Case Series

Crestal Bone Changes at Teeth and Implants in Periodontally Healthy and Periodontally Compromised Patients. A 10-Year Comparative Case-Series Study

Giulio Rasperini,* Vincenzo Iorio Siciliano,† Carlo Cafiero,† Giovanni E. Salvi,‡ Andrea Blasi,† and Marco Aglietta†

Background: Limited data exist on the longitudinal crestal bone changes around teeth compared with implants in partially edentulous patients. This study sought to compare the 10-year radiographic crestal bone changes (bone level [BL]) around teeth and implants in periodontally compromised (PCPs) and periodontally healthy (PHPs) patients.

Methods: A total of 120 patients were evaluated for the radiographic crestal BL around dental implants and adjacent teeth at time of implant crown insertion and at the 10-year follow-up. Sixty patients had a previous history of periodontitis (PCPs), and the remaining 60 were PHPs. In each category (PCP and PHP), two different implant systems were used. The mean BL change at the implant and at the adjacent tooth at the interproximal area was calculated by subtracting the radiographic crestal BL at the time of crown cementation from the radiographic crestal BL at the 10-year follow-up.

Results: At 10 years after therapy, the survival rate ranged from 80% to 95% for subgroups for implants, whereas it was 100% for the adjacent teeth. In all eight different patient categories evaluated, teeth demonstrated a significantly more stable radiographic BL compared with adjacent dental implants (teeth BL, 0.44 ± 0.23 mm; implant BL, 2.28 ± 0.72 mm; $P < 0.05$). Radiographic BL changes around teeth seemed not to be influenced by the presence or absence of advanced bone loss (≥3 mm) at the adjacent implants.

Conclusions: Natural teeth yielded better long-term results with respect to survival rate and marginal BL changes compared with dental implants. Moreover, these findings also extend to teeth with an initial reduced periodontal attachment level, provided adequate periodontal treatment and maintenance are performed. As a consequence, the decision of tooth extraction attributable to periodontal reasons in favor of a dental implant should be carefully considered in partially edentulous patients. *J Periodontol 2014;85: e152-e159.*

KEY WORDS

Alveolar bone loss; peri-implantitis; periodontitis; smoking.

* Department of Biomedical, Surgical, and Dental Sciences, Unit of Periodontology, Istituti di Ricovero e Cura a Carattere Scientifico (IRCC), University of Milan, Milan, Italy.
† Department of Periodontology, University Federico II, Naples, Italy.
‡ Department of Periodontology, School of Dental Medicine, University of Bern, Bern, Switzerland.

doi: 10.1902/jop.2013.130415

The use of dental implants is currently considered one of the first therapeutic options for the rehabilitation of partially edentulous patients[1] because of the good long-term survival and success rates reported in several publications.[2-6]

However, recent long-term studies have shown that biologic complications (e.g., peri-implantitis) occur more frequently, especially in patients who were periodontally compromised (PCPs) and cigarette smokers.[7,8]

Data from 10-year studies comparing implant therapy in PCPs and periodontally healthy patients (PHPs) demonstrated that the radiographic bone loss was significantly greater in PCPs and smokers,[9-13] with the worst results found in PCPs with a history of smoking.[14]

Implant therapy should be considered as a therapeutic option to restore partially or totally edentulous jaws. However, in clinical practice, the possibility of an implant rehabilitation is often considered an alternative to complex therapies aimed at the preservation of the natural dentition.

Several studies showed that advanced periodontal therapies, such as guided tissue regeneration (GTR) or root-resective therapy of furcated molars, have a long-term prognosis at least as good, if not even better, compared with implant therapy, with lower treatment costs, time, and morbidity.[4-6,15,16]

Mengel and Flores-de-Jacoby[17] demonstrated that higher clinical attachment loss (AL) occurs at implants as well as at teeth in patients with an initial history of aggressive generalized periodontitis compared with PHPs or patients with a previous history of chronic periodontitis (CP). Furthermore, clinical AL at implants was always greater compared with that at teeth, independently from the initial periodontal diagnosis.

Based on the fact that scarce evidence exists comparing teeth versus implants in the same dentition, the aim of the present investigation is to assess the radiographic bone loss rate around teeth and implants in relation to the initial periodontal diagnosis (PCP or PHP), the smoking history, and the type of implant inserted and to evaluate the impact of peri-implant bone loss on the radiographic crestal bone level (BL) changes of the adjacent teeth.

MATERIALS AND METHODS

Patient Selection

The data of the present investigation were collected from the pool of patients used for two previous studies.[11,14] Briefly, patients consecutively treated in the Department of Periodontology, University Federico II, Naples, Italy, and the Department of Periodontology, University of Milan, Milan, Italy, and receiving a dental implant in a single-unit gap from January 1997 to July 1997 were examined 10 years after crown insertion.

This research study uses a retrospective clinical database that includes patients who were treated previously as part of either an approved research protocol or routine periodontal care using accepted therapy for each patient's specific clinical needs. Because the current research involves a retrospective analysis of preexisting data and current investigators do not have access to identifiable private information, this research does not require approval by an institutional ethics board or committee.

If patients received more than one implant during this period, only the first one inserted was considered for the analysis.

Four groups of 30 patients each were formed based on the implant treatment and periodontal conditions. An additional division was made on the basis of smoking habits; therefore, results are shown for eight groups. The four implant treatment groups included the following: 1) PCPs treated for CP and with a screw-shaped implant with a machined surface (N-implant)§; 2) PCPs treated for CP and with a screw-shaped implant with a titanium plasma-sprayed (TPS) surface (S-implant)‖; 3) PHPs treated with N-implant; and 4) PHPs treated with S-implant.

In each category, 20 patients were non-smokers and 10 patients were smokers (i.e., >10 cigarettes/day). Sex and age ranges of patients can be found in previously reported studies.[11,14] All patients met the following inclusion criteria: 1) aged ≥18 years; 2) absence of relevant medical conditions contraindicating surgical interventions; 3) 4 to 6 months of healing after tooth extraction; 4) presence of sufficient residual alveolar bone volume for implant insertion without concomitant or previous bone augmentation; 5) presence of a tooth mesially and distally to the implant site; 6) loading 4 to 6 months after implant placement; 7) availability of a periapical radiograph at time of crown insertion obtained with the parallel long-cone technique, with the mesial and distal teeth completely visible; 8) full-mouth plaque score (FMPS)[18] ≤25% at baseline; 9) full-mouth bleeding score (FMBS)[19] ≤25% at baseline; and 10) enrollment in a regular periodontal maintenance protocol. Patients were excluded on the basis of the following: 1) FMPS >25% at baseline; 2) FMBS >25% at baseline; 3) untreated periodontal conditions; and 4) erratic compliance with a periodontal maintenance protocol.

Implant Placement

The N-implants had a machined surface and were placed following a two-stage protocol, with the implant shoulder approximating the bone crest and

§ Nobel Biocare, Zürich-Flughafen, Switzerland.
‖ Straumann Dental Implant System, Institute Straumann, Basel, Switzerland.

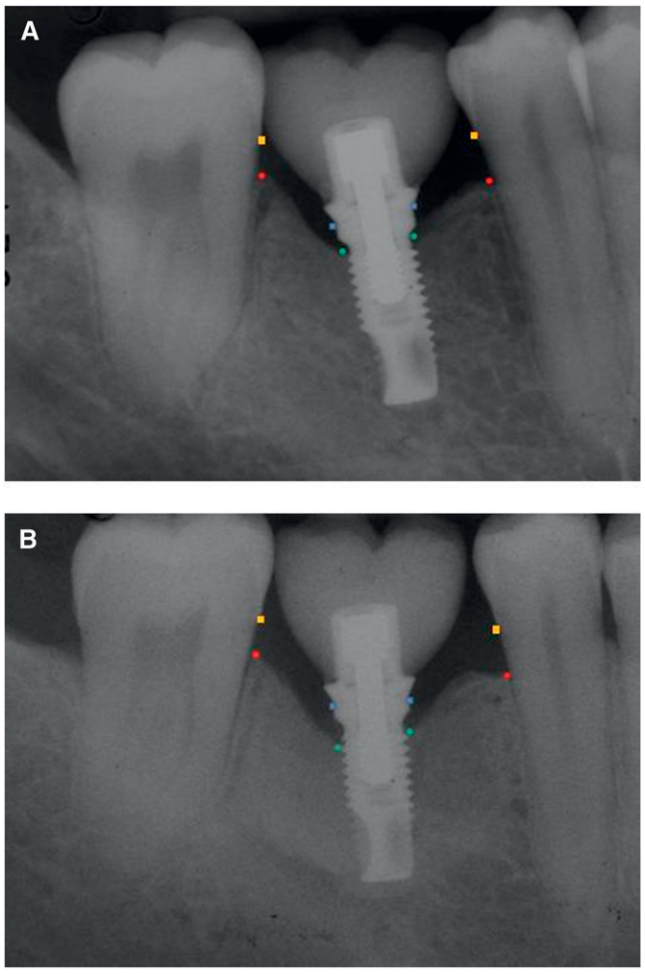

Figure 1.
A) *Radiographic view of an N-implant and adjacent teeth at baseline.* ***B)*** *Ten-year follow-up measurements around N-implant and adjacent teeth. Blue and green markers identify the reference points used for measurements: blue markers identify implant shoulder, and green markers identify BL. Yellow markers identify the cemento-enamel junction. Red markers identify the BL around the teeth.*

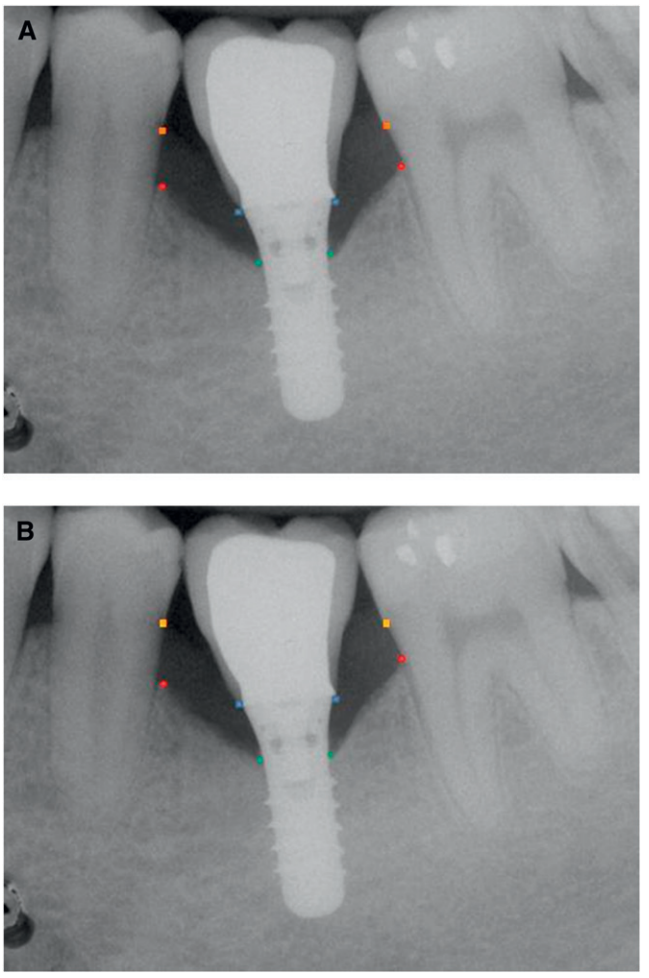

Figure 2.
A) *Radiographic view of an S-implant and adjacent teeth at baseline.* ***B)*** *Radiographic view of the same implant at the 10-year follow-up. Blue markers identify the implant shoulder. Green markers identify BL. Yellow markers identify the cemento-enamel junction. Red markers identify BL around teeth.*

covered with mucosal flaps (Fig. 1). The second-stage surgery was performed 4 to 6 months later.

The S-implants were placed in a transmucosal manner, according to the instructions of the manufacturer. However, to have the buccal aspect of the implant shoulder 1 mm below the ideal line connecting the gingival margin of the adjacent teeth, it was sometimes necessary to place the implant with the border of the rough surface deeper than the crestal BL, especially on the mesial and distal sites (Fig. 2). After placement of appropriate healing screws, close adaptation of the wound margins around the implant shoulder was achieved. If necessary, an excision of soft tissue was performed.[20]

Permanent single-unit crowns (SCs) were delivered 4 to 6 months after surgery. All restorations were fabricated to facilitate oral hygiene procedures and peri-implant probing. A control radiograph was performed at the time of crown insertion.

At the end of treatment, the patients were enrolled in an individually tailored supportive periodontal therapy program based on the initial periodontal diagnosis.

Follow-Up Examination

Ten years after insertion of the SCs, a new radiograph was obtained. For the patients who experienced implant loss, data relative to the causes and the timing of explantation were collected.

Radiographic Examination

Radiographs taken at the time of crown insertion (i.e., baseline) and at the 10-year examination were used to calculate the radiographic crestal BL change. All the radiographs were taken by applying the long-cone technique and using a film holder.[21]

Table 1.

Study Sample and Demographic Characteristics

	Non-Smokers				Smokers				
	PCPs		PHPs		PCPs		PHPs		
Demographic	N-Implant (n = 20)	S-Implant (n = 20)	N-Implant (n = 20)	S-Implant (n = 20)	N-Implant (n = 10)	S-Implant (n = 10)	N-Implant (n = 10)	S-Implant (n = 10)	*P* Value
Age (years)	47.2 ± 1.4	46.5 ± 1.7	47.5 ± 2.9	48.1 ± 2.1	51.3 ± 3.23	51.7 ± 3.50	51.2 ± 2.39	51.5 ± 2.68	<0.001
Sex (% males)	60%	65%	45%	40%	40%	50%	60%	40%	NS

NS = not significant. Data are mean ± SD unless otherwise noted.

Table 2.

Survival Rate (number of units lost) of Implants and Teeth in the Eight Groups

	Non-Smokers				Smokers			
	PCPs		PHPs		PCPs		PHPs	
Parameter	N-Implant (n = 20)	S-Implant (n = 20)	N-Implant (n = 20)	S-Implant (n = 20)	N-Implant (n = 10)	S-Implant (n = 10)	N-Implant (n = 10)	S-Implant (n = 10)
Implants	95% (1)	85% (3)	95% (1)	95% (1)	90% (1)	80% (2)	90% (1)	100% (0)
Teeth	100% (0)	100% (0)	100% (0)	100% (0)	100% (0)	100% (0)	100% (0)	100% (0)
P value	NS	NS	NS	NS	NS	NS	NS	NS

NS = not significant.

After digitalization of the films, the location of the crestal BL in relation to the implant shoulder and the cemento-enamel junction was assessed mesially and distally to the implants and to the adjacent teeth, respectively, by using a software program.¶ To take into account the anatomic magnification and distortion of the films, the linear dimensions of the digitized images were calibrated. This was achieved by setting the scale in the image to the known distance between the implant threads.

The radiographic crestal bone change was calculated by subtracting the crestal BL at baseline from the crestal BL at the 10-year follow-up.

Statistical Analyses

The groups were compared at baseline for age, sex, and position of implants. A Kruskal-Wallis test was used for non-parametric variables. A survival rate analysis was performed to estimate differences between implants and teeth in each group by using Kaplan-Meier survival test. An analysis of variance (ANOVA) test was performed to evaluate differences between groups for BL around implants and teeth, respectively. Furthermore, a multivariate analysis was used to evaluate differences between BL at implants and adjacent teeth. ANOVA test with Bonferroni post hoc analysis was used to evaluate differences in mean bone loss around teeth among each group. Finally, a comparison between BL on teeth facing the implant with BL >3 and <3 mm was performed using an unpaired *t* test. All tests were performed with a statistical software package.#

RESULTS

Study Sample

One hundred twenty patients divided in eight groups were included in the study (Table 1). The groups did not display any statistically significant differences at baseline with respect to sex distribution and implant position. The mean age was statistically significantly lower (P <0.001) in the four non-smoking groups compared with the four smoking groups.

Implant- and Tooth-Survival Rates

During the follow-up, 10 of the 120 implants inserted were lost (Table 2). The highest survival rate was observed in the PHPs (95% for both smokers and non-smokers) and decreased to 90% and 85% for PCP non-smokers and smokers, respectively. On the contrary, no tooth loss was reported in any of the groups. The Kaplan-Meier analysis did not reveal

¶ VixWin Platinum Imaging Software, Gendex, Hatfield, PA.
# SPSS v.20, IBM, Chicago, IL.

Table 3.

Radiographic Crestal Bone Loss (mean ± SD) at Implants and Teeth Over the 10-Year Follow-Up in the Eight Groups

	Non-Smokers				Smokers			
	PCPs		PHPs		PCPs		PHPs	
Parameter	N-Implant (n =20)	S-Implant (n = 20)	N-Implant (n = 20)	S-Implant (n = 20)	N-Implant (n = 10)	S-Implant (n = 10)	N-Implant (n = 10)	S-Implant (n = 10)
Implants (mm)	2.32 ± 0.41	2.32 ± 0.41	1.43 ± 0.38	1.95 ± 0.42	3.47 ± 1.09	3.77 ± 1.43	2.65 ± 0.41	2.51 ± 0.31
Teeth (mm)	0.49 ± 0.83	0.65 ± 0.91	0.21 ± 0.50	0.23 ± 0.47	0.85 ± 0.14	0.78 ± 0.17	0.25 ± 0.05	0.32 ± 0.04
P value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 4.

Radiographic Crestal BL Changes at Teeth in Relation to the Bone Loss at the Adjacent Implants in PCP Non-Smokers

	Teeth Adjacent to Implant Sites With Bone Loss ≥3 mm	Teeth Adjacent to Implant Sites With Bone Loss <3 mm	*P* value
Mean ± SD BL at teeth (mm)	0.55 ± 0.23	0.58 ± 0.26	NS
Mean ± SD BL at the radiographic tooth surface facing the implant (mm)	0.54 ± 0.19	0.58 ± 0.26	NS

NS = not significant.

statistically significant differences in any of the groups comparing implant and tooth survival rates.

Mean Radiographic Bone Loss

The mean radiographic crestal bone loss was significantly greater around implants compared with that of teeth in all groups (Table 3). At 10 years, the overall bone loss at teeth was 0.44 ± 0.23 mm but 2.28 ± 0.72 mm at implants, with a significance of $P < 0.001$ (S-implants; $P < 0.05$).

In the group receiving N-implants, the mean peri-implant bone loss increased gradually from the non-smoking PHPs (1.43 ± 0.38 mm) to the smoking PCPs (3.47 ± 1.09 mm), with the smoking PHPs (2.65 ± 0.41 mm) and the non-smoking PCPs (2.32 ± 0.41 mm) showing results between. Similar results were obtained in patients treated with S-implants: non-smoking PHPs showed the lowest mean BL (1.95 ± 0.42 mm), and smoking PCPs showed the greatest one (3.77 ± 1.43 mm). Smoking PHPs and non-smoking PCPs, again, displayed a mean BL situated between the other two categories (2.51 ± 0.31 and 2.32 ± 0.41 mm, respectively).

The mean BL recorded around teeth displayed similar trends (Table 3). Indeed, smoking and non-smoking PHPs revealed a mean radiographic crestal bone loss ranging from 0.21 ± 0.50 to 0.32 ± 0.04 mm, without any statistically significant differences among the four subgroups. Non-smoking PCPs displayed a mean BL of 0.49 ± 0.83 and 0.65 ± 0.91 mm and smoking PCPs of 0.85 ± 0.14 and 0.78 ± 0.17 mm for N-implants and S-implants, respectively. Both smoking and non-smoking PCPs displayed a statistically significantly higher mean BL compared with that of PHPs ($P < 0.001$). Smoking PCPs had a statistically significantly higher mean BL compared with that of non-smoking PCPs ($P < 0.001$).

Influence of the Peri-Implant BL on the BL Around Teeth in Non-Smoking PCPs

By comparing the mean BL around teeth adjacent to implants with BL ≥3 mm (0.55 ± 0.23 mm) to the BL at teeth adjacent to implants with BL <3 mm (0.58 ± 0.26 mm), no statistically significant difference was found ($P = 0.55$; Table 4). Similar results were obtained when assessing on radiographs for tooth surfaces facing the implant surfaces with a BL ≥3 or <3 mm (0.54 ± 0.19 and 0.58 ± 0.26 mm, respectively; $P = 0.49$; Table 4).

DISCUSSION

The outcomes of the present 10-year comparative study showed that the survival rate and the stability of

the radiographic crestal BL was greater at teeth than at implants. These results were observed in all patient groups and were independent from the type of implant used.

As reported in two previous publications,[11,14] the bone loss around implants in the present study is correlated with the initial diagnosis of periodontitis and smoking history. This is in agreement with the findings of other studies reporting that a history of periodontitis and/or smoking habit negatively affected the long-term outcomes of implant therapy.[18,12,22-24]

The bone loss around teeth paralleled the findings at implants. Indeed, teeth in PCPs demonstrated a statistically higher mean bone loss compared with PHPs after 10 years of follow-up. Despite being included in a regular, individually tailored periodontal maintenance protocol, non-smoking patients with a history of periodontitis displayed a mean crestal bone loss at the examined teeth that ranged from 0.49 to 0.65 mm, whereas in smoking PCPs, this value ranged from 0.78 to 0.85 mm. These results agree with data reported by Rosling et al.[25] In that study, patients treated for periodontitis and maintained on a regular maintenance protocol displayed a mean bone loss from 0.3 to 0.8 mm over a 12-year follow-up, depending on the susceptibility to periodontal disease.[25]

In the present study, PHPs demonstrated a minimal amount of bone loss (0.22 to 0.31 mm) over the 10-year follow-up period. Data on the radiographic BL changes around teeth in PHPs over a long period of time are scarce. However, an independent correlation between aging and bone loss was reported by Streckfus et al.[26] Hence, some minor changes in the BL over a long period of time could be considered as physiologic.

Smoking PCPs displayed a statistically significantly higher radiographic bone loss around teeth compared with non-smoking PCPs. This finding is in agreement with previous studies associating smoking with additional periodontal breakdown in PCPs.[27] On the contrary, the difference in crestal BL at teeth in smoking and non-smoking PHPs was not statistically significant. This is in accordance with the concept that smoking is a modifying factor of periodontal disease and not the cause of periodontal breakdown per se.[28]

Mengel and Flores-de-Jacoby[17] reported greater clinical AL at implants compared with that at teeth over a 3-year period of follow-up in patients with and without a previous history of periodontitis. This is in accordance with the finding of higher radiographic crestal bone loss at implants than at teeth in the present study.

In the present investigation, teeth in PCPs display a reduced radiographic BL at baseline compared with PHPs (data not shown). This reflects the fact that those teeth had a previous history of periodontitis that had been treated before implant placement. Despite the reduced periodontal tissue support, these teeth demonstrated less radiographic crestal bone loss and a greater survival rate compared with the adjacent, newly inserted implants. The finding that teeth with a history of treated periodontitis display long-term results at least as good as, if not even better than, implants is in accordance with data reported in the literature. Fugazzotto[16] reported on the long-term outcomes of 701 furcated molars treated with resective periodontal therapy compared with 1,472 implants inserted in the molar region. The cumulative success rates were 96.8% for root-resected molars and 97.0% for molar implants. Cortellini et al.[15] performed a randomized controlled study to compare the 5-year outcomes of GTR at teeth with a hopeless prognosis (tests) or tooth extraction and prosthetic rehabilitation with or without implants (controls). Fourteen teeth in the control group were replaced with implant-supported restorations. All fixed partial dentures survived the 5-year follow-up period, and 83% were free from biologic complications. In the test group, two teeth were lost 1 year after treatment, whereas the other 23 showed clinical improvements, yielding a survival and success rate of 92%.

In a systematic review, Tomasi et al.[29] showed that in patients regularly enrolled in a maintenance care program, teeth display a higher survival rate and a lower radiographic bone loss when compared with dental implants.

Several studies support the concept of high survival rates of periodontally compromised teeth treated with conservative, regenerative, or resective periodontal procedures and in patients enrolled in a regular maintenance program.[5,30-32] Even if difficult to compare, data in the literature on long-term success and survival rates of dental implants seem to indicate that implant therapy does not yield better results compared with more or less advanced periodontal procedures aimed at maintaining the natural dentition, displaying survival rates of ≈90% at 10 years and a relatively high number of biologic complications.[9,12,13,22,23,29]

In the present study, the radiographic BL changes at teeth were analyzed as a function of the radiographic bone loss at the adjacent implants. The presence of an advanced peri-implant bone loss (i.e., ≥3 mm) failed to jeopardize the radiographic BL stability of the neighboring teeth. To the best of the authors' knowledge, data on the influence of peri-implant bone loss on the periodontal health of the adjacent dentition are scarce. Previous investigations demonstrated that the approximal bone crest

reduction at teeth is significantly influenced by the horizontal distance between the implant and the neighboring tooth,[33] although this effect could be limited for certain types of implants.[34]

CONCLUSIONS

The findings of the present study demonstrate that natural teeth displayed lower radiographic crestal bone loss compared with implants in both PHPs and PCPs over a period of 10 years. Thus, provided that periodontitis has been treated and that patients comply with a regular periodontal maintenance protocol, the long-term prognosis of teeth is at least as good as that of dental implants. This observation is also valid for teeth with reduced periodontal support. As a consequence, great caution should be exercised when considering tooth extraction for periodontal reasons in favor of implant therapy. Cigarette smoking negatively influences the long-term outcomes at teeth as well as at implants.

ACKNOWLEDGMENTS

The authors are grateful to Dr. William V. Giannobile for the helpful critical review of the manuscript and Miss Sabrine Fessi for her help and assistance during the preparation of the manuscript. The authors report no conflicts of interest related to this study.

REFERENCES

1. Bornstein MM, Halbritter S, Harnisch H, Weber HP, Buser D. A retrospective analysis of patients referred for implant placement to a specialty clinic: Indications, surgical procedures, and early failures. *Int J Oral Maxillofac Implants* 2008;23:1109-1116.
2. Pjetursson BE, Lang NP. Prosthetic treatment planning on the basis of scientific evidence. *J Oral Rehabil* 2008;35(Suppl. 1):72-79.
3. Buser D, Janner SF, Wittneben JG, Brägger U, Ramseier CA, Salvi GE. 10-year survival and success rates of 511 titanium implants with a sandblasted and acid-etched surface: A retrospective study in 303 partially edentulous patients. *Clin Implant Dent Relat Res* 2012;14: 839-851.
4. Carnevale G, Cairo F, Tonetti MS. Long-term effects of supportive therapy in periodontal patients treated with fibre retention osseous resective surgery. II: Tooth extractions during active and supportive therapy. *J Clin Periodontol* 2007;34:342-348.
5. Sculean A, Kiss A, Miliauskaite A, Schwarz F, Arweiler NB, Hannig M. Ten-year results following treatment of intra-bony defects with enamel matrix proteins and guided tissue regeneration. *J Clin Periodontol* 2008;35: 817-824.
6. Cortellini P, Tonetti MS. Long-term tooth survival following regenerative treatment of intrabony defects. *J Periodontol* 2004;75:672-678.
7. Heitz-Mayfield LJ. Peri-implant diseases: Diagnosis and risk indicators. *J Clin Periodontol* 2008;35(Suppl. 8):292-304.
8. Heitz-Mayfield LJ, Huynh-Ba G. History of treated periodontitis and smoking as risks for implant therapy. *Int J Oral Maxillofac Implants* 2009;24(Suppl.): 39-68.
9. Karoussis IK, Salvi GE, Heitz-Mayfield LJ, Brägger U, Hämmerle CH, Lang NP. Long-term implant prognosis in patients with and without a history of chronic periodontitis: A 10-year prospective cohort study of the ITI Dental Implant System. *Clin Oral Implants Res* 2003; 14:329-339.
10. Roccuzzo M, Aglietta M, De Angelis N, Bonino L. Ten-year results of a three-arm prospective cohort study on implants in periodontally compromised patients. Part 1: Implant loss and radiographic bone loss. *Clin Oral Implants Res* 2010;21:490-496.
11. Matarasso S, Rasperini G, Iorio Siciliano V, Salvi GE, Lang NP, Aglietta M. A 10-year retrospective analysis of radiographic bone-level changes of implants supporting single-unit crowns in periodontally compromised vs. periodontally healthy patients. *Clin Oral Implants Res* 2010;21:898-903.
12. Levin L, Ofec R, Grossmann Y, Anner R. Periodontal disease as a risk for dental implant failure over time: A long-term historical cohort study. *J Clin Periodontol* 2011;38:732-737.
13. Swierkot K, Lottholz P, Flores-de-Jacoby L, Mengel R. Mucositis, peri-implantitis, implant success, and survival of implants in patients with treated generalized aggressive periodontitis: 3- to 16-year results of a prospective long-term cohort study. *J Periodontol* 2012; 83:1213-1225.
14. Aglietta M, Siciliano VI, Rasperini G, Cafiero C, Lang NP, Salvi GE. A 10-year retrospective analysis of marginal bone-level changes around implants in periodontally healthy and periodontally compromised tobacco smokers. *Clin Oral Implants Res* 2011;22: 47-53.
15. Cortellini P, Stalpers G, Mollo A, Tonetti MS. Periodontal regeneration versus extraction and prosthetic replacement of teeth severely compromised by attachment loss to the apex: 5-year results of an ongoing randomized clinical trial. *J Clin Periodontol* 2011;38: 915-924.
16. Fugazzotto PA. A comparison of the success of root resected molars and molar position implants in function in a private practice: Results of up to 15-plus years. *J Periodontol* 2001;72:1113-1123.
17. Mengel R, Flores-de-Jacoby L. Implants in patients treated for generalized aggressive and chronic periodontitis: A 3-year prospective longitudinal study. *J Periodontol* 2005;76:534-543.
18. O'Leary TJ, Drake RB, Naylor JE. The plaque control record. *J Periodontol* 1972;43:38.
19. Ainamo J, Bay I. Problems and proposals for recording gingivitis and plaque. *Int Dent J* 1975;25:229-235.
20. Buser D, von Arx T, ten Bruggenkate C, Weingart D. Basic surgical principles with ITI implants. *Clin Oral Implants Res* 2000;11(Suppl. 1):59-68.
21. Updegrave WJ. Right angle dental radiography described, simplified, and standardized (part I). *Compend Contin Educ Dent* 1981;2:379-384.
22. Roccuzzo M, De Angelis N, Bonino L, Aglietta M. Ten-year results of a three-arm prospective cohort study on implants in periodontally compromised patients. Part 1: Implant loss and radiographic bone loss. *Clin Oral Implants Res* 2010;21:490-496.
23. Roccuzzo M, Bonino F, Aglietta M, Dalmasso P. Ten-year results of a three arms prospective cohort study on implants in periodontally compromised patients.

Part 2: Clinical results. *Clin Oral Implants Res* 2012;23: 389-395.
24. Vervaeke S, Collaert B, Cosyn J, Deschepper E, De Bruyn H. A multifactorial analysis to identify predictors of implant failure and peri-implant bone loss [published online ahead of print September 4, 2013]. *Clin Implant Dent Relat Res.* doi:10.1111/cid.12149.
25. Rosling B, Serino G, Hellström MK, Socransky SS, Lindhe J. Longitudinal periodontal tissue alterations during supportive therapy. Findings from subjects with normal and high susceptibility to periodontal disease. *J Clin Periodontol* 2001;28:241-249.
26. Streckfus CF, Parsell DE, Streckfus JE, Pennington W, Johnson RB. Relationship between oral alveolar bone loss and aging among African-American and Caucasian individuals. *Gerontology* 1999;45: 110-114.
27. Bergström J, Eliasson S, Dock J. Exposure to tobacco smoking and periodontal health. *J Clin Periodontol* 2000;27:61-68.
28. Palmer R, Soory M. Modifying factors. In: Lindhe J, Lang NP, Karring T, eds. *Clinical Periodontology and Implant Dentistry*, vol. 1. Munksgaard, Denmark: Blackwell; 2008: 316-322.
29. Tomasi C, Wennström JL, Berglundh T. Longevity of teeth and implants — A systematic review. *J Oral Rehabil* 2008;35(Suppl. 1):23-32.
30. Lindhe J, Nyman S. Long-term maintenance of patients treated for advanced periodontal disease. *J Clin Periodontol* 1984;11:504-514.
31. Silvestri M, Rasperini G, Milani S. 120 infrabony defects treated with regenerative therapy: Long-term results. *J Periodontol* 2011;82:668-675.
32. Carnevale G, Cairo F, Tonetti MS. Long-term effects of supportive therapy in periodontal patients treated with fibre retention osseous resective surgery. I: Recurrence of pockets, bleeding on probing and tooth loss. *J Clin Periodontol* 2007;34:334-341.
33. Krennmair G, Piehslinger E, Wagner H. Status of teeth adjacent to single-tooth implants. *Int J Prosthodont* 2003;16:524-528.
34. Vela X, Méndez V, Rodríguez X, Segalá M, Tarnow DP. Crestal bone changes on platform-switched implants and adjacent teeth when the tooth-implant distance is less than 1.5 mm. *Int J Periodontics Restorative Dent* 2012;32:149-155.

Correspondence: Dr. Giulio Rasperini, Via XX Settembre, 119, 29121 Piacenza, Italy. Fax: 39-0523-335523; e-mail: giulio@studiorasperini.it.

Submitted July 1, 2013; accepted for publication September 28, 2013.