Effects of uncontrolled periodontitis on marginal bone alterations around implants: A case-control study

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Abstract

Background: The hypothesis of bacterial infection initiating marginal bone loss around dental implant in analogy with natural tooth is still in debate.

Purpose: The aim of this retrospective study was to investigate the effects of uncontrolled periodontitis on marginal bone alterations around implants compared with the periodontal health group at a mean follow-up of at least 6 years.

Materials and methods: Thirty consecutive uncontrolled periodontally compromised patients (PCP) and 30 periodontally healthy patients (PHP), with a total of 96 Straumann implants (PCP 55, PHP 41) were matched for age, gender, smoking, and implant characteristics. The inclusion criteria for PCPs were continuing tooth loss due to uncontrolled periodontal disease and no supportive periodontal maintenance after implant therapy. Peri-implant conditions were examined and the number of teeth lost during the follow-up periods was recorded in both groups. Radiographic marginal bone loss of implants and adjacent teeth was calculated having the restoration time point as baseline.

Results: No implant loss occurred in both groups. The mean number of teeth lost during the follow-up periods was 0.67 ± 0.80 in the PHP group, 3.93 ± 2.36 in the PCP group with statistical significance. The average overall bone loss was significantly greater at teeth than that around implants in the PCP group (0.54 ± 0.27 versus 0.22 ± 0.25 mm, P < .001), while no statistically significant differences were observed in the PHP group (0.18 ± 0.08 versus 0.22 ± 0.18 mm, P = .317). No statistically significant differences were observed between PC and PH patients when comparing the peri-implant marginal bone loss. No significant correlations were found between teeth loss and crestal bone loss at implants sites in both groups.

Conclusion: This study indicated that the marginal bone level around implants seemed more stable in comparison to that around the natural teeth when exposed to uncontrolled periodontal disease.

KEYWORDS
bone loss, dental implants, peri-implantitis, periodontally compromised patients, periodontitis

1 | INTRODUCTION

Over the past decades, implant therapy has been identified as a commonly used alternative to conventional prosthetic rehabilitation in partially or totally edentulous patient.1,2 Clinical evidences show that implant therapy has high predictability and long-term survival rate.3,4 However, biological complications may occur leading to progressive peri-implant tissue destruction. Peri-implant diseases, categorized as peri-implant mucositis and peri-implantitis, are the most common problems.5-7

Peri-implantitis has been defined as an infection around oral implant in analogy with periodontitis around natural tooth.5,6 Progressive marginal bone loss is considered as the primary feature of peri-implantitis.8 Most implants yield adaptive changes of the peri-implant
bone levels during the first year of function, and seem to show rather stable crestal bone levels with small changes in the following time.\textsuperscript{9,10} But a small percentage of implants exhibit more and continuous marginal bone loss over time.\textsuperscript{11} Some authors assumed that the etiologic factor of peri-implantitis was similar to that of periodontitis, and bone resorption around implant was mainly due to bacterial infection.\textsuperscript{12,13} The reason for this hypothesis was that a similar gram (-) anaerobic pathological micro-flora formed around diseased teeth and affected implants.\textsuperscript{14–17}

However, recent clinical studies show that multiple factors involved in crestal bone loss around implant are difficult to be explained by the infectious hypothesis, such as concomitant systemic diseases,\textsuperscript{18} soft tissue thickness,\textsuperscript{19,20} the interimplant distance,\textsuperscript{21} implant location,\textsuperscript{22} the crown–implant ratio,\textsuperscript{23,24} the different implant system used,\textsuperscript{25} implant neck design,\textsuperscript{26} the implant surface topography,\textsuperscript{27} antagonistic occlusion,\textsuperscript{28} or the characteristics of the prosthesis.\textsuperscript{29} Furthermore, Albrektsson and colleagues\textsuperscript{30} described the loss of bone surrounding an implant may be initiated by breakdown of a foreign body equilibrium and followed by a secondary biofilm-mediated infection.

Although several studies concluded that the radiographic marginal bone loss around implants was significantly greater in patients with periodontitis compared with periodontally healthy patients,\textsuperscript{31–34} other studies considered no relationships between bone loss around implants and ongoing periodontal conditions around teeth in progressive periodontitis patients.\textsuperscript{35,36} In addition, Cecchinato and colleagues\textsuperscript{37} showed that marginal bone loss might be mutually independent of each other at implants and teeth in lots of partially edentulous patients. Therefore, it was hypothesized that the mechanism leading to progressive marginal bone loss around implants is of difference from that of around natural teeth due to differences between the biological apparatus at the tissue-implant interface and the periodontium around teeth.

The purpose of this retrospective study was mainly to investigate radiographical peri-implant bone level changes and the prevalence of peri-implant diseases in uncontrolled periodontitis-susceptible patients compared with periodontally healthy patients at a mean follow-up of at least 6 years.

2 | MATERIALS AND METHODS

2.1 | Patient enrollment

After approval by the ethical committee of The Fourth Military Medical University, Xi’an, China, a retrospective review of the medical records was performed at the Department of Oral Implants, School of Stomatology at the Fourth Military Medical University. The Patients who underwent their first implant surgery since January 2005 were identified. The implant-supported prosthetic suprastructure had normal function for at least 6 years. Then eligible patients were divided into two groups: periodontally compromised patients (PCP) group and periodontally healthy patients (PHP) control group. Patients who fulfilled the following inclusion criteria were enrolled as the PCP group: (1) diagnosed with generalized chronic periodontitis according to the periodontal diagnosis based on the classification of periodontal diseases introduced by the 1999 International Workshop;\textsuperscript{38} (2) had no regular support periodontal therapy (SPT) record and appealed for additional implant therapy, (3) continued to lose their teeth due to uncontrolled periodontitis after initial implant therapy (Figure 1), (4) aged more than 18 years, (5) present at least one tooth adjacent to the implant site. Exclusion criteria were chosen as follows: (1) patients with systemic disease that may influence the bone healing, (2) patients who received sustained bisphosphonate therapy, (3) patients with uncontrolled diabetes. PHPs were referred to the patients who displayed no radiographic signs in combination with clinical manifestations of chronic periodontitis at the first time of diagnosis.

Based on the literatures,\textsuperscript{39–41} a clinically significant difference in bone loss of 0.5 mm, with a standard deviation of 0.8 mm and 80% power with a $P < .05$, gave a sample size of at least 41 implants in each group. In this study, a total of 30 consecutive patients with 55 implants were identified for PCP group after reviewing the medical records. This cohort was then matched with 30 periodontally healthy patients (PHP) with 41 implants treated in the same period in terms of age, sex, smoking habit, implant location (classified into four categories: anterior maxilla, anterior mandible, posterior maxilla, posterior mandible). The last examination was carried out during the period of June 2012 to April 2016.

2.2 | Implant placement and prosthetic reconstruction

All implants installed were soft tissue level implants with Sandblasted and acid-etched (SLA) surface (Institute Straumann AG, Waldenburg, Switzerland). Following careful clinical and radiological examinations,
the patients underwent implant surgery under local anesthesia in accordance with a standardized surgical procedure by the corresponding author.22 Solid-screw implants were placed according to the manufacturer’s instructions. The appropriate implant type was selected depending on the vertical bone height and the crest width available. If necessary, bone augmentation technique using guided bone regeneration was employed. The implants were inserted in the planned recipient sites with satisfactory primary stability. The insertion depth was planned as the border of the roughened surface was located slightly below the alveolar bone crest. After placement of appropriate healing screws, tension-free adaptation of the wound margins to the implant post or the healing screw was achieved. Nonsubmerged fashion is generally used in nonesthetic sites while the submerged approach is utilized in esthetic sites. Prosthetic reconstructions were delivered after approximately 3–6 months of healing. All implant-supported restorations were fabricated to facilitate the individual oral hygiene procedures and circumferential probing.

2.3 | Clinical evaluation

The patients’ detailed clinical examinations were recorded based on their personal report at the stage of loading and subsequent visits. Two trained and calibrated examiners performed the clinical examination and collected the following information:

- Presence or absence of peri-implant suppuration and/or fistula (yes/no);
- Bleeding on probing (yes/no);
- Modified Plaque Index (mPLI) at six sites around the implant;
- Probing depth at the four sides of the implants using a periodontal probe (Williams Colorvue probes, Hu-Friedy Chicago, Illinois). The measurement was rounded off to the nearest millimeter;
- Number of lost teeth at baseline;
- Number of lost teeth at the last examination.

At the same time, number of implants loss or removal was recorded whenever occurred.

2.4 | Radiographic analysis

Radiographic evaluations were conducted on peri-apical and/or panoramic radiographs at the time of restoration and peri-apical radiographs at the time of latest follow-up. All the peri-apical radiographs were taken using long cone paralleling technique. Radiographs were digitalized at a resolution of 1200 dpi with a scanner (BenQ 5560C, BenQ Corporation) and imported to the software (Image J, Image J64; National Institutes of Health, Bethesda, Maryland).

The known typical designs of the implants (length, diameter, and the distance between consecutive threads) were utilized for the calibration of the peri-implant bone height measurements and adjustment for distortion and magnification. Two different radiographic reference marks to measure bone levels around teeth and implants were as follows: (1) the cement–enamel junction or restoration margin at teeth and (2) the implant/abutment junction. Crestal bone level was the distance from implant shoulder to the first bone to implant contact at mesial and distal aspect of each implant. The marginal bone level of the adjacent tooth was measured analogously to that of the implants. The radiographic crestal bone levels and the bone level changes were assessed at the mesial and distal sites of all implants and adjacent teeth to the nearest 0.01 mm. The radiographic crestal bone loss was calculated by subtracting the crestal bone level at baseline from the crestal bone level at the last time follow-up. All measurements were taken by one independent examiner with specific training. Ten randomly selected implants were measured three times each on separate days for interexaminer reproducibility, and a reliable repeatability frequency was determined (R > 0.90). These radiographs were chosen by means of a table of random numbers.

2.5 | Diagnosis of peri-implant disease

Based on consensus reports of the seventh and eighth European Workshop on Periodontology, peri-implant diseases were classified into two categories by the following case definitions.5,43 Peri-implant mucositis is defined as a reversible inflammation of the gingival soft tissue surrounding the implant with concomitant presence of bleeding and/or suppuration on gentle probing. While Peri-implantitis is characterized by bleeding on probing and/or suppuration in combination with PPD ≥5 mm and radiographic crestal bone loss >2 mm.

2.6 | Statistical analyses

Although the general characteristic of patients in the periodontally healthy control group were matched for that in the periodontally compromised group as homogeneous as possible, the heterogeneity between the two groups was assessed using the Kruskal–Wallis test with respect to age, gender, implant location (ie, anterior or posterior).

Descriptive statistics (mean ± SD) was used for statistical analysis of peri-implant bone level change at mesial and distal site of both tooth and implant. Normality of the distribution of the parametric data was confirmed with a Shapiro–Wilk W test. A one-way ANOVA test was performed to evaluate differences between groups for average bone loss around implants and teeth, respectively. A generalized linear model was fit to depict the relation between teeth loss and crestal bone loss in each group. Spearman rank correlations were performed and their corresponding P-values were calculated for the two groups.

The subject was used as the statistical unit whenever relevant. All the tests were two-tailed, and a P-value <.05 was set to indicate a statistically significant difference. As the number of patient sample enrollment in the clinical examination was small, no attempts were made to evaluate the impact of risk indicators such as history of treated periodontitis, oral hygiene levels, smoking on the presence of peri-implant diseases. All statistical analyses were performed with SPSS, version 20.0, for Windows (IBM Corp., Chicago, Illinois).
3 | RESULTS

3.1 Sample characteristics

A total of 60 patients were enrolled in the final sample, 46 were men and 14 were women. They had a mean age of 49.87 ± 9.03 years at implant surgery and mean prosthesis function time of 92.26 ± 11.50 months. Seven male patients had smoking habits in each group matched. Table 1 shows the characteristics of the patient population with respect to variables concerned: such as age, sex, prosthesis function time, smoking habits. With subjects matched, no significant difference of above mentioned terms could be observed in PCP and PHP groups.

With respect to teeth loss at the baseline, PHP group had lost 81 teeth with mean 2.70 ± 1.88, and PCP group had lost 141 teeth with mean 4.70 ± 3.26, respectively. PCP group displayed a statistically significantly more teeth loss ($P < .0001$) compared with that of PHP group. About 53.33% (16/30, range 4–13) and 20% (6/30, range 4–9) patients lost more than four teeth at baseline in PCP and PHP group, respectively. During the observation period, eight patients lost one tooth, 6 patients lost 2 teeth, and 16 patients had no missing teeth in the PHP group. Contrarily, one patient lost one tooth, 11 patients lost 2 teeth, 18 patients lost more than 3 teeth and up to 13 teeth in the PCP group. The mean number of teeth lost was 0.67 ± 0.80 (range 0–2) for PHP, and 3.93 ± 2.36 (range 1–10) for PCP, showing significant difference ($P < .0001$).

3.2 Radiographic bone loss

The Shapiro–Wilk W test showed the parametric data of radiographic bone loss values were normally distributed. In both groups, >80% of implant sites experienced no obvious bone loss (<0.5 mm). One implant site in the PCP group had lost >2 mm bone.

In the PHP group, the cumulative percentage distribution of implant and adjacent tooth sites that experienced varying degrees of bone-level alterations during the examination interval is depicted in Figure 2. About 92.68% of the mesial or 90.24% of the distal side of the implants showed no obvious bone loss. The mean amount of marginal bone loss that had occurred during the examination interval on the mesial side were: 0.20 ± 0.20 mm at implants, 0.18 ± 0.09 mm at teeth sites. On the distal side, the corresponding values were: 0.23 ± 0.22 mm at implants, 0.18 ± 0.11 mm at teeth sites, respectively. No statistically significant differences were observed between implants and teeth when comparing the average overall bone loss (0.20 ± 0.18 versus 0.18 ± 0.08 mm, $P = .317$).

The crestal bone loss data in the PCP group is depicted in Figure 3. 85.45% of the mesial and 83.33% of the distal sides showed no obvious bone loss. The mean amount of marginal bone loss that had occurred during the examination interval on the mesial side were: 0.24 ± 0.41 mm at implants, 0.50 ± 0.25 mm at teeth sites. On the
distal side, the corresponding values were: 0.24 ± 0.28 mm at implants, 0.57 ± 0.33 at teeth sites. In total, the mean loss of bone at implant level was 0.22 ± 0.25 mm and tooth level was 0.54 ± 0.27 mm, respectively. The average overall bone loss at teeth were significantly greater compared with that of implants in the PCP group (P < .001).

Figure 4 illustrates the radiographic bone loss of implants and teeth from the time of suprastructure delivery to the last examination of two groups. No statistically significant differences (P > .05) were observed between PCP and PHP when comparing the peri-implant marginal bone loss (0.22 ± 0.25 versus 0.20 ± 0.18 mm, P = .622). The mean radiographic bone loss at teeth that had occurred during the examination interval was 0.54 ± 0.27 mm and 0.18 ± 0.08 mm in the PCP group and PHP group, respectively. PCPs displayed a statistically greater (P < .0001) mean bone loss compared with that of PHPs.

Furthermore, Spearman’s rank correlations between teeth loss and crestal bone loss were calculated in each group (Table 4). In the PCP group, teeth loss was significantly correlated with crestal bone loss at adjacent teeth sites (P < .05). No significant correlations were found between teeth loss and crestal bone loss at implants sites in both groups.

### 3.3 | Clinical parameters

Table 5 presents the mean values as well as the maximum and minimum values of the clinical parameters assessed for implants at the end of the observation time. Figure 5 shows the frequency distribution of the percentage of sites with PPD from 0 to 7 mm, which indicated that, around implants, probing depth values of 3 mm were frequently present in both groups. The mPLI value C21 was 14.55% (8/55) and 9.76(4/41), deepest PPD >5mm was 12.73% (7/55) and 4.88% (2/41) in the PCP group and PHP group, respectively.

### 3.4 | Incidence of biological complications

In both groups, no implant loss was observed, yielding a survival rate of 100% at the 6 to 10 years follow-up.

In the PCP, the prevalence of peri-implantitis and peri-implant mucositis was 3.33% (1/30) and 26.67% (8/30), respectively, at patient level. At implant level, the prevalence of peri-implantitis and peri-implant mucositis was 1.82% (1/55) and 21.82% (12/55), respectively.

In the PHP, the prevalence of peri-implant mucositis was 16.67% (5/30) and 14.63% (6/41) at patient level and at implant level, respectively. All the implants in patients of this group remained free of peri-implantitis.
4 | DISCUSSION

This retrospective study mainly investigated radiographic marginal bone alterations around implants in a group of periodontally compromised patients who did not follow the regular SPT programs and appealed for additional implant therapy after nearly 6-10-year follow-up. It was cued that those patients had progressive periodontitis on the basis of continued tooth loss. The outcomes of the present study showed that the alterations of the radiographic crestal bone level at implants in PCPs were identical to that in PHPs, while marginal bone level around implants seemed more stable in comparison to that around the natural teeth when exposed to uncontrolled periodontal disease.

In the present study, a pool of patients without regular SPT characterized by continuing tooth loss was selected to evaluate the impact of uncontrolled progressive periodontitis on crestal bone loss around implants. Renvert and Persson,44 showed that tooth loss was associated with alveolar bone loss and the number of lost teeth provided significant predictive factors for alveolar bone loss in periodontitis. In this study, the number of teeth lost was also used as the most visible result of the progression of periodontitis. It was observed that tooth loss totality was 111 in PCPs, with mean 3.93 ± 2.36, and was significantly more than that in PHP. Moreover, mean bone loss of nature tooth adjacent to implant was 0.54 ± 0.27 mm in PCPs, while 0.18 ± 0.08 mm in the PHPs. Statistically significant difference was found between the two groups, which showed continued worsening of periodontal conditions in patients of PCP group.

Long-term stability of bone level around osseointegrated implant is the key to success of oral implants. The influence of periodontal status on the marginal bone resorption and survival rate of dental implant is still undetermined. Recently, consensus reports from the European Federation of Periodontology or the European Association for the Osseointegration stated that periodontal disease was among risk factors for marginal bone loss.5,6,43 Numerous studies demonstrated that patients treated with periodontitis may experience more implant failures and biologic complications than nonperiodontitis patients. However, several systematic reviews concerning this issue have reached no definitive conclusions.7,32,45

In the current study, it was observed that crestal bone alterations around implants were comparable between PCPs and PHPs. The average bone loss that had occurred during a 6- to 10-year follow-up period in the prosthetic positions was 0.22 ± 0.25 mm versus 0.20 ± 0.18 mm at implants in PCP and PHP group, respectively. No statistically significant difference was found. This finding of bone loss at SLA-surfaced implants is consistent with what described by Rokn and colleagues,46 in a retrospective study. Mean bone loss of 274 tissue-level implants were 0.28 ± 0.53 mm after a 5-year period of functional loading without any regular peri-implant maintenance program. Also, Choy and colleagues.39 presented that the overall mean bone loss was 0.26 mm in the PHP group and 0.23 mm in the PCP group (no residual pockets with PPD >6 mm) with strict maintenance program at follow-ups of 5 years minimally. In contrast to the findings from the present study, Rasperini and colleagues.47 described that progressive bone loss was greater at implants than at teeth in periodontally compromised patients restored with implant-supported prosthesis. Interestingly, the alteration trends of crestal bone level of the implants in the PHP and PCP group were completely different in both studies, but the bone level changes of adjacent teeth were similar. Likewise, Karoussis and colleagues.48 found that crestal bone loss was not significantly associated with history of chronic periodontitis although a higher mean marginal peri-implant bone loss was expected in PCPs. The underlying reason is unknown, but possibly related to differences in patient selection and/or implant systems used.49

The main finding in this study was the discrepancy of crestal bone loss between implants and adjacent teeth in the two groups. Our observations are also supported by previous reports. In a group of 84 partially edentulous patients with different periodontal status, Quirynen and colleagues.36 could not find any correlation between the bone loss around implants and teeth when compared the marginal bone level changes around machined surfaced implants and teeth within the same patient over the same long period of time. Significant difference was found between bone loss around teeth and implants independent of the rate of bone changes around the remaining teeth, while the implants showed less bone loss with a smaller variation. Therefore, the author concluded that ongoing periodontitis does not imply an increased chance for peri-implantitis at least for screw shaped implants with a machined surface. Van Steenberghe and colleagues.50 reported the same implant system which had been followed in five partially edentulous patients suffering from refractory periodontitis. Although the teeth did not respond to the periodontal therapy, the marginal bone level around the implants remained unchanged over time. Similar results also presented in a recent 5-year retrospective study which demonstrated no statistically significant relationship between peri-implant bone loss and chronic periodontitis.25

Peri-implant vertical bone loss is considered as an important radiographic parameter for analyzing treatment outcomes and long-term success.51 To date, it is still in the focus of debate that the reasons for development of progressive bone resorption around dental implants and to what extent it could be defined as "disease." Numerous animal experiments and clinical studies demonstrated that the presence of a
subgingival biofilm plays an important role in the bone resorption of the implant. However, the hypothesis of bacterial infection due to plaque accumulation as the etiologic factor is under question. Recent evidence demonstrated that periodontitis and peri-implantitis lesions exhibit critical histopathologic differences and distinct genome wide transcriptome profiles. Furthermore, some authors suggested that a number of factors other than infection including implant design, patient conditions, clinician error, and provoked foreign body reaction as well as trauma from occlusion might be related to marginal bone loss. The results in this study showed that the alteration of marginal bone level around implant was different from that of adjacent tooth in the uncontrolled periodontitis group. It seemed that crestal bone level of soft tissue level implants with the SLA surface was more stable than that of the natural teeth in the same oral environment, even though one or more remaining teeth in this group were lost due to ongoing periodontitis during implants in function. The findings indicated that the bone pathological biology around implants might be different from that of teeth.

Like other similar studies on the issues of peri-implantitis, peri-implant conditions based on probing implant sites combined with marginal bone loss were considered as the diagnostic criteria in this study. However, the authors are aware of a recent publication by Coli and colleagues. pointed out the shortcomings of periodontal indices used by probes to identify peri-implant disease. Probing parameters may not be reliable indices to assess peri-implant healthy or compromised conditions and the entire diagnostics of mucositis may be criticized based on the findings of Coli and colleagues. Furthermore, selecting a certain accumulated marginal bone loss as the hallmark to define peri-implantitis may also be challenged. In fact, initiation of marginal bone loss around implants in many cases may be aseptic in nature and due to immunological adverse reactions to the disturbances affecting the foreign body equilibrium. Based on recently published papers it may be questioned whether the entire topic of "peri-implantitis" would be in need of a re-evaluation.

In this study, the overall implant survival rate was 100% for each group, and the prevalence of peri-implantitis was 1.82% at implant level in the PCP group. In a retrospective analysis on a large cohort of partially edentulous patients treated by means of titanium implants with SLA surface, Buser and colleagues. presented that implant survival rate was 98.8% during a 10-year period and the prevalence of peri-implantitis was low with 1.8%. In the respects of long term outcomes, this observation is in agreement with previous findings from clinical trials including the use of ITI soft tissue level implants with SLA surface, Buser and colleagues. presented that implant survival rate was 100% during a 10-year period and the prevalence of peri-implantitis was low with 1.8%. However, Renvert and colleagues. revealed that only a few studies investigating the effect of implant surfaces on the initiation of peri-implant disease, provided limited evidence that implant surface characteristics can have a significant impact on course of established peri-implantitis. Safii and colleagues. in a systematic review advocated that long-term prospective observational studies are needed as results of different fixtures cannot be transferred from one system to another.

The present investigation has limitations and the results need to be interpreted with caution. (1) Despite of matched design with some factors controlled, there still exist some confounding factors such as with or without guided bone regeneration procedures, the type of reconstruction, number and distribution of multiple implants, bone quality and quantity. (2) It is a retrospective study design on a relatively limited number of patients. Data were not recorded prospectively and some information was missing or incomplete. (3) It seems arbitrary to attribute tooth loss to the results of the evolution of periodontitis in the PCP group. It is difficult to clarify the real reason of tooth loss in the PCP group because of poor patient compliance, and more objective indicators are needed to illustrate the patient’s periodontal status.

Within the limitations of the present study, it can be concluded that the survival rate and the stability of the radiographic crestal bone level were identical at implants between uncontrolled periodontitis and non-periodontitis. The crestal bone level around soft tissue level implants with a SLA surface was not influenced by the progression of periodontal destruction in the PCP, while the natural tooth presented more susceptible to bone loss in the same periodontally compromised patient.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES


