CLINICAL ORAL IMPLANTS RESEARCH

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Peri-implant conditions and their relationship with periodontal conditions in Chinese patients: a cross-sectional study

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Key words: location of crown margin, peri-implant disease, periodontal disease, plaque, risk factor, susceptibility

Abstract

Objectives: To analyze the relationships between peri-implant conditions and periodontal conditions in Chinese patients with dental implants in place for at least 1 year.

Material and methods: Seventy-six patients (mean age, 41 ± 10 years; range, 21–69 years) who received placement of 120 dental implants (Straumann®), (mean 1.6 implants per subject; range, 1–5 implants per subject) after a mean period of 25 months (range, 12–66 months) responded to recall. Clinical examinations were performed around the implants and natural teeth. Periapical radiographs were taken by the long cone technique for implants, and radiographic bone level (BL) was measured. Comparisons of the peri-implant conditions were performed between the patients with different periodontal conditions by *t*-test and chi-square test. The relative risk of periodontal condition as a risk factor for peri-implant conditions was analyzed by logistic regression.

Results: Subjects who presented with ≥5% sites with probing depth (PD) ≥ 4 mm and ≥30% sites with bleeding on probing (BoP) in the dentition showed significantly poorer peri-implant conditions (58% vs. 18% subjects who had maximum modified gingival index (mGI) 2 or 3, $P = 0.003$; 94% vs. 62% subjects who had maximum PD ≥ 4 mm, $P = 0.008$; 100% vs. 79% subjects who had BoP, $P = 0.044$; mean PD 3.36 ± 0.66 vs. 2.75 ± 0.66 mm, $P = 0.002$; and sites% with BoP 68 ± 23% vs. 36 ± 31%, $P < 0.001$), as compared with those who had <5% sites with PD ≥ 4 mm and <30% sites with BoP on the remaining teeth. The relative risk for subjects with the more severe and extensive periodontal conditions compared to those with better periodontal conditions to have PD ≥ 5 mm with BoP at peri-implant sites was 23.3 ($P = 0.003$, 95% CI, 2.8–192.3.

Conclusions: The peri-implant conditions were significantly related to the periodontal conditions around the remaining natural teeth, which implies that control of periodontal disease is essential for successful implant treatment.

Implant treatment was introduced to dentistry almost 50 years ago. Over the years, as the technology pushes the reported cumulative success rate for implant (Straumann®) treatment is well above 97% over a 10-year period (Blanes et al. 2007). Dental implants offer advantages over conventional dental prostheses under certain circumstances. In addition, the dental industry makes this treatment modality more user-friendly. Consequently dental implant treatment has become an overwhelming modality in dentistry nowadays. Meanwhile, peri-implant disease, which may lead to failure of dental implant treatment, has become a common problem.

The definitions of peri-implant disease were first proposed in a consensus report from the 1st European Workshop on Periodontology. Peri-implant disease is a collective term for inflammatory reactions in the tissue surrounding an implant (Zitzmann & Berglundh 2008). In accordance with periodontal disease, peri-implant disease is classified into peri-implant mucositis and peri-implantitis. Peri-implant mucositis is recognized as 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 (Zitzmann & Berglundh 2008).

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Similar to periodontal disease, peri-implant disease is also considered to be a multifactorial disease. In fact, periodontal and peri-implant diseases share many risk factors like poor oral hygiene, smoking, and diabetes. Furthermore, the past history or experience of periodontal disease *per se* is an important risk factor for the development of peri-implant disease (Lindhe & Meyle 2008). Data suggest that probing depth (PD) around implants placed in patients with a history of chronic periodontitis tends to increase throughout a long-term period (Ellegaard et al. 1997). Moreover, the proportion of deep pockets seems to be higher in patients with a history of chronic periodontitis than in periodontally healthy subjects (Karoussis et al. 2003). It appears that the history of chronic periodontitis may predispose to the development of peri-implantitis. However, the body of evidence supporting this notion is limited (Karoussis et al. 2003; Evian et al. 2004; Roos-Jansaker et al. 2006b).

For ethical reasons, when the long-term studies are designed periodontal treatment has to be included as part of the study. However, this cannot reflect the situation in the real world, where peri-implant or periodontal treatment could be neglected. This perhaps is the reason why many studies could not find difference of the peri-implant clinical parameters between treated periodontitis group and periodontally healthy group (Sbordone et al. 1999; Mengel & Flores-de-Jacoby 2005). On the other hand, in Chinese population the prevalence of periodontal disease is 85.5%, while periodontal treatment rate is low and peri-implant maintenance rate is low as well. It is therefore reasonable to undertake a cross-sectional study on peri-implant and periodontal conditions and try to find a relationship between the two conditions. Thus, the aim of this study was to analyze the relationships between peri-implant condition and periodontal condition in a "real world situation."

Material and methods

The subjects were patients who had received dental implant treatment at least 1 year ago (Straumann®, Straumann, Basel, Swizerland) by two experienced surgeons and one experienced periodontist from The Second Dental Center of Peking University School of Stomatology. The inclusion criteria were the following: patients who received implant surgery at least 1 year ago; non-smokers; patients without history of diabetes; patients who did not take antibiotics in the recent 3 months.

The patients were invited to a follow-up visit by telephone calls. Of all the 166 patients who received implant surgery at least 1 year ago, 86 (52%) participated in the study. The major reason of non-respond was that the patients were not reachable or not in the city (31%), and 26% of the patients refused to participate. The study protocol was approved by the Ethics Committee of the Peking University Health and Science Center. Written informed consent form was obtained from each patient included in the study.

Medical history, time of implant surgery and demographic data were collected from the patients' records. Questionnaires regarding the home oral hygiene practice and smoking status were filled in by the patients prior to clinical examination. According to the inclusion criteria, eight smoking patients and two diabetic patients were excluded from the study.

Clinical examinations were carried out by one examiner using Williams probes. Periodontal charting on the remaining natural teeth was performed for each patient, and the number of remaining teeth, PD more than 3 mm and the percentage of bleeding on probing (BoP) on the remaining natural teeth were recorded.

In addition to the above, clinical examinations were also performed around implants, including assessment of the following parameters at six aspects (Mesiobuccal, buccal, distobuccal, distolingual, lingual, and mesiolingual) of each implant: (i) modified plaque index (PI) according to Silness & Löe (1964); (ii) modified gingival index (mGI) (0 = Absence of visual signs of gingival inflammation; 1 = A slight change in color; 2 = Visual inflammation with blunting of gingival margin; 3 = Overt inflammation with severe swelling); (iii) peri-implant PD; (iv) peri-implant BoP or peri-implant suppuration (S); and (v) the location of crown margin (M) (distance from the gingival margin to the crown margin).

Periapical radiographs were taken with the long cone technique. Bone level (BL) was measured as the distance from the junction between the smooth and rough surface on the implant to the first bone-to-implant contact by one examiner (Fig. 1).

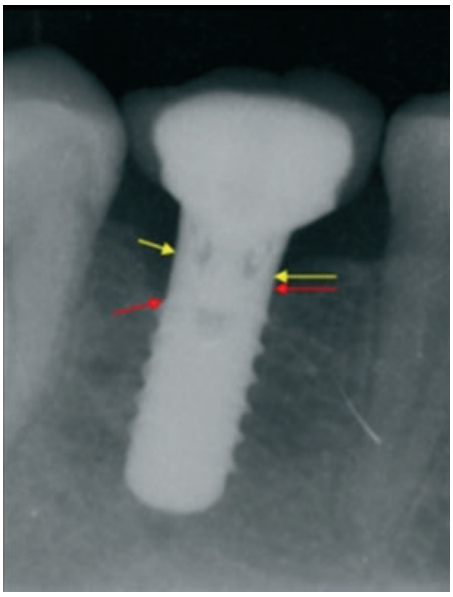

Fig. 1. Yellow arrows illustrate the reference points on the implant, and red arrows indicate the first bone-to-implant contact. Bone level (BL) was measured as the distance between these two points.

Data analysis

All statistical analyses were conducted using SPSS version 19 (SPSS Inc., Chicago, IL, USA). The statistical analysis has been performed on three levels: subject level, implant level, and site level. On subject level, the subjects were divided into two groups according to their periodontal conditions. Frequency of peri-implant bleeding pockets (PD $\geq$ 4 mm and BoP positive sites) was compared in the two groups with chi-square tests. Logistic regression was performed to analyze the relative risk of worse periodontal conditions on the frequency of peri-implant bleeding pockets. Frequencies of peri-implant sites with mGI 2 or 3 or BoP (+) were also compared in the two groups with chi-square tests. Independent samples *t*-tests were performed to compare the difference of the mean peri-implant PD, mean BoP percentage, and mean BL of the subjects in the two groups. The above-mentioned peri-implant parameters were also compared between genders in the same manners. The correlation between mean peri-implant PD/BoP percentage/mean BL and age was analyzed by linear regression.

On implant level, independent samples *t*-tests were performed to compare the difference of mean peri-implant PD, mean BoP percentage, and mean BL of the implants between different implant locations (maxilla vs. mandible, anterior region vs. posterior region). The correlation between the mean peri-implant PD/mean BoP percentage/mean BL of the implants and the time elapsed after implant surgery was analyzed by linear regression. On site level, the frequency of bleeding pockets (PD $\geq$ 4 mm and BoP positive sites) was compared with chi-square tests between sites with and without plaque, and between sites with the sub-mucosal

crown margin deeper than 1 mm vs. sites with supra-mucosal crown margin or sub-mucosal margin not deeper than 1 mm. Logistic regression was performed to analyze the relative risk of plaque and deeper location of crown margin for the frequency of bleeding pockets. Chi-square tests were also performed to compare the frequencies of peri-implant sites with mGI 2 or 3 or BoP (+) between sites with and without plaque, and between sites with the sub-mucosal crown margin deeper than 1 mm and sites with supra-mucosal crown margin or sub-mucosal margin not deeper than 1 mm. Independent samples *t*-tests were performed to compare the difference of mean peri-implant PD, mean BoP percentage, and mean BL between sites with and without plaque, and between sites with the sub-mucosal crown margin deeper than 1 mm and sites with supra-mucosal crown margin or sub-mucosal margin not deeper than 1 mm.

Results

Periodontal conditions

Totally 76 patients (120 implants) were assessed, including 26 men and 50 women. The mean age of the patients at the time of study was 41 ± 10 years (range, 21–69 years). The periodontal conditions of the subjects were described in Table 1. On average, each subject had 27 ± 2 natural teeth. 25 (32.9%) patients had BoP ≥ 30% around the remaining natural teeth, and each subject had 4.8 ± 5.3% (range, 0–26%) sites with pockets of PD ≥ 4 mm and 0.4 ± 1.0% (range, 0–6%) sites with pockets of PD ≥ 6 mm.

Peri-implant conditions

Overall, 24 (20%) of the implants had healthy looking tissue around them, 66 (55%) implants had maximum mGI score 1, 29 (24.2%) implants had maximum mGI score 2, and 1 (0.8%) implant had maximum mGI score 3. The peri-implant BL was 1.0 ± 0.9 mm (range, 0–4 mm) on the mesial and 1.1 ± 0.8 mm (range, 0–3.7 mm) on the distal. The peri-implant PD was 3.0 ± 0.7 mm (range, 1–8 mm). 103 implants (85.8%) had BoP positive sites, and no implant had suppuration (Table 2).

Table 1. **Patients' periodontal conditions (*n* = 76)**

Gender (M/F)	26/50
Age (years)	41 ± 10 (range, 21–69)*
No. of remaining teeth	27 ± 2 (range, 20–31)*
% of BoP sites	23.4 ± 17.4% (range, 0–80%)*
No. of patients with BoP ≥ 30%	25 (32.9%)
% of PD ≥ 4 mm sites	4.8 ± 5.3% (range, 0–26%)*
% of PD ≥ 6 mm sites	0.4 ± 1.0% (range, 0–6%)*

BoP, bleeding on probing; PD, probing depth.
*Mean ± SD.

Table 2. **Overall peri-implant conditions**

Implant level (*n* = 120)	
Time elapsed since implant surgery (months)	25 ± 10 (range, 12–66)*
Location (maxilla/mandible)	37.5%/62.5%
Location (anterior/posterior)	10%/90%
Restoration (cement/screw retained)	93.3%/6.7%
mGI (0/1/2/3)	20%/55%/24.2%/0.8%
BoP%	85.8%
Bone level (mesial/distal, mm)	1.0 ± 0.9/1.1 ± 0.8 (range, 0–4/0–3.7)*
Site level (*n* = 720)	
PI (0/1/2/3)	44.7%/35.1%/17.5%/2.6%
mGI (0/1/2/3)	46.7%/38.9%/13.9%/0.4%
BoP%	47.5%
PD (mm)	3.0 ± 0.7 (range, 1–8)*
Bleeding pockets% (PD ≥ 4 mm, BoP +)	20.7%

BoP, bleeding on probing; PD, probing depth; PI, plaque index.
*Mean ± SD.

On subject level, the frequencies of peri-implant sites with mGI 2 or 3, BoP (+), bleeding pockets, mean peri-implant PD, mean BoP percentage, and mean BL were not related to gender. The mean peri-implant PD, mean BoP percentage, and mean BL were not related to age either. On implant level, 45 (37.5%) implants were located in the maxillas and 75 (62.5%) in the mandibles. No statistically significant difference was found on the mean peri-implant BoP percentage or PD/BL between the maxillary implants and mandibular ones. Overall, 12 (10%) implants were located in the anterior region and 108 (90%) in the posterior region. No significant difference was found on the mean peri-implant BoP percentage, but there was a significant difference ($P = 0.008$) on the mean peri-implant PD between the anterior implants (2.5 ± 0.7 mm) and the posterior ones (3.0 ± 0.7 mm).

The mean time elapsed since implant surgery was 25 ± 10 months (range, 12–66 months). Linear regression did not show any correlation between the time period and mean peri-implant BoP percentage, or between the time period and the mean peri-implant PD/BL.

On site level, of all the 720 sites 44.7% had PI score 0 (no plaque), 55.3% had PI score 1, 2, or 3. As shown in Fig. 2 and Table 3, when compared with sites having no plaque, the sites having PI score 1, 2, or 3 had significantly higher percentage of mGI score 2 or 3 (8.1% vs. 19.4%, $P < 0.001$), higher percentage of BoP (38.8% vs. 54.5%, $P < 0.001$), deeper PD (2.8 ± 1.1 vs. 3.2 ± 1.1 mm, $P < 0.001$); and overall, they had higher percentage of bleeding pockets (PD ≥ 4 mm, BoP [+]; 15.0% vs. 25.3%, $P < 0.001$). The relative risk for sites with PI score 1, 2, or 3 having bleeding pockets was 1.9 ($P = 0.001$, 95% CI, 1.3–2.8) as compared with the sites with PI score 0.

As illustrated in Fig. 3 and Table 4, compared with the 60.3% sites that had their crown margins located supra-mucosally or not deeper than 1 mm sub-mucosally, the 39.7% sites having their crown margins located deeper than 1 mm sub-mucosally had higher percentage of mGI score 2 or 3 (8.3% vs. 23.4%, $P < 0.001$), higher percentage of BoP (34.3% vs. 67.5%, $P < 0.001$), deeper PD (3.6 ± 1.1 vs. 2.6 ± 1.0 mm, $P < 0.001$); and overall, they had higher percentage of bleeding pockets (PD ≥ 4 mm, BoP [+]; 9.0% vs. 38.4%, $P < 0.001$). The relative risk for sites with sub-mucosal crown margin deeper than 1 mm having bleeding pockets was 6.3 ($P < 0.001$, 95% CI, 4.2–9.4) as compared with the sites with supra-mucosal margin or sub-mucosal margin not deeper than 1 mm.

Relationships between peri-implant conditions and periodontal conditions

To analyze the relationship between peri-implant and periodontal conditions, the subjects were divided into two groups according to their periodontal conditions: subjects in Group A (*n* = 19) presented with ≥5% sites with periodontal PD ≥ 4 mm and ≥30% sites with periodontal BoP, and subjects in Group B (*n* = 39) presented with <5% sites with periodontal PD ≥ 4 mm and <30% sites with periodontal BoP. The rest 18 patients' periodontal conditions did not fall into either of the groups, so these

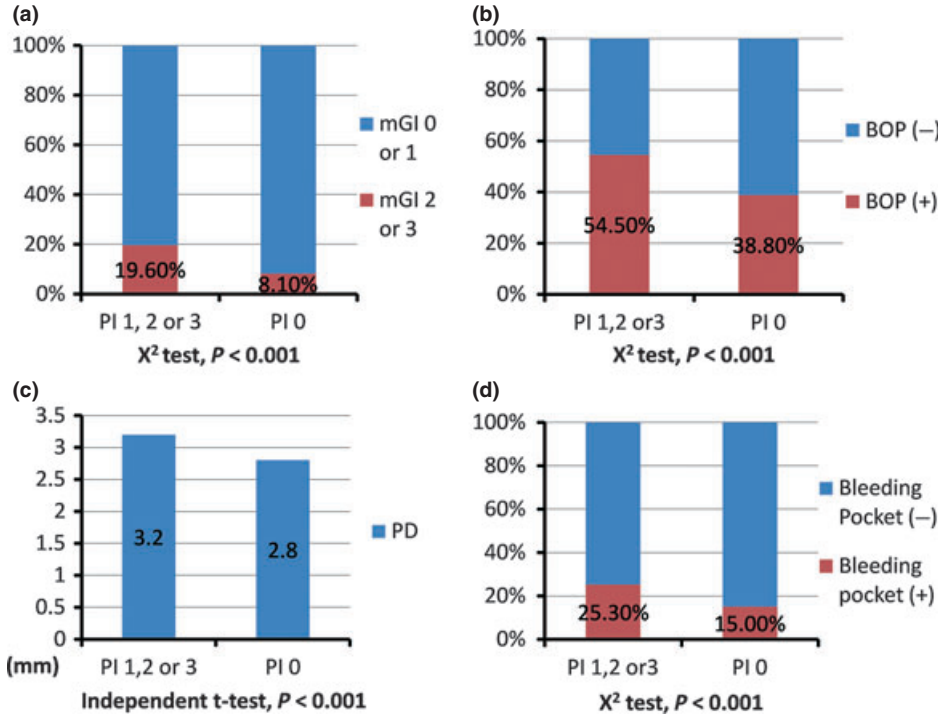

Fig. 2. Comparison of peri-implant parameters between sites having plaque index (PI) score 1, 2, or 3 and sites having PI score 0 (no plaque). (a) Percentage of sites with peri-implant mGI 2 or 3 vs. mGI 0 or 1. (b) Percentage of peri-implant bleeding on probing (BoP) positive sites. (c) Peri-implant probing depth (PD). (d) Percentage of peri-implant bleeding pockets.

***Table 3.* Comparison of peri-implant parameters between sites having PI score 1, 2, or 3 and sites having PI score 0 (no plaque)**

	Peri-implant PI	
Peri-implant conditions	1, 2 or 3 (n = 398)	0 (n = 322)
Sites with mGI 2 or 3	19.6%	8.1% ($P < 0.001$)
Sites BoP	54.5%	38.8% ($P < 0.001$)
Mean PD (mm)	3.2 ± 1.1	2.8 ± 1.1 ($P < 0.001$)
Bleeding pockets	25.3%	15% ($P < 0.001$)

BoP, bleeding on probing; PD, probing depth; PI, plaque index.

subjects were not included for the data analysis. In this study, PD ≥ 4 mm and ≥30% were arbitrary cut-off points for dividing the patients into two groups with better or worse periodontal conditions. Notably, the number of subjects was more or less even in these two groups based on their periodontal conditions.

As demonstrated in Fig. 4 and Table 5, the percentage of subjects having maximum peri-implant mGI score 2 or 3 was significantly higher in Group A than in Group B (57.9% vs. 15.4%, P = 0.001). The percentage of peri-implant bleeding pockets was also significantly higher in Group A than in Group B (94.7% vs. 43.6%, $P < 0.001$). The relative risk for subjects in Group A having peri-implant bleeding pockets was 23.3 (P = 0.003, 95% CI, 2.8–192.3) compared with in subjects in Group B. Compared to Group B, the subjects in Group A had significantly higher percentage of peri-implant BoP (36 ± 31% vs. 68 ± 23%, $P < 0.001$), and deeper peri-implant PD (2.7 ± 0.7 vs. 3.4 ± 0.7 mm). However, the peri-implant BL was not found to be significantly different between the two groups. Overall, the worse peri-implant conditions were significantly related to worse periodontal conditions of the subjects.

Discussion

Plaque is a major risk factor for periodontitis. In a previous cross-sectional study on the possible risk factors for peri-implant disease, it showed that very poor oral hygiene had an OR of 14.3 for peri-implantitis (Ferreira et al. 2006). Unlike in the above-mentioned study, which analyzed plaque as a risk factor for peri-implantitis on subject level, the present study evaluated this factor on site level, as plaque is a local factor and site specific. The results of the present study showed that the relative risk for sites with PI score 1, 2, or 3 having bleeding pockets was 1.9 (P = 0.001, 95% CI, 1.3–2.8) as compared with the sites with PI score 0. This finding indicates that plaque is also a risk factor for peri-implant disease.

The influence of the location of crown margin on peri-implant condition has not been documented before. In the present study, this factor was addressed. The relative risk for sites with sub-mucosal crown margin deeper than 1 mm having bleeding pockets was 6.3 ($P < 0.001$, 95% CI, 4.2–9.4) as compared with the sites with supra-mucosal margin or sub-mucosal margin not deeper than 1 mm. This result shows that deep sub-mucosal margin could be a potential risk factor for peri-implant disease.

The relative risk for subjects presented with worse periodontal condition having peri-implant bleeding pockets was 23.3 (P = 0.003, 95% CI, 2.8–192.3) as compared with those having better periodontal condition. The peri-implant BoP and PD were also found to be significantly higher in patients with worse periodontal condition. On the other hand, the peri-implant BL was not different between the patients with worse periodontal condition and those with better periodontal condition. This could be explained by the design of the study, periodontal conditions which were only assessed in terms of periodontal PD and BoP, as well as attachment level and BL around the natural teeth were not measured. One other possibility is that, as there were no baseline peri-apical radiographs to compare with, the peri-implant BL in the present study was estimated by measuring from a reference point, which may not reflect the true bone loss around the implants. For further study on the relationship between peri-implant conditions and periodontal conditions, the authors suggest that adequate baseline information and periodontal assessment including periodontal attachment loss and BL should be considered.

There have been a few systematic reviews addressing the implant success and survival rates among patients with treated periodontitis or those with a history of periodontitis (Quirynen et al. 2001; Van der Weijden et al. 2005; Ong et al. 2008). It is concluded that there is limited evidence suggesting that implants placed in patients with treated periodontitis have lower survival and success

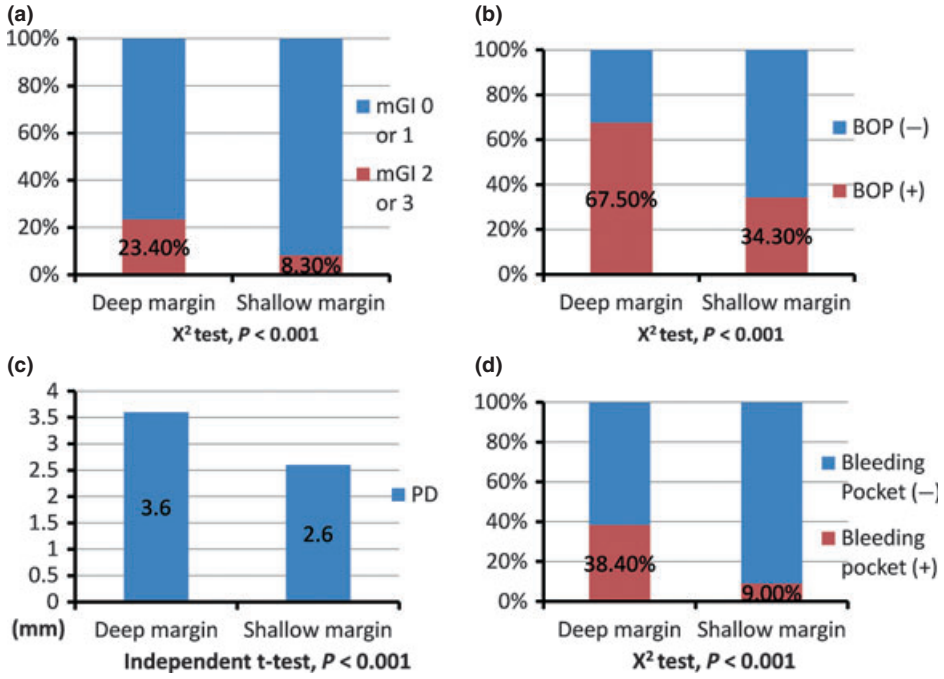

Fig. 3. Comparison of peri-implant parameters between sites having sub-mucosal crown margins deeper than 1 mm and sites having supra-mucosal margins or sub-mucosal margins not deeper than 1 mm. (a) Percentage of sites with peri-implant mGI 2 or 3 vs. mGI 0 or 1. (b) Percentage of peri-implant bleeding on probing (BoP) positive sites. (c) Peri-implant probing depth (PD). (d) Percentage of peri-implant bleeding pockets.

***Table 4.* Comparison of peri-implant parameters between sites having sub-mucosal crown margins deeper than 1 mm and sites having supra-mucosal margins or sub-mucosal margins not deeper than 1 mm**

	Location of crown margin	
Peri-implant conditions	Sub-mucosal margin deeper than 1 mm (n = 434)	Supra-mucosal margin or sub-mucosal not deeper than 1 mm (n = 286)
Sites with mGI 2 or 3	23.4%	8.3% ($P < 0.001$)
Sites BoP	67.5%	34.3% ($P < 0.001$)
Mean PD (mm)	3.6 ± 1.1	2.6 ± 1.0 ($P < 0.001$)
Bleeding pockets	38.4%	9% ($P < 0.001$)

BoP, bleeding on probing; PD, probing depth.

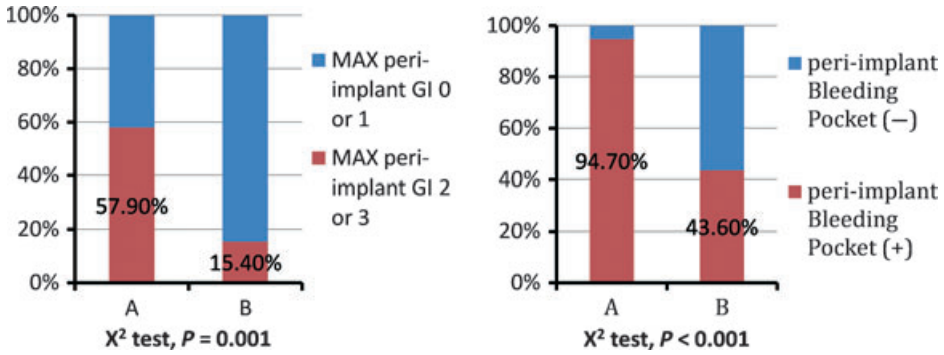

Fig. 4. Comparison of peri-implant parameters in different periodontal condition groups: Group A: subjects presented with ≥5% sites with periodontal probing depth (PD) ≥ 4 mm and ≥30% sites with periodontal bleeding on probing (BoP); Group B: subjects presented with <5% sites with periodontal PD ≥ 4 mm and <30% sites with periodontal BoP.

rates. The body of evidence is not strong mainly because of the heterogeneity of the design and quality of the studies as well as the different definitions for treated periodontitis or implant success. Therefore, the present study did not focus on the definition

***Table 5.* Peri-implant parameters between subjects with different periodontal conditions**

	Periodontal conditions	
Peri-implant conditions	Group A (n = 19)	Group B (n = 39)
Sites with mGI 2 or 3	57.9%	15.4% ($P < 0.001$)
Sites with BoP	68%	36% ($P < 0.001$)
PD (mm)	3.4 ± 0.7	2.7 ± 0.7 ($P = 0.002$)
Bleeding pockets	94.7%	43.6% ($P < 0.001$)
Bone level (mm)	1.0 ± 0.8	0.9 ± 0.7 (NS)

BoP, bleeding on probing; PD, probing depth. Group A: subjects with BoP ≥ 30% and PD ≥ 4 mm sites ≥5% around natural teeth. Group B: subjects with BoP < 30% and PD ≥ 4 mm sites <5% around natural teeth.

of periodontitis or peri-implant success. Instead, the grouping factor was periodontal conditions, and the outcome measures were peri-implant conditions. The main outcome measure of the present study was the prevalence of peri-implant bleeding pockets, as the bleeding pockets around natural teeth may indicate active periodontal disease, due to the similarities of anatomic features and pathogenises between periodontal and peri-implant tissues. The authors adopted this concept on peri-implant conditions.

The findings in the present study are in accordance with previous studies that found a continuous increase of the percentage of implants exhibiting PD ≥ 4 and 6 mm throughout the study in a periodontally compromised group (Ellegaard et al. 1997). A 3-year study reported that bone loss around implants was 0.86 mm in the generalized chronic periodontitis group with reference to 0.7 mm in periodontally healthy subjects, although this difference was not statistically significant (Mengel & Flores-de-Jacoby 2005).

Among the patients who were recalled by telephone, 31% of the contacted patients were not reachable or not available and 26% refused to participate in the study. Hypothetically, those patients who did come and participate in the study might be more concerned about their dental health. It is reasonable to presume that the participants may have better periodontal and peri-implant conditions than those who did not join the study. In another word, the true periodontal and peri-implant conditions could be worse than the results shown in this study.

In conclusion, the present study shows that the peri-implant conditions may be significantly associated with the periodontal conditions around the remaining natural

teeth, implying that control of periodontal disease is essential for successful implant treatment. The findings strongly suggest that control of periodontal disease prior to implant surgery should be adequately addressed in clinical practice, and regular review after implant treatment should not only include peri-implant maintenance but also periodontal assessment and care for long-term periodontal and implant stability.

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