Journal of Clinical Periodontology

Official Journal of The European Federation of Periodontology

Founded by the British, Dutch, French, German, Scandinavian, and Swiss Societies of Periodontology

J Clin Periodontol 2009; 36: 357–363 doi: 10.1111/j.1600-051X.2009.01375.x

Journal of Clinical Periodontology

Extent of peri-implantitis-associated bone loss

Christer Fransson, Jan Wennström, Cristiano Tomasi and Tord Berglundh

Department of Periodontology, The Sahlgrenska Academy at University of Gothenburg, Göteborg, Sweden

Fransson C, Wennström J, Tomasi C, Berglundh T. Extent of peri-implantitis-associated bone loss. J Clin Periodontol 2009; 36: 357–363. doi: 10.1111/j.1600-051X.2009.01375.x.

Abstract

Objective: The purpose of the present study was to describe the extent of peri-implantitis-associated bone loss with regard to implant position.

Material and methods: Patient files and intra-oral radiographs from 182 subjects were analysed. Among the 1070 examined implants, 419 exhibited peri-implantitis-associated bone loss. The position of each implant within the jaw and fixed reconstructions was determined. In the radiographs the distance between the abutment-fixture junction and the most coronal position of bone to implant contact was assessed at the 419 ''affected'' implants using a magnifying lens (× 7) with a 0.1 mm graded scale.

Results: About 40% of the implants in each subject was affected by peri-implantitis-associated bone loss. The proportion of such implants varied between 30% and 52% in different jaw positions and the most common position was the lower front region. In addition, affected implants were found in larger proportions among ''mid'' than ''end'' abutments irrespective of supporting fixed complete or fixed partial dentures.

Conclusion: It is suggested that peri-implantitis occurs in all jaw positions and that an ''end''-abutment position in a fixed reconstruction is not associated with an enhanced risk for peri-implantitis.

Key words: bone loss; dental implants; implant position; peri-implantitis

Accepted for publication 2 December 2008

Dental implants have been used for more than 25 years in the treatment of edentulous and partially edentulous subjects. The design of clinical studies evaluating the outcome of such treatment was in most cases longitudinal in character. In a systematic review on biological complications in implant therapy evaluated in prospective studies it was reported that implant loss was the most commonly reported variable, while marginal bone loss assessed in radiographs or clinical findings that indicated peri-implant pathology was described infrequently (Berglundh et al. 2002).

Conflict of interest and source of funding statement

The authors declare that there are no conflicts of interest in this study.

This study was supported by grants from TUA Research, Gothenburg and Swedish Dental Society.

Peri-implant disease is a collective term for inflammatory reactions in the tissues surrounding an implant. Peri-implant mucositis is used to describe the presence of inflammation in the mucosa at an implant with no signs of loss of supporting bone, while peri-implantitis in addition to inflammation in the mucosa is characterized by loss of supporting bone (Lindhe & Meyle 2008, Zitzmann & Berglundh 2008). The prevalence of a disease describes ''the number of cases of a disease that is present in a population at one point in time'' (Newman Dorland 1994). Thus, information on the prevalence of peri-implantitis must be generated from data assessed in studies with a cross-sectional design and requires study samples with an appropriate size. In addition, subject-based data should be provided rather than information on number and proportion of affected implants. While the prevalence of the disease reveals the proportion of subjects that are affected, the *extent* of the disease describes the number or proportion of affected implants for each subject. An appropriate epidemiological description of peri-implantitis must also include the *severity* of the disease, i.e. the amount of bone loss that occurred around the affected implants.

In a series of studies we aim to describe the prevalence, extent and severity of peri-implantitis. Thus Fransson et al. (2005) analysed radiographs from 1346 patients who had attended annual follow up visits at the Brånemark Clinic, Public Dental Services, Göteborg, Sweden. The subjects were provided with implant-supported (Brånemark System® Nobel Biocare, Göteborg, Sweden) fixed partial dentures (FPD) or fixed complete dentures (FCD) or single tooth replacements, with a function time of

5–20 years. Of the 662 subjects who fulfilled the inclusion criteria, 184 (27.8%) had $\geqslant 1$ implants with ''progressive'' bone loss, i.e. (i) a marginal bone level corresponding to $\geqslant 3$ threads and (ii) detectable bone loss after the first year in function. It was also demonstrated that neither age, gender, construction function time nor maxillary or mandibular position of the implants influenced the probability for subjects to exhibit bone loss according to the defined criteria. On the other hand, the number of placed implants in each subject had a significant influence on the likelihood to exhibit implants with bone loss to the threshold level.

In a subsequent study, Fransson et al. (2008) reported that the affected implants demonstrated clinical signs of pathology, such as bleeding on probing, pus and probing pocket depth $\geqslant 6$ mm and were, hence, classified as peri-implantitis.

Using the previously identified subject sample (Fransson et al. 2005, 2008) the purpose of the present study was to describe the extent of peri-implantitis-associated bone loss with regard to implant position.

Material and Methods

Patient files and intra-oral radiographs from 182 previously identified subjects were analysed. Among the 1070 examined implants, 419 were found to exhibit peri-implantitis-associated (''progressive'') bone loss (for details see Fransson et al. 2005).

The position of each implant was determined in relation to a preceding tooth position. Thus, the implants in the maxilla were assigned positions extending from 17 to 27 and the implants in the mandible were given positions from 47 to 37. Furthermore, the implants were grouped into either front (13–23 or 43–33) or posterior (17–14 or 47–44 and 24–27 or 34–37) position categories. Four groups of positions were hereby created; upper posterior (UP), upper front (UF), lower posterior (LP) and lower front (LF). The implant positions within the fixed reconstructions were also determined. Thus, an implant was defined as a ''mid'' abutment if another implant within the reconstruction was positioned in both its mesial and distal aspect. In other cases the implant was classified as an ''end'' abutment.

In the radiographs the distance between the abutment-fixture junction and the most coronal position of bone to implant contact was assessed at the mesial and distal aspects of each of the 419 identified ''affected'' implants using a magnifying lens ($\times$ 7) with a 0.1 mm graded scale. In cases where implants were displayed in different radiographs, the largest value for the distance was used. The measurements were performed on radiographs representing the 1-year follow-up and the end-point examination (5–23 years), respectively. In the absence of radiographs from the 1-year follow-up, information was obtained from the 2-year examination. Furthermore, with regard to the amount of bone loss the implants were grouped into two bone loss categories (<2 mm or $\geqslant 2$ mm).

Data analyses

The percentage distribution of (i) affected (''progressive'' bone loss) and non-affected implants and (ii) implant bone loss groups among the different position categories within the jaws and the fixed reconstructions was evaluated using the Fishers exact test. A p-value <0.05 was considered statistically significant.

The number of affected implants was related to the total number of implants in each subject and expressed as percentage. The mean value of bone loss between the 1-year and the end-point assessments of the selected implants was calculated for each subject.

A logistic multilevel regression model was applied to evaluate the influence of implant position (within the jaw or within the prosthetic reconstruction) and of type of prosthetic reconstruction on the risk for peri-implantitis-associated bone loss.

The logit function was used to link the linear model with the probability of the binary event such that, using ß as the intercept, the antilogit function of the parameter ß was calculated with the formula $[(1+\exp(-\beta))^{-1}]$ to obtain the probability of peri-implantitis-associated bone loss (Snijders & Bosker 1999).

The model was applied to the data and the variables were estimated with a second-order penalized quasi-likelihood procedure implemented in the software, and the significance of each covariate was tested using a Wald test. The covariates were estimated individually by adding them to the null model and testing the significance. The final model included all factors. The intra-class correlation (ICC), i.e. the proportion of the total variance attributed to the subject level, was approximated using the formula:

$$\mathrm{ICC} = \frac{\sigma_u^2}{\sigma_u^2 + \frac{\pi^2}{3}}$$

where σ_u^2 is the variance at the higher levels (Snijders & Bosker 1999).

A statistical package specifically designed for multilevel modeling was used (MLwiN 2.10, ©Multilevel Models Project Institute of Education, London, UK).

Results

The mean number and proportion of affected implants for each subject were 2.3 (SD 1.5) and 41.8% (SD 24.6), respectively. The number of affected and non-affected implants in relation to positions in the jaws is described in Fig. 1. The positions 14, 24, 34, 44 were the most frequently used sites for implant placement, while few implants resided in molar regions.

The distribution of affected and non-affected implants with regard to the jaw-position categories is presented in Fig. 2. The number of implants within the different jaw-position groups varied between 255 and 276. The largest frequency of affected implants was found in the lower front (LF) region (52%). The proportions of affected implants in other positions were 39% (UF), 35% (LP) and 30% (UP). The difference in percentage of affected implants between the lower front position and the other regions was statistically significant. Eighty-one of the 182 subjects had implants within the lower front (LF) region. The percentage of subjects with $\geqslant 1$ affected implants in this jaw position was 87.6%.

Figure 3 illustrates the number of affected and non-affected implants in FCD and FPD, respectively. While the number of implants supporting FCDs was about three times larger than that in FPDs, there was no difference in the proportion of affected implants between the two types of prosthesis (FCD 39%, FPD 40%).

The number of implants classified as ''end'' abutments was smaller than that of ''mid'' abutments (451 *versus* 619; Fig. 4). The proportion of affected implants was significantly larger among ''mid'' than ''end'' abutments (44%

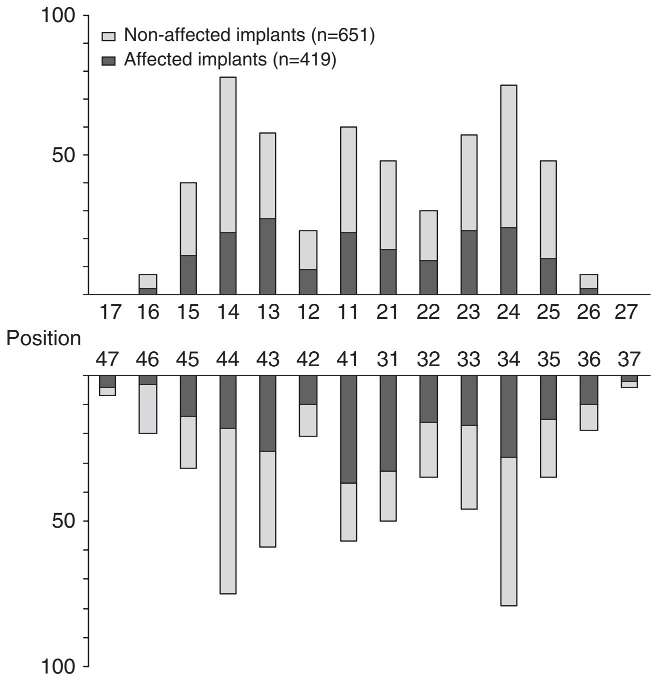

Fig. 1. Number of affected and non-affected implants in relation to jaw position.

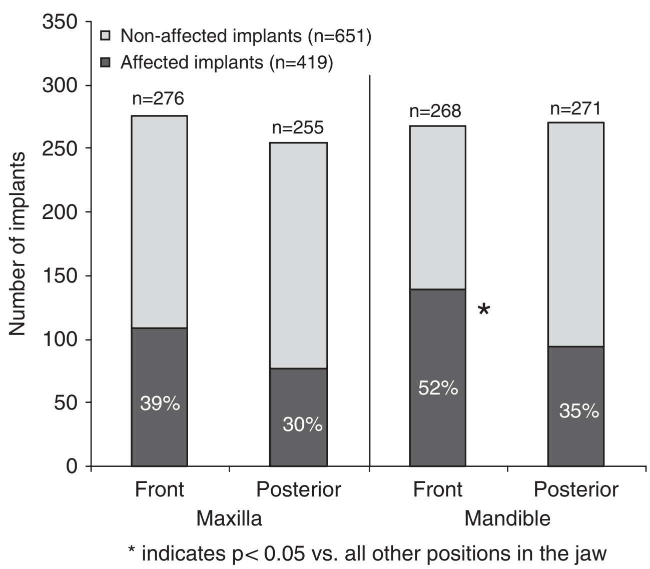

Fig. 2. Number and proportion of affected and non-affected implants in relation to jaw position category.

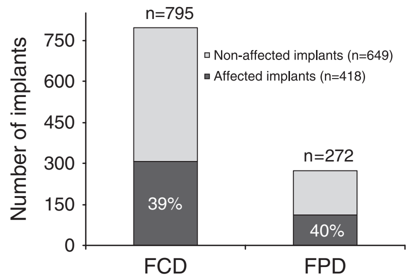

Fig. 3. Distribution of affected and non-affected implants within fixed complete dentures (FCD) and fixed partial dentures (FPD).

versus 32%). The results from the analysis of ''end'' and ''mid'' positions in FCDs and FPDs are presented in Fig. 5. The majority of implants in FCDs was in ''mid'' positions (512 *versus* 283), while in FPDs most implants were classified as ''end'' abutments (165 *versus* 107). The proportion of affected implants was significantly larger among ''mid'' than ''end'' abutments in both types of reconstructions (FCD; 43% *versus* 31% and FPD; 49% *versus* 35%).

The distribution of affected implants with regard to bone loss categories and jaw positions is presented in Fig. 6. The highest frequency of implants with bone loss $\geqslant 2$ mm was found in the LF region (37%). The proportion of implants with such a degree of bone loss in other jaw positions was 33% (UF), 29% (UP) and 25% (LP). The differences in percentage of implants with bone loss $\geqslant 2$ mm between the jaw position categories were not statistically significant. The proportion of implants with bone loss $\geqslant 2$ mm among ''end'' and ''mid'' abutments was 29% and 32%, respectively (Fig. 7).

The building of the logistic multilevel model with peri-implantitis-associated bone loss as the outcome event is presented in Table 1. A three-levels model was initially tested using the subject, reconstruction and implant as the levels. The database consisted of 182 subjects, with 221 reconstructions supported by 1070 implants. However, as the variance for the intermediate level (reconstruction) was 0, the level was removed from the subsequent analysis. A two-level model was therefore constructed and tested using the subject as the highest level.

When reconstruction type was added to the model to verify the probability for an implant to present peri-implantitis-associated bone loss if supporting FPD or a FCD, no significant difference was detected.

When the position of the implant in the reconstruction was added using an implant positioned in the mid portion as a reference, the model showed that an implant serving as an end abutment has a lower probability to present peri-implantitis-associated bone than a mid abutment [odds ratio (OR) 0.6; 95% confidence interval (CI) 0.4–0.8].

Position of the implant in different jaw positions was also tested using the upper posterior as the reference category. An implant positioned in the upper front showed a statistically significant higher risk of presenting a peri-implantitis-associated bone loss than an implant in the upper posterior area (OR 1.5; 95% CI 1.0–2.1). In addition, an implant positioned in the lower front area presented a statistically significant higher probability of peri-implantitis associated bone loss than an implant in

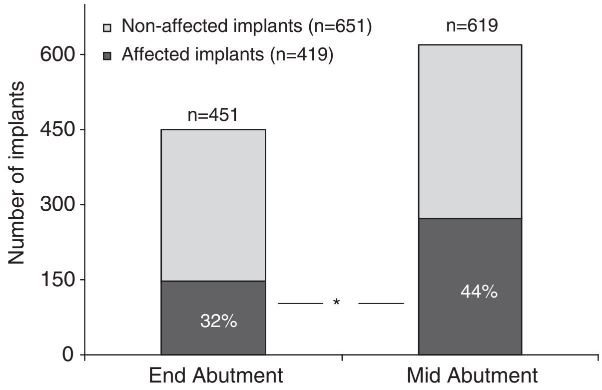

Fig. 4. Number and proportion of affected and non-affected implants in relation to position in prosthetic reconstruction. $^{*}p<0.05$.

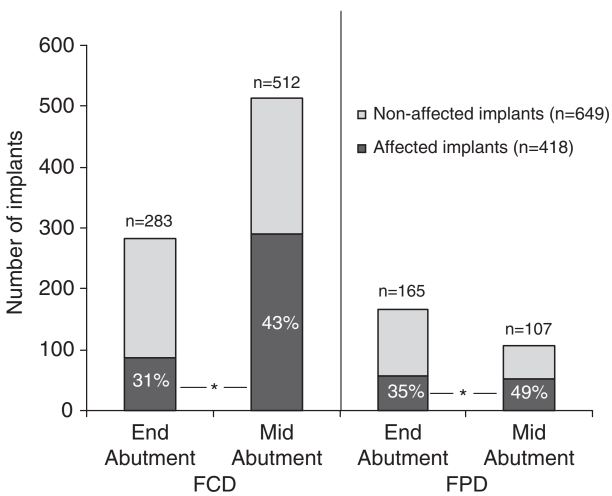

Fig. 5. Number and proportion of affected and non-affected implants in relation to position in prosthetic reconstruction in FCDs and FPDs. FPD, fixed partial dentures; FCD, fixed complete dentures. $^{*}p<0.05$.

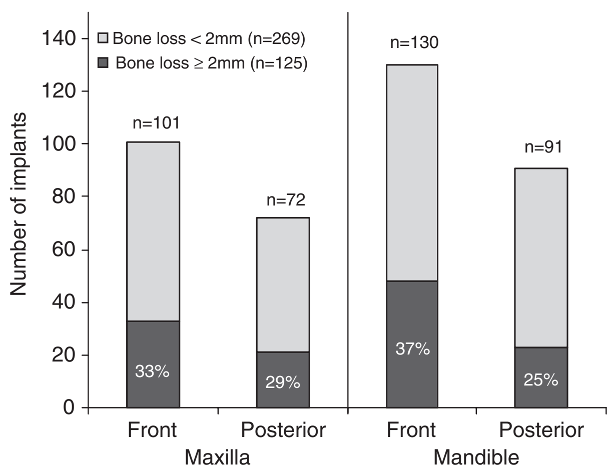

Fig. 6. Number and proportion of affected implants in relation to bone loss category and jaw position.

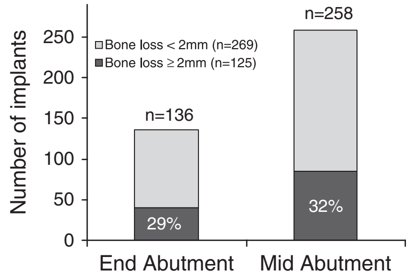

Fig. 7. Number and proportion of affected implants in relation to bone loss category and position in prosthetic reconstruction.

the upper posterior area (OR 2.8; 95% CI 1.9–4.2). Implants in the lower posterior positions, however, did not present a significant difference from the reference position regarding the risk for peri-implantitis-associated bone loss.

The model including all the significant covariates showed that the implant position within the prosthetic reconstruction, i.e. ''mid'' or ''end'' abutment, did not affect the occurrence of peri-implantits-associated bone loss when the factor ''jaw position'' was included in the analyses. Among the jaw-positions of the implants, the lower front region showed a significantly increased risk to exhibit peri-implantits-associated bone loss. Only the positioning of the implant at the lower front area increased significantly the probability of detecting peri-implantitis-associated bone loss (OR 2.4; 95% CI 1.5–3.9). An ICC of 0.11 suggests that 11% of the unexplained variance was attributable to differences between subjects.

Table 2 shows the predicted probabilities of peri-implantitis-associated bone loss for implants at different locations and acting as mid or end abutment. The highest probability of presenting a peri-implantitis associated bone loss was associated to implants located at lower front area as mid abutments, with a probability of 54%.

Discussion

In the present study the extent of peri-implantitis-associated bone loss with regard to implant positions was examined. It was demonstrated that in each subject about 40% of the implants were affected by this type of bone loss. The proportion of such implants varied between 30% and 52% in different jaw positions and the most common position was the lower front region. In addition, affected implants were found in larger

Table 1. Stepwise description of logistic model-building with the dichotomous outcome variable ''Peri-implantitis''

Variables	Type of reconstruction				Position in the bridge				Position in the jaw				Final model			
	value	SE	OR	95% CI	value	SE	OR	95% CI	value	SE	OR	95% CI	Value	SE	OR	95% CI
FPD *versus* FCD	0.000	0.172	1	0.7–1.4												
	$p = 0.9992$															
End *versus* mid Abutment					−0.555	0.134	0.6	0.4–0.8					−0.223	0.192	0.8	0.6–1.2
					$p < 0.0000$								$p = 0.2453$			
Upper front*									0.409	0.192	1.5	1.0–2.1	0.281	0.221	1.3	0.9–2.0
									$p = 0.0334$				$p = 0.2046$			
Lower front*									1.025	0.207	2.8	1.9–4.2	0.876	0.243	2.4	1.5–3.9
									$p < 0.0000$				$p = 0.0003$			
Lower posterior*									0.191	0.208	1.2	0.8–1.8	0.227	0.211	1.3	0.8–1.9
									$p = 0.3594$				$p = 0.2819$			
Intercept	−0.445	0.092			−0.216	0.097			−0.870	0.155			−0.715	0.197		
Subject level variance	0.369	0.117			0.398	0.122			0.402	0.123			0.404	0.124		
Intra class correlation	0.10				0.11				0.11				0.11			

*Reference upper posterior.

FCD, fixed complete dentures; FPD, fixed partial dentures; CI, confidence interval; OR, odds ratio.

proportions among ''mid'' than ''end'' abutments irrespective of supporting FCD or FPD. It is suggested that peri-implantitis occurs in all jaw positions and that an ''end''-abutment position in a fixed reconstruction is not associated with an enhanced risk for peri-implantitis.

The finding that the frequency of bone loss associated with peri-implantitis was higher among implants placed in the LF positions than in other regions is in agreement with previous observations. Thus, Lindquist et al. (1996) evaluated 47 subjects who were treated with mandibular FCDs supported by Brånemark implants. After 12–15 years the implants in anterior positions had a more pronounced bone loss compared with implants placed in posterior regions.

Thirty of the 47 subjects were evaluated in a 20-year follow-up study (Ekelund et al. 2003). It was reported that findings on peri-implant bone loss in the mandible were consistent with the 15-year data and that the mean bone level at the anterior implants was located about 1 mm more apically than at posterior implants.

In a 10-year follow-up study on implant-supported FCDs in 13 subjects it was reported that the mean bone loss was similar in the maxilla and the mandible (Carlsson et al. 2000). Anterior implants exhibited more bone loss than posterior ones in the mandible, while no such difference was found in the maxilla. The findings regarding the different patterns of peri-implant bone loss in the maxilla and in the mandible in the study by Carlsson et al. (2000) are in agreement with observations made in the current study. Different results were presented in a retrospective study on 339 implants placed in 65 subjects (Chung et al. 2007). The amount of bone loss in intraoral radiographs that occurred after the first year in function and up to 3–24 years was not related to whether the implants were placed in the maxilla or in the mandible or in posterior or anterior positions of the jaw. In this context it is important to realize that in the study referred to almost twice as many implants were installed in molar and premolar (posterior) regions as in incisor and cuspid (anterior) positions. The implants in the present material, however, were equally distributed between anterior and posterior regions (544 *versus* 526).

The analysis of affected implants in relation to positions within the prosthetic

Table 2. Predicted probability of peri-implantitis for an implant at different positions (95% CI)

	Upper front	Lower front	Upper posterior	Lower posterior
Mid abutment	39% (33–46)	54% (47–61)	33% (25–42)	38% (29–49)
End abutment	34% (25–45)	49% (37–60)	28% (22–35)	33% (27–40)

CI, confidence interval.

reconstructions in the current study revealed a higher frequency among ''mid'' than ''end'' abutments irrespective of supporting FCD or FPD. This finding indicates that implants that served as end-abutments in fixed prosthetic reconstructions were not associated with an increased risk for bone loss. Similar observations were made in a retrospective study by Wennström et al. (2004). They reported that no differences in peri-implant bone loss were found between FPDs with and without cantilever extensions after 5 years in function.

In a study on 82 subjects with affected implants a strong association was found between clinical signs of pathology and peri-implant bone loss (Fransson et al. 2008). It was also reported that smokers had a larger number of affected implants than non-smokers and that the proportion of affected implants that exhibited pus and probing pocket depth $\geqslant 6$ mm was higher in smokers than non-smokers. The microbial challenge and the ensuing inflammatory response in the peri-implant mucosa are obviously an important aetiological factor for bone loss at implants. This observation is in agreement with the conclusion presented in the study by Lindquist et al. (1996) referred to above; ''smoking and poor oral hygiene had a significant influence on bone loss while occlusal loading factors such as maximum bite force, tooth cleansing and lengths of cantilevers were of minor importance''.

In the description of prevalence and extent of peri-implantitis the analogy to periodontitis is evident. Laurell et al. (2003) reported on periodontal bone loss around 998 teeth in 433 subjects. Although all tooth categories demonstrated signs of bone loss at the 17-year follow-up, lower incisors and upper molars exhibited more pronounced bone loss than other sites. In a 10-year prospective study Paulander et al. (2004) evaluated intra-oral pattern of periodontal bone loss. It was reported that mandibular incisors showed larger amount of bone loss than other tooth categories. These observations are in accordance with data presented in the present study and indicate that although destructive disease in the tissues surrounding teeth and implants may occur in all areas of the jaws, anatomical aspects in the LF region may render a risk for periodontal and peri-implant bone loss.

Acknowledgements

We acknowledge Dr. Solveig Sundén-Pikner and Dr. Kerstin Gröndahl, Department of Oral & Maxillofacial Radiology, University of Gothenburg for radiographic analyses.

References

Berglundh, T., Persson, L. & Klinge, B. (2002) A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. *Journal of Clinical Periodontology* **29** (Suppl. 3), 197–212.

Carlsson, G.E, Lindquist, L. W. & Jemt, T. (2000) Long-term marginal periimplant bone loss in edentulous patients. *International Journal of Prosthodontics* **13**, 295–302.

Chung, D. M., Oh, T. J., Lee, J., Misch, C. E. & Wang, H. L. (2007) Factors affecting late implant bone loss: a retrospective analysis. *International Journal of Oral and Maxillofacial Implants* **22**, 17–126.

Ekelund, J. A., Lindquist, L. W., Carlsson, G. E. & Jemt, T. (2003) Implant treatment in the edentulous mandible: a prospective study on Branemark system implants over more than 20 years. *International Journal of Prosthodontics* **16**, 602–608.

Fransson, C., Lekholm, U., Jemt, T. & Berglundh, T. (2005) Prevalence of subjects with progressive bone loss at implants. *Clinical Oral Implants Research* **16**, 440–446.

Fransson, C., Wennström, J. & Berglundh, T. (2008) Clinical characteristics at implants with a history of progressive bone loss. *Clinical Oral Implants Research* **19**, 142–147.

Laurell, L., Romao, C. & Hugoson, A. (2003) Longitudinal study on the distribution of proximal sites showing significant bone loss. *Journal of Clinical Periodontology* **30**, 346–352.

Lindhe, J. & Meyle, J. (2008) Peri-implant diseases: consensus report of the sixth european workshop on periodontology. *Journal of Clinical Periodontology* **35** (Suppl. 8), 282–285.

Lindquist, L. W., Carlsson, G. E. & Jemt, T. (1996) A prospective 15-year follow-up study of mandibular fixed prostheses supported by osseointegrated implants. Clinical results and marginal bone loss. *Clinical Oral Implants Research* **7**, 329–336.

Newman Dorland, W. A. (1994) *Dorland's Illustrated Medical Dictionary*, 28th edition. Philadelphia: WB Saunders Company.

Paulander, J., Axelsson, P., Lindhe, J. & Wennström, J. (2004) Intra-oral pattern of tooth and periodontal bone loss between the age of 50 and 60 years. A longitudinal prospective study. *Acta Odontologica Scandinavica* **62**, 214–222.

Snijders, T. A. B. & Bosker, R. J. (1999) *Multilevel Analysis: An Introduction to Basic and Advanced Multilevel Modeling*. Thousand Oaks, Calif.; London: SAGE.

Wennström, J., Zurdo, J., Karlsson, S., Ekestubbe, A., Gröndahl, K. & Lindhe, J. (2004) Bone level change at implant-supported fixed partial dentures with and without cantilever extension after 5 years in function. *Journal of Clinical Periodontology* **31**, 1077–1083.

Zitzmann, N. U. & Berglundh, T. (2008) Definition and prevalence of peri-implant diseases. *Journal of Clinical Periodontology* **35** (Suppl. 8), 286–291.

Address:
Christer Fransson
Department of Periodontology
The Sahlgrenska Academy at University of Gothenburg
Box 450
S-405 30 Göteborg
Sweden
E-mail: christer.fransson@odontologi.gu.se

Clinical Relevance

Scientific rationale for the study: Peri-implantitis is an increasing problem in dentistry. While data on prevalence of the disease have been presented, there is a lack of information regarding its extent and severity. In the present study the positions within the jaws and within the bridge reconstruction of implants with peri-implantitis associated bone loss were reported.

Principal findings: About 40% of the implants in each subject were affected by peri-implantitis-associated bone loss. Such bone loss occurred in all regions of the maxilla and mandible, but was most prevalent in the LF region. In addition, the proportion of affected implants was larger among ''mid'' than ''end'' abutments in both FCD and FPD.

Practical implications: Clinicians should be aware of that peri-implantitis occurs in all jaw positions and that an ''end''-abutment position in a fixed reconstruction is not associated with an enhanced risk for peri-implantitis.