) and implant ($N = 987$) basis, measured at the mesial and distal sites of the implant, between 1-year radiographic control and final examination

| | Bleeding/ suppuration | No bleeding/ suppuration |
|---|---|---|
| *No bone loss* | | |
| Patients | 79.2 | 6.0 |
| Implants | 42.2 | 14.2 |
| *Bone loss* | | |
| *One or two threads* | | |
| Patients | 55.6 | 4.2 |
| Implants | 18.2 | 7.0 |
| *Three or four threads* | | |
| Patients | 14.4 | 0.5 |
| Implants | 4.6 | 0.8 |
| *> Five threads* | | |
| Patients | 7.4 | 0.5 |
| Implants | 2.0 | 0.3 |
| *Bone gain* | | |
| *One or two threads* | | |
| Patients | 24.1 | 1.4 |
| Implants | 8.0 | 2.2 |
| *Three or four threads* | | |
| Patients | 1.4 | 0.5 |
| Implants | 0.4 | 0.1 |

tive periodontal therapy. These data, in combination with a low yearly visit to dental hygienists (0.6 times per year), indicate that this group of patients, as a whole, did not attend a structured supportive treatment programme. This information is of importance evaluating the data provided in this paper on the presence of peri-implant lesions.

The prevalence of peri-implant infections has been reviewed by Berglundh et al. (2002). They calculated that limited data exist on the percentage of peri-implant infections after 5 years. The data presented in our paper may reflect the outcome among subjects who are not attending frequently administered SPT programmes.

Twenty-two patients had died and 54 patients from the total sample did not wish to participate or were unable to attend owing to health reasons. Radiographic data existed for 40 patients in this group at 5 years, and it was found that the percentage of implant loss in this group was higher than in the study group at 5 years (Roos-Jansåker et al. 2006). Also, the 5-year data on bone loss at existing implants available in the drop-out group demonstrated that bone loss was evident at 70% of the implants after 5 years (Table 5). This figure should be compared with the data for the final examination of the study group. It may therefore be pertinent to claim that the percentage of peri-implant lesions at 9–14 years reported in this paper would have been higher if these individuals had participated and could have been included in the analysis.

The intraexaminer analysis demonstrated complete concordance in 86% of the measurements, and the interexaminer analysis demonstrated complete concordance in 83.5%. Pitiphat et al. (2004) concluded that in epidemiological studies valid assessments of periodontal disease may be provided from pre-existing radiographs. Gröndahl et al. (1998) demonstrated a small interobserver variation measuring 0.1 mm changes in bone levels using a $\times 7$ magnifying lens at Brånemark implants.

Peri-implant mucositis has been defined as an inflammatory process affecting the tissues around an osseointegrated implant without loss of supporting bone, and peri-implantitis as an inflammatory process affecting the tissues around an osseointegrated implant with loss of bone (Albrektsson & Isidor 1994). If these criteria to define the two entities had been applied in this paper, 30.1% of the implants would have been diagnosed as having peri-implant mucositis and 43.3% as peri-implantitis. It may therefore be argued that such a strict definition (inflammation+bone loss) of peri-implantitis as the one put forward at the European workshop of Periodontology 1994 may not be useful in clinical practice. Brånemark implants have been shown to show bone loss to the first thread during the healing period and the first year after abutment connection. In the study by Adell et al. (1981), a mean bone loss of 1.5 mm was found during the healing phase and the first year in function. In a paper by Oh et al. (2002) factors like surgical trauma, occlusal overload, micro-gap, biological width, implant crest module and peri-implantitis were suggested as causative factors for initial bone loss to implants.

In this study, after 1 year of function, almost half of the implants demonstrated bone levels at or apical to the first thread. This could be explained by remodelling during the healing phase and/or a possible measurement error of one to two

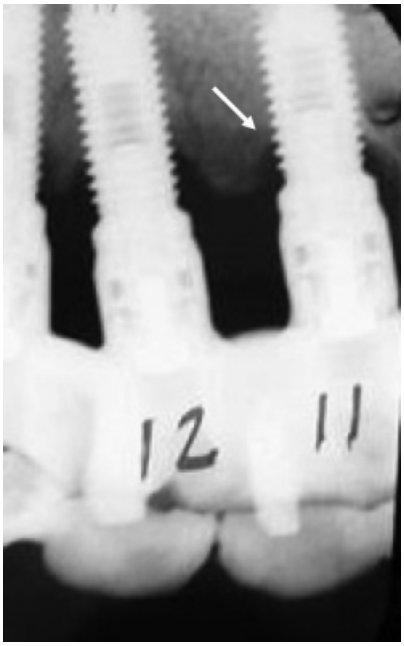


*Fig. 1.* Arrow points at an implant with bone loss amounting to approximately 3 mm after 10 years in function.

threads on radiographs. Therefore, from a clinical point of view it may be more reasonable to define peri-implantitis as implants demonstrating BOP and/or pus that have lost bone in the range of $\geqslant$1.8 mm (three threads in the Brånemark system) following the first year of healing.

10.7% of the implants demonstrated bone gain $\geqslant$1 threads between the 1- and 9–14-year examination. This may represent a true bone apposition, but it may also be owing to the error in the radiographic technique as well as a measurement error while analysing the radiographs (i.e. the final radiograph may be differently angulated in comparison with the 1-year radiograph). A few implants were diagnosed as gaining $>$3 threads. These cases were re-analysed by two independent examiners who agreed on the amount of recorded bone gain. Accordingly, it seems possible that ''bone apposition'' may occur in areas that have lost bone adjacent to implants although no surgical treatment has been performed. The measurement errors described above will most likely also have an impact on the recorded bone loss.

Implant success has been defined as ''bone loss during the first year of function should not exceed 1.5 mm and bone loss after the first year should not exceed 0.2 mm per year'' (Albrektsson et al. 1986). A bone loss of 0.2 mm/year taking a 10-year perspective after the first year of remodelling (1.5 mm) would roughly result in loss of bone support for three threads using Brånemark smooth surface implants (each thread measures 0.6 mm and the implant neck measures 1.3 mm) (Fig. 1). It may, however, be debated whether such a case is to be considered as a success, especially as implants are now frequently used in younger individuals who will need to retain them for much more than 10 years. The use of a new term like ''implant success'' may accordingly inadvertently make implant treatment seem more favourable than it is. Therefore, instead of using arbitrary definitions of success, in this paper we have presented the presence of peri-implantitis lesions using different thresholds for probing depth and presence/absence of bleeding on probing both with and without different degrees of bone loss.

Depending on how peri-implantitis is defined, the frequencies of occurrence will vary considerably and it may accordingly be difficult to compare studies. This was evident in a recent systematic review by Berglundh et al. (2002). They reported frequencies of peri-implantitis in the range of 0–14.4%, with a weighted mean on fixed partial dentures of 6.4%. In one of the included studies (Behneke et al. 2000), 14.4% of the implants (ITI, Straumann, Waldenburg, Switzerland) were reported to have led to peri-implantitis, whereas the two included studies of the Brånemark implant system reported that 0 or 1.6% of the patients had peri-implantitis (Hemmings et al. 1994, Eliasson et al. 2000). These figures previous reported for the Brånemark system are far from what was found in the large group of individuals in the present report. One explanation may be the difference in observation time between the above-cited papers and the present study. It has been pointed out before that it is possible that peri-implantitis will be more frequently found after increasing time within the oral cavity. This view is supported by data from this study (Tables 4 and 5). Another explanation for differences in the prevalence of peri-implant lesions may be differences in the supportive care programme. The patients in this study were not subjected to a uniform supportive periodontal treatment program, which may increase the risk of developing peri-implant lesions. It is most likely that the supported care will influence the outcome of the implant treatment.

In our study 6.6%, of the implants and 16% of the patients were diagnosed as having peri-implantitis (defined as bone loss $\geqslant$3 threads compared with the 1-year follow-up). In a recent study by Fransson et al. (2005), high prevalence of progressive bone loss was also found.

Bone loss in the dropout group was more evident after 5 years than in the study group after 9–14 years. Seventy per cent of implants in the drop-out group had bone levels at or below the level of the first thread after 5 years (Table 5) compared with 60% of the implants in the study group after 9–14 years (Table 4). In a previous paper (Roos-Jansåker et al. 2006), late implant losses were more frequent in the drop out group as compared with the study group (4.5% *versus* 0.3%). It is likely that these implants were lost owing to progressive peri-implantitis. Long-term data based on complying patients, willing to attend dental checkups may not mirror the true clinical reality. Hence, the present study, may to some extent, present more realistic figures in what to expect in the future when a majority of implant therapy and follow-up is performed in general practice.

The data presented in this paper highlight the necessity to report on outcome variables including clinical and radiographic conditions of implants in addition to survival data. For further studies, it is also of importance to analyse patient-related factors involved in the pathological process of peri-implantitis.

In conclusion, peri-implant lesions were a common entity in this patient material. It should, however, be kept in mind that these patients had not been part of a structured supportive periodontal care programme.

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Address:
*Stefan Renvert*
*Department of Health Sciences*
*Kristianstad University*
*291 88 Kristianstad*
*Sweden*
E-mail: stefan.renvert@hv.hkr.se

**Clinical Relevance**

*Scientific rationale*: There is limited information in the existing literature on the prevalence of peri-implant lesions in patient populations who have had their implants for a long period of time.

*Principal findings*: Bone loss of more than 3 mm and pocket depths $\geqslant$6 mm were common around implants after 9–14 years in function.

*Practical implications*: It is of utmost importance that the clinician is aware that peri-implant infections may occur among more than half of the subjects after 10 years if a systematic supportive periodontal therapy is not provided.