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## Prevalence of periimplant disease in partially edentulous patients: a practice-based cross-sectional study

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### Abstract

**Objectives:** Evaluation of the prevalence rates of periimplant mucositis and periimplantitis in partially edentulous patients in a private dental practice.

**Material and methods:** The data of 89 patients were collected (52 female, 37 male, age at time of implant placement:  $51.8 \pm 10.3$  years). All patients had been treated with dental implants of the same type and fixed superstructures between January 1999 and June 2006 (observational period:  $68.2 \pm 24.8$  months).

**Results:** The patient-related prevalence rate of periimplant mucositis (probing depth  $\geq 4$  mm and bleeding on probing [BOP]) was over all 44.9%. The respective rates in non-smokers without periodontal history were 30.4% and in smokers with periodontal history 80%. The multiple logistic regression analysis identified a significant association of mucositis with the independent variable "smoker" (odds ratio [OR] 3.77;  $P=0.023$ ). The patient-related prevalence rate of periimplantitis (probing depth  $\geq 5$  mm, BOP/pus, radiographic bone loss) was 11.2% (smokers with periodontal history: 53.3%, non-smokers: 2.8%). No periimplant disease was diagnosed in non-smoking patients without periodontal history and with a good compliance after treatment. Statistical analysis identified a significant association of periimplantitis with "smoker" (OR: 31.58;  $P<0.001$ ) and "compliance" (OR: 0.09;  $P=0.011$ ). Periodontal history in general showed no significant association with periimplantitis.

**Conclusions:** Smoking and compliance are important risk factors for periimplant inflammations in partially edentulous patients.

Comprehensive data on survival or success of endosseous implants are documented in numerous clinical studies. In the beginning, the studies were focused on successfully osseointegrated implants in different ranges of indication and bone qualities as well as on the influence of various implant designs (Gernhardt & Ulbrich 2000). Subsequent studies evaluated implant failures during the prosthetic period in function more explicitly. Besides technical complications, biological failures were a failure risk for implant restorations during function (Norowski & Bumgardner 2009). In most cases, progressive periimplant inflammation was the reason for biologically induced failures in an advanced state. They destroyed the periimplant hard tissue and finally led to implant loss (Lang et al. 2000).

To some extent, periimplant diseases require comprehensive intervention to save the implant. Moreover, at the moment not all available therapies are based on firm scientific ground. Regeneration of periimplant tissue that was lost due to inflammation is not a predictable outcome.

Therefore, patients, cost bearers, and dental professionals should be interested in an efficient prevention of periimplant diseases. To evaluate the potential effect of periimplant infections on the long-term success of implant therapy, precise information on the incidence of these diseases is required. In a structured review, Zitzmann and Berglundh (2008) noticed that only limited data are available on the frequency of periimplant diseases. The authors evaluated cross-sectional and longitudinal studies covering more than 50 implants with an observational period of at least 5 years each. Frequency of periimplant mucositis ranged between 24% and 91%. Only three publications determined the frequency of periimplantitis, five publications analyzed the data (Karoussis et al. 2004; Bragger et al. 2005; Fransson et al. 2005, 2008; Roos-Jansaker et al. 2006a, 2006b, 2006c). After a period in function of 9–11 years, between 28% and 56% of the patients were diagnosed with periimplantitis.

Several authors presumed that the published frequencies of periimplant diseases rather under-

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estimate the risk of affection due to insufficient diagnosis (e.g. no periimplant assessment of probing depths during routine examinations). Furthermore, many clinical studies only documented relatively short observational periods (Tonetti 1998; Quirynen et al. 2002; Klinge et al. 2005). Considering this, on the long term the disease ratio is likely to be significantly higher. Because of the limited number of studies available and short observational periods, the prevalence rates for observational periods of more than 5–10 years can only be estimated.

To gather sufficient information on the prevalence of periimplant disease, a cross-sectional study design with clinical and radiographic examinations is recommended. Ideally, patients should be recruited from dental practices rather than from universities, thus providing information on the applicability of a therapy in daily practice (Zitzmann & Berglundh 2008).

Based on these recommendations, the present study evaluated the prevalence rates of periimplant diseases in implants placed and followed-up in a private dental office. Besides a merely descriptive analysis (prevalence rates), applicable statistical methods provide information on possible causal coherence of different risk factors and the dependent variables periimplant mucositis and periimplantitis.

## Material and methods

### Patients

The present retrospective cross-sectional study includes the data of partially edentulous patients who were restored with Ankylos implants (Dentsply Friadent, Mannheim, Germany) by a dentist in a private dental office between January 1, 1999 and June 30, 2006. Patients who met the following criteria were included:

- regular or irregular prophylaxis or supportive periodontal therapy (SPT) at the same dental office where the implants had been surgically inserted;
- restoration with a fixed superstructure and a function period of the final prosthetic restoration of at least 24 months;
- panoramic radiograph (PT) immediately after surgery;
- PT within 6 months before data acquisition;
- periodontal examination (probing pocket depth [PPD], bleeding on probing [BOP] at four sites per tooth/implant within 6 months before data acquisition) using a periodontal probe (PCP11, HuFriedy, Rotterdam, the Netherlands);
- complete medical history including information on smoking/non-smoking.

Patients were excluded for the following reasons

- aggressive periodontitis;
- no systematic post-therapeutic therapy at all;
- inadequate radiograph;
- no osseointegration of implant;
- function time documented <2 years;
- other missing data.

Patients were defined as smokers if they smoked at the time of follow-up examination or had quit smoking for <5 years (Lang et al. 2003).

Patients were classified as having a “periodontal history” if they had received active periodontal therapy (scaling and root planning or surgical therapy) within 5 years before implant placement.

A patient who did not exceed the recommended intervals for prophylaxis/SPT after implant placement by more than 100% was classified as “regular prophylaxis/SPT.” Patients who exceeded the recommended interval at least once by more than 100% (e.g. recommended SPT interval = 6 months, patient showed up after 13 months) were classified as “irregular prophylaxis/SPT” (Eickholz et al. 2008).

During the survey period (November 2008 to November 2009), radiographs were obtained only for purposes of routine diagnosis. The study was evaluated by the Ethics Committee of the Medical Faculty of the Johann Wolfgang Goethe-University Frankfurt, Germany and voted positively on May 27, 2008 (application no. 156/08).

### Case definition

Peri-implant mucositis and periimplantitis were the dependent variables of the study. Mucositis was documented according to the definition of Roos-Jansaker et al. (2006a) (PPD  $\geq$  4 mm and BOP). According to the definition by Karoussis et al. (2004) and Roos-Jansaker et al. (2006b), periimplantitis was diagnosed if a progressive bone loss could be determined in addition to the symptoms of periimplant mucositis. Bone loss was determined by a metric analysis of the PT. Criteria had to be met in at least one implant per patient. All PTs were obtained using the same digital X-ray device (Orthophos, Sirona Dental Systems, Bensheim, Germany). Data were analyzed using the respective PC program (Sidexis XG, Sirona Dental Systems), and a calibrated monitor (SyncMaster 2443SW, Samsung, Schwalbach, Germany). The distance between the implant shoulder and marginal bone level (BL) was measured at the mesial and distal aspect of each implant. BL was defined as the most coronal location of the bone margin adjacent to an implant surface. The site with the most pronounced bone loss was chosen to represent the

patient. Threshold level for a progressive bone loss was a BL located at least 3.5 mm apically of the implant shoulder at the last available radiograph. Baseline radiographs after implant placement were used to check the original BL around the implant. The original protocol for the implant system used in this study recommend a position of the implant shoulder slightly subcrestal (0.5 mm). Implants with a supracrestally placed implant shoulder, thus violating the surgical protocol, were excluded from the examination. All radiographs were read by the same calibrated operator (S.O.). Radiographs from 10 patients with 46 implant sites were selected for a second analysis of the periimplant BL to assess the intra-examiner variability. These radiographs were chosen using a table of random numbers. In 83% of the analyzed implants, the intra-examiner analysis demonstrated a difference of the measurements <0.5 mm, while in the remaining implant sites a measurement difference of 0.5–0.8 mm was obtained.

### Prophylaxis/SPT

Prophylaxis was performed in patients without a history of periodontal disease, and SPT in patients with a history of periodontal disease. The treatment encompassed the following elements for all patients at each appointment: assessment of GBI (Ainamo & Bay 1975) and PCR (O’Leary et al. 1972), re-instruction, and re-motivation to effective individual plaque control, professional tooth cleaning, and polishing of all teeth using rubber cups and polishing paste, application of a fluoride gel. Twice a year, dental status and PPD measurements were obtained at four sites per tooth. Thirty seconds after probing, BOP was recorded. Sites exhibiting PPD = 4 mm and BOP as well as sites with PPD  $\geq$  5 mm were scaled subgingivally using ultrasonic and hand instruments. For subgingival scaling of implants, a special ultrasonic tip (Kavo Sonicflex Implant, Kavo Dental GmbH, Biberach, Germany) was used, followed by manual instrumentation with titanium curettes. This was the only difference in treatment between natural teeth and implants.

Prophylaxis/SPT was rendered to most patients in 3-month intervals during the first year after implant insertion and later on in 6-month intervals. Patients exhibiting ineffective plaque control during the post-therapeutic phase (PCR > 35%) were seen four times a year for SPT (3-month intervals). This frequent recall was maintained until a PCR < 20% was established for three consecutive SPTs.

### Statistical analysis

The patient was considered a statistical unit. Prevalence of periimplant mucositis (yes/no)

and periimplantitis (yes/no) at the time of data acquisition were defined as the main outcome variables. Using logistic regression models, the influence of the following independent variables (risk factors) was assessed:

- gender;
- age at time of implant placement;
- follow-up period;
- smoker (yes/no);
- history of periodontal disease (yes/no);
- regular/irregular prophylaxis/SPT (yes/no);
- number of implants per patient.

A level of significance of < 5 % was accepted in order to determine a statistically significant influence. Statistical analysis of a possible influence of the independent variables on the dependent variables was performed using a multiple logistic regression model with backward elimination of the variables. The backward variable selection starts with a model, which includes all variables. Variables are then deleted from the model one by one. At each step, the least significant variable is removed. This process is repeated until all non-significant variables are eliminated. A Wald test was used to assess the statistical significance of each coefficient. The Hosmer–Lemshow test was applied to evaluate the goodness of fit of the final model (Hosmer & Lemeshow 1989). Complete statistical analysis was performed using a computer program (SAS 9.2, SAS Institute Inc., Cary, NC, USA).

## Results

### Patients

Between January 1, 1999 and June 30, 2006, 134 partially edentulous patients were treated with Ankylos implants. The patients had lost their teeth mostly due to endodontic failures or periodontal reasons, and a mean number of  $3.9 \pm 2.8$  implants per patients were placed (Fig. 1). From this group, 89 patients (52 female, 37 male) met all inclusion criteria and a complete documentation was available at the point of final data acquisition (Table 1). The mean age of the sample at the time of implant insertion was  $51.8 \pm 10.3$  years. The mean follow-up period of the prosthetically restored implants was  $68.2 \pm 24.8$  months (minimum: 24 months, maximum: 11.3 years). Seventeen patients (19.1%) were smokers. Forty-nine (68%) of the non-smokers and 15 (88%) of the smokers had a history of periodontal disease. Fifty-eight out of 89 patients (65%) participated on a regular basis in prophylaxis or SPT. The remaining 31 patients (35%) only participated in irregular intervals (deviation of more than 100% from the predefined intervals).

### Prevalence rate of periimplant mucositis

Following the criteria of Roos-Jansaker et al. (2006a), 40 of the 89 patients were diagnosed with a positive BOP and a probing depth > 4 mm (prevalence: 44.9%). Twenty-eight of the 72 non-smoking patients exhibited at least one site of periimplant mucositis. This equals a prevalence rate for periimplant mucositis of 38.9%. Twelve of the 17 smoking patients suffered from mucositis, too (prevalence rate: 70.6%).

Non-smokers without a history of periodontal disease showed a prevalence rate of 30.4% (42.8% for non-smokers with a history of periodontal disease). Twelve out of 15 smokers with a history of periodontal disease were diagnosed with mucositis (prevalence rate: 80%, Fig. 2). The very high prevalence rate in this subgroup leads to the assumption that there might be a positive quantitative interaction of the two variables “smoker” and “history of periodontal disease.”

Non-smokers regularly participating in prophylaxis/SPT had a prevalence rate of mucositis of 39.5%. Ten of 17 smokers (58.8%) participated regularly in prophylaxis/SPT, six of them showed signs of mucositis. From seven smokers who only participated in post-therapy treatment at irregular intervals, six suffered from mucositis (85.7%). These high prevalence rates indicate a

slightly positive interaction between the variables “smoker” and “non-compliance” (Fig. 3).

Multiple regression analysis with a backward variable elimination for the dependent variable “mucositis” leads to a final model containing the variable “smoker.” A statistically significant association of the independent variable “smoker” ( $P=0.023$ ) at an odds ratio (OR) of 3.77 (CI: 1.20–11.86) was determined (Table 2). Within each interval used for the calculation, the Hosmer–Lemshow test revealed that the expected frequencies equal the achieved frequencies, resulting in a good model fit.

This means that smokers hold a 3.7-fold higher chance for periimplant mucositis than non-smokers. The independent variables “gender,” “history of periodontal disease,” “age at time of implant placement,” “follow-up period,” “number of implants per patient,” and “compliance” were eliminated during the variable selection process, and thus had no effect on the chance of mucositis in the sample examined (Table 2).

### Prevalence rate of periimplantitis

Peri-implantitis was diagnosed in 10 (four female, six male) of the 89 patients (prevalence rate: 11.2%). Eight of the 17 smokers suffered from periimplantitis (prevalence rate: 47%),

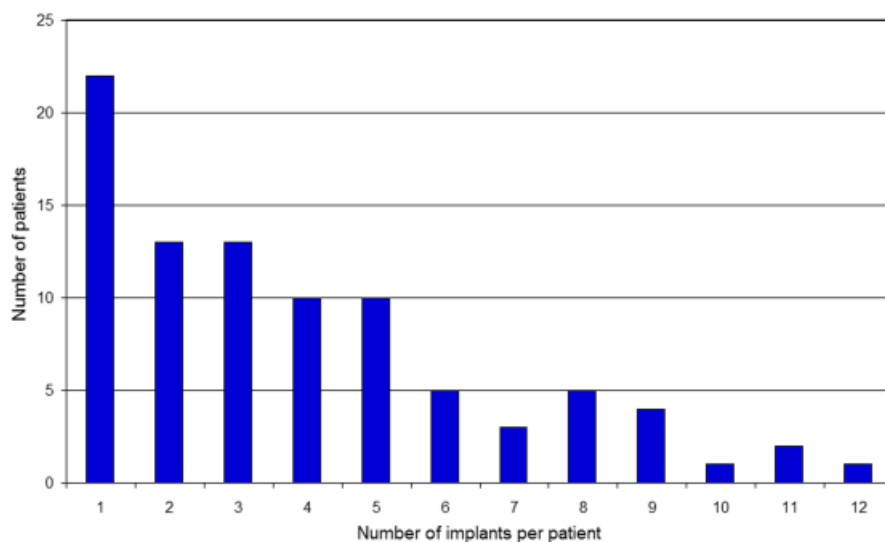


Fig. 1. Distribution of number of implants placed per patient.

Table 1. Number of included and excluded subjects and distribution of exclusion categories

Total number of patients	134
Number of included subjects	89
Number of excluded subjects	45
Reasons for exclusion	
Aggressive periodontitis	3
No post-therapeutic therapy	16
Inadequate radiograph	7
No osseointegration of implant	2
Function time documented <2 years	11
Other missing data (e.g. medical history, periodontal status)	6

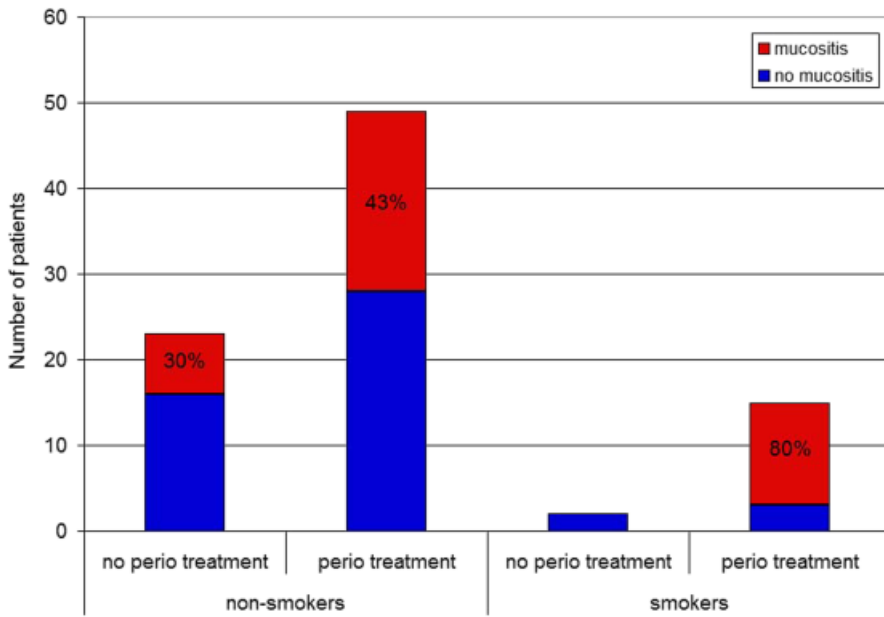


Fig. 2. Distribution of patients with periimplant mucositis according to "smoking" and "history of periodontal disease."

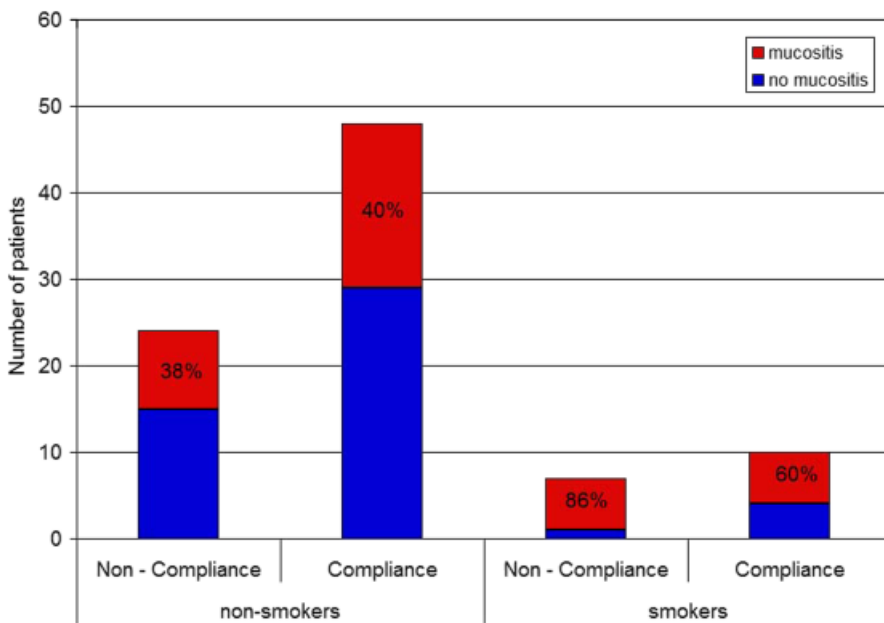


Fig. 3. Distribution of patients with periimplant mucositis according to "smoking" and "compliance."

while only two of the 72 non-smoking patients exhibited the respective symptoms (prevalence rate: 2.8%).

Two cases of periimplantitis were determined in non-smokers: one patient with and one without a history of periodontal disease. Both failed to attend prophylaxis/SPT on a regular base (prevalence: 8.3%) (Fig. 4a and b). The remaining eight cases of periimplantitis occurred in the 15 smokers with a history of periodontal disease (prevalence rate: 53%) (Fig. 5). However, in the small group of seven smokers without compli-

ance, six patients suffered from periimplantitis (prevalence rate: 85.7%) (Fig. 6). These high prevalence rates in the subgroups lead to the assumption of a positive quantitative interaction of the variables "smoker" and "history of periodontal disease" as well as for the variables "smoker" and "non-compliance." No case of periimplant disease was determined in the group of non-smokers with regular prophylaxis/SPT (Fig. 7).

Multiple logistic regression analysis with the backward variable selection leads to a final model

containing the variables "smoker" and "regular prophylaxis/SPT." The Hosmer-Lemeshow test indicated an appropriate goodness of fit ( $P = 0.620$ ). A statistically significant association between the dependent variable "periimplantitis" and "smoker" ( $P < 0.001$ ) at an odds ratio of 31.58 (CI 5.13-194.25) (Table 2) was observed. Thus, when compared with non-smokers, smokers have a 31-fold increased chance of suffering from periimplantitis. Moreover, regular attendance in prophylaxis/SPT was statistically significantly ( $P = 0.011$ ) associated with a reduced chance of periimplantitis (OR: 0.09, CI: 0.01-0.57) (Table 2). Patients not regularly attending prophylaxis/SPT therefore carry an 11-fold higher chance for periimplantitis than patients with a good compliance.

## Discussion

Despite the fact that implants are considered a routine treatment for edentulous and partially edentulous patients, only limited data on the prevalence of periimplant disease are available. Most of these data derive from longitudinal studies with relatively small samples and show a wide range of variation (Berglundh et al. 2002; Pjetursson et al. 2004). A frequency of occurrence between 8% and 44% is indicated for periimplant mucositis, whereas prevalence values between 0% and 14% are published for periimplantitis.

In the present study, prevalences of periimplant mucositis and periimplantitis amounted to 44.9% and 11.2%, respectively. Similar values were reported in other studies. In their systematic review, Pjetursson et al. (2004) reported that the cumulative incidence of periimplantitis in follow-up studies with a minimum follow-up period of 5 years was determined at 8.6%.

In studies with a follow-up period of more than 5 years, Berglundh et al. (2002) reported a prevalence of periimplantitis of 6.4% in partially edentulous patients. However, it has to be considered that only half of the studies included in this systematic review covered biologic complications. The authors therefore concluded that the frequency of periimplantitis was underestimated. Despite the different criteria applied (different follow-up periods, different implant systems), the results of the present study confirm the findings already published.

The variability in prevalence of periimplantitis may be explained by different factors:

- Different diagnostic criteria for periimplant mucositis and periimplantitis are applied. In some studies, the mere existence of a positive BOP is defined as mucositis (Ferreira et al.

**Table 2. Logistic regression and the Wald test for the dependent variables mucositis and periimplant disease**

Variable	Odds ratio: periimplant mucositis	P-values (Wald test)
Smoking status	3.77 (1.20–11.86)	P = 0.023
Variable	Odds ratio: periimplantitis	P-values (Wald test)
Smoking status	31.58 (5.13–194.25)	P < 0.001
Regular prophylaxis/SPT	0.09 (0.01–0.57)	P = 0.011

SPT, supportive periodontal therapy.

2006) while others use a combination of BOP and increased PPD (Roos-Jansaker et al. 2006c).

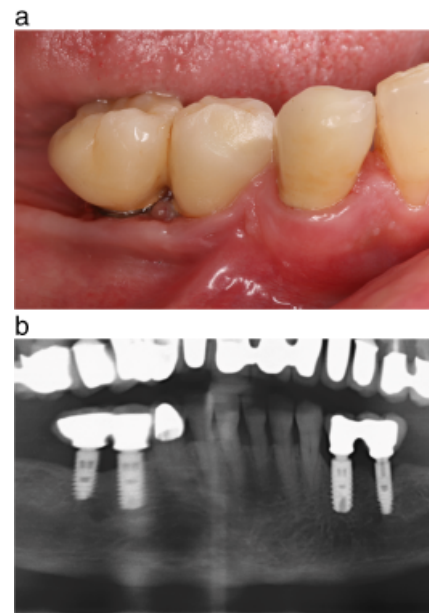
- Prevalence rates are influenced by a varying composition of the risk population. There are results of studies only including non-smokers as well as results of studies including smokers and non-smokers. Additional differences may be due to the extent of post-therapeutic maintenance or the number of patients with a history of periodontal disease (Berglundh et al. 2002; Pjetursson et al. 2004). At large, only a few studies exist that allow the identification of putative risk factors for the incidence of periimplant infection and inflammation (Brägger et al. 2004; Karoussis et al. 2004; Ferreira et al. 2006; Roos-Jansaker et al. 2006a).
- The study type is another crucial factor for the significance of the published data. To achieve sufficient information on the prevalence of periimplantitis, an epidemiologic approach is preferred. Therefore, the application of cross-sectional studies is recommended for this approach. Cross-sectional studies on patients restored with endosseous implants are rare. Up to the authors' best knowledge, in five publications only the data of three study samples are available (Fransson et al. 2005, 2008; Ferreira et al. 2006; Roos-Jansaker et al. 2006b, 2006c). Some prerequisites regarding the study design should be considered; the number of examined patients should be appropriate. Moreover, clinical and radiographic examinations are required. The sample may vary as with regard to gender, age, number of implants, and their respective time of exposure. A patient-related analysis is reasonable to allow for identification of the patient-related risk factors (Berglundh et al. 2002; Ferreira et al. 2006). Regarding the parameters influencing the prevalence rates, the results of the present study should preferably be compared with results of studies with equal or similar designs. Up to now, only three other cross-sectional studies on the prevalence of periimplantitis are published.

Ferreira et al. (2006) examined the prevalence of periimplant inflammation in 221 partially

edentulous patients who had been treated with implants of three different designs in a dental school at a Brazilian university. The 578 implants were exclusively placed in non-smokers who participated in follow-up examinations at the treatment center. In this study, the mean follow-up period after prosthetic restoration was 42 months. It was determined that 26.4% (n = 56) of the patients exhibited healthy periimplant soft tissues. 64.6% of the patients (n = 137) were diagnosed with periimplant mucositis. It has to be considered that the mere existence of a positive BOP was the diagnostic criterion for mucositis. Periimplantitis according to the criteria of Karoussis et al. (2004) was diagnosed in 8.9% (n = 19) of the patients. With a mean follow-up period of 42.5 ± 17.1 months, these results are in good accordance with the rate of disease determined for non-smoking patients without regular prophylaxis in the present study (prevalence: 9.5%).

The cross-sectional studies of Fransson et al. (2005, 2008) and Roos-Jansaker et al. (2006a, 2006b, 2006c) provide information on the prevalence of periimplantitis in patients who have been restored with endosseous implants for approximately 10 years. In both studies, the patients were restored exclusively with Branemark implants. No systematic post-therapeutic therapy was provided.

Fransson et al. (2005) evaluated the radiographs of 662 patients who had been restored with implant-prosthetic restorations for more than 5 years. Patients with augmentation were excluded before analysis. 27.8% of the patients showed progressive bone loss of more than three threads. Four hundred and twenty-three (12.4%) of the overall 3412 implants included in the study had a progressive bone loss (Fransson et al. 2005). Because of the methodological approach, information on prevalence of periimplant mucositis is missing in this study. In a follow-up study, the 82 patients with progressive bone loss were clinically re-examined (Fransson et al. 2008). This group included 40 smokers and 42 non-smokers. Forty percent of the re-examined implants in smokers showed probing depths of 6 mm and deeper while this applied to only 20% of the non-smoking patients. Suppuration



**Fig. 4.** (a) Clinical pathology of a periimplantitis in a non-smoking patient without compliance in post-therapeutic care. (b) Radiographic findings of the situation in (a).

was determined in 20% of the implants in smokers (non-smokers: 6%). The present study, too, demonstrates that smokers have a statistically significantly higher chance for periimplantitis with an odds ratio of 33.45 (CI: 4.06–275.63). It thus confirms these results.

In the cross-sectional study of Roos-Jansaker et al. (2006b), a total of 987 implants placed in 216 patients was re-evaluated. On a patient-related basis, the prevalence of periimplant mucositis was determined at 76.6%. Diagnostic criteria were a positive BOP and a periimplant probing depth of >4 mm.

In 16% of the patients and 6.6% of the implants, a periimplantitis with progressive bone loss of more than three threads was determined. The authors conclude that periimplant inflammation is a frequent biological complication after a prosthodontic period in function of 10 years without systematic supportive therapy (Roos-Jansaker et al. 2006a, 2006b, 2006c). The higher prevalence rates in comparison with the present study may be explained by an extended follow-up period and a missing post-therapeutic supervision.

The threshold level for progressive bone loss in the present study was defined as a distance of at least 3.5 mm between implant shoulder and BL. Other cross-sectional studies using different implant systems have used a comparable threshold level of >3 mm distance between implant–abutment connection and BL (Fransson et al. 2005; Roos-Jansaker et al. 2006a). In another cross-sectional study, only the presence of a vertical bone defect in proximal surfaces without a given

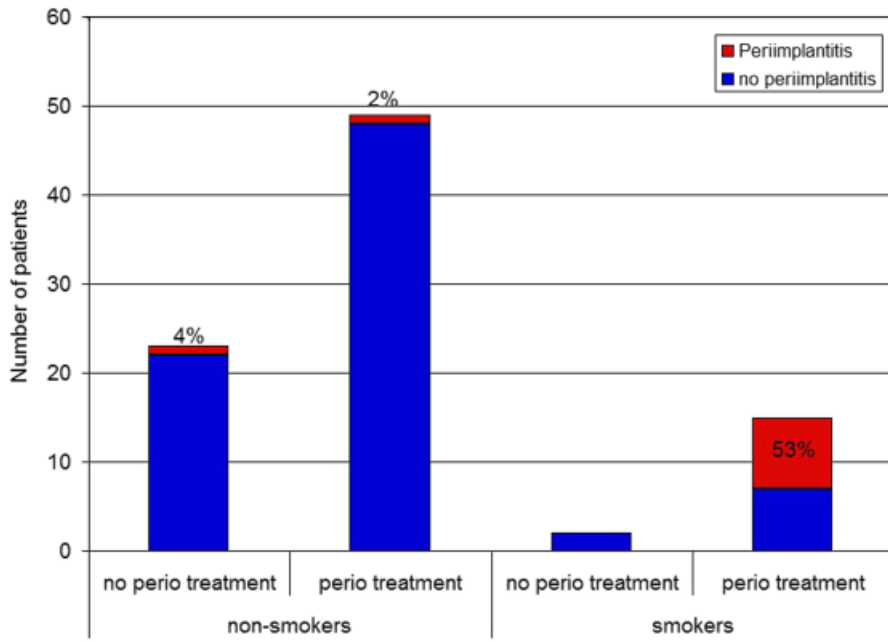


Fig. 5. Distribution of patients with a periimplantitis according to "smoking" and "history of periodontal disease."

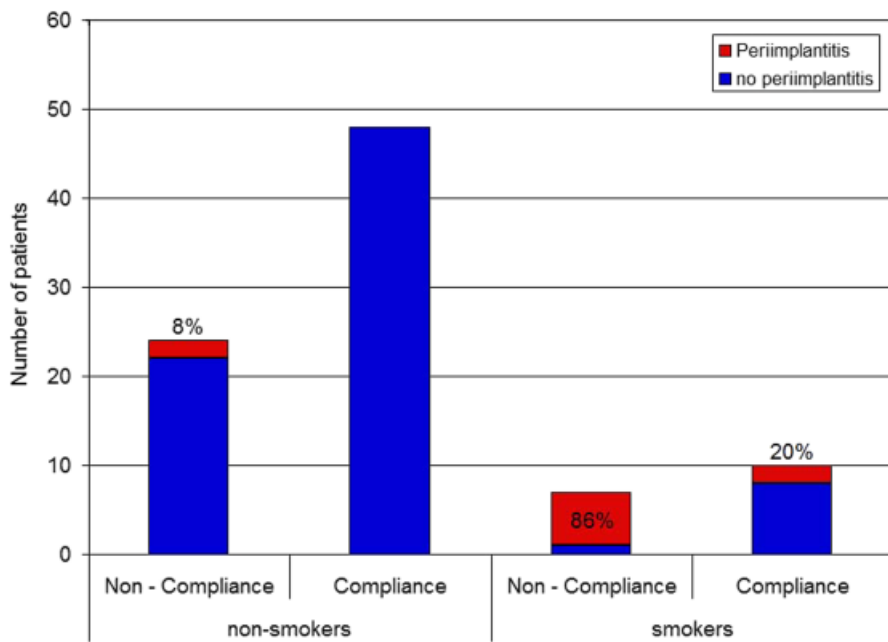


Fig. 6. Distribution of patients with a periimplantitis according to "smoking" and "compliance."



Fig. 7. X-ray shows no periimplant bone loss 7 years after prosthetic treatment. Patient is non-smoker without a history of periodontal disease who regularly participates in prophylaxis.

$P = 0.1934$ ) on the chance for periimplantitis. The missing association may be explained by the difference in the mean number of implants per patient in the two studies. In the present study, the mean number of implants was  $3.9 \pm 2.8$ , while the mean number of implants in the study of Fransson et al. (2005) was  $6 \pm 2.2$ .

The effect of cigarette smoking on periimplant tissues has been documented in a number of studies (Roos-Jansaker et al. 2006a, 2006c, Heitz-Mayfield 2008). In the present study, smoking was associated with a significantly increased chance for periimplantitis (OR: 31.58, CI: 5.13–194.25,  $P < 0.001$ ) and mucositis (OR: 3.77, CI: 1.20–11.86,  $P = 0.023$ ). This supports the findings of other cross-sectional studies revealing smoking as a relevant chance factor for periimplantitis and mucositis (Roos-Jansaker et al. 2006a, 2006c).

A recent systematic review indicates that subjects with a history of periodontitis are at a greater risk for periimplantitis (Heitz-Mayfield 2008). However, in the present study periodontal disease could be determined as a risk factor neither for periimplant mucositis nor periimplantitis. Why did the present study fail to determine history of periodontal disease as a risk indicator for periimplant diseases? (1) The present study included only patients with chronic periodontitis. It appears plausible that patients with aggressive periodontitis are likely to exhibit a higher risk for periimplant diseases. However, this has not been demonstrated clearly up to now (Karoussis et al. 2007). Karoussis et al. (2003) found lower survival rates in implants replacing teeth lost due to chronic periodontitis than in implants replacing teeth lost due to other reasons. However, they followed-up their sample for a longer time and used another main outcome variable (i.e. implant survival) (Karoussis et al. 2003). (2) All patients

threshold level was defined as progressive bone loss (Ferreira et al. 2006).

Retrospective and cross-sectional studies can identify risk indicators for disease. In the present study, age, gender, and observational period showed no association with periimplant disease using a multiple logistic regression model. This is in accordance with findings of other studies (Fransson et al. 2005; Ferreira et al. 2006). It is a specific issue of the present study that the patient age at the time of implant insertion is

considered as a risk factor, while other cross-sectional studies consider the patient age at the time of data acquisition (Fransson et al. 2005; Ferreira et al. 2006). This explains the difference in the mean age of the patients between the different studies. Fransson et al. (2005) revealed that the number of implants per patient had a significant impact on the likelihood for subjects to exhibit a progressive bone loss. In the present study, the number of implants per patient had no statistically significant influence (OR: 1.23;

followed-up in this study participated at least irregularly in post-therapeutic maintenance. The present study demonstrates that regular maintenance reduces the risk for periimplant inflammation significantly as compared with irregular maintenance. However, it could be hypothesized that even irregular maintenance is better than none.

Up to now, no information on the effect of a systematic post-therapeutic treatment (prophylaxis/SPT) on the chance for periimplant disease is available. Based on the findings of the present study, patients who do not participate in regular post-treatment programs bear an 11-fold higher chance for periimplantitis than patients showing a good compliance (OR: 0.09, CI:0.01–0.58,  $P=0.011$ ).

A specific issue for cross-sectional studies on the prevalence of periimplant disease is the implant loading time in the evaluated sample. The present study covers a time under risk of  $68.2 \pm 24.8$  months (5.7 years). Other cross-sectional studies on the same topics evaluated samples with mean observational periods of  $42.5 \pm 17.1$  months (Ferreira et al. 2006) or  $8.4 \pm 2.9$  years (Fransson et al. 2005). In other studies, the observational periods ranged from 9 to 14 years (Roos-Jansaker et al. 2006a, 2006c). Therefore, the observational period of the present study is short but in the range of other studies with the same design.

Moreover, it has to be considered that the pool of 89 patients in the present study only represents a comparatively small sample. Other cross-sectional studies include 216–662 patients (Fransson et al. 2005; Ferreira et al. 2006; Roos-Jansaker et al. 2006a, 2006b, 2006c). However, these limitations are compensated by presenting a practice-based study, which not

only analyzes the well-documented risk factors smoking status and periodontal history, but also the effect of a systematic post-therapeutic therapy. This aspect is essential, as results of cross-sectional studies up to now only were conducted at universities (Zitzmann & Berglundh 2008) and hardly provided any information on the effects of a systematic prophylaxis/SPT on the prevention of periimplant inflammations in the environment of a dental practice.

The method used for radiographic evaluation is another specific issue of the present study. While in most cross-sectional studies on periimplant disease, intraoral radiographs were used, in this study PTs were evaluated for the detection of marginal bone loss. There are only a few studies that have assessed to what extent similar diagnostic results can be obtained comparing readings from intraoral and PT radiographs. Persson et al. 2003 found a high agreement between panoramic and intraoral radiographs when evaluating periodontal bone height. Taking into account the increasing concern about patient exposure to radiation and replacing a series of intraoral films (for a patient with multiple implants) with a single PT, this method certainly reduces the amount of exposure.

Accounting the findings of Persson et al. (2003) and the high intra-examiner agreement of the measurements together with the advantage of a reduced radiation exposure, the use of PT for the detection of a progressive bone loss seems to be justified, especially for practice-based investigations. A positive aspect of this method is that valid assessments of periimplant disease can be provided from pre-existing radiographs.

Despite the limited sample and the relatively short follow-up period, the present study confirms existing findings regarding a connection

between smoking status and the risk of periimplant disease. However, the association between regular prophylaxis/SPT and the reduction of the risk for periimplantitis by more than 11 times is a new finding that has not yet been presented this concise.

## Conclusion

Based on these findings, the following conclusions may be drawn:

1. Because of insufficient evidence-based therapies for the management of periimplant diseases, the repeatedly proven association of the risk factor "smoking" requires a special risk disclosure statement for the respective patients.
2. Ideally, patients may be informed on the beneficial effect of a regular patient-related post-therapy care before implant insertion. Consequently, a practice focusing on implant prosthetics requires the necessary logistics and personnel resources for a respective professional attendance.

Considering the present scientific state of knowledge without a generally accepted concept for the treatment of periimplant diseases, an effective limitation of the risk of disease by patient selection as well as consequent post-treatment care are essential. Patients with an accumulation of several risk factors have to be accounted for; they must be informed about the increased risk of disease. Especially if a patient bears several risk factors, a construction should be chosen that allows for an extension or modification of the construction in case of implant loss.

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