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Long-term outcomes after peri-implantitis treatment and their influencing factors: a retrospective study

Sung-Bae Lee [iD] [1], **Bo-Ah Lee** [iD] [1], **Seong-Ho Choi** [iD] [2], **Young-Taek Kim** [iD] [1,*]

[1]Department of Periodontology, National Health Insurance Service Ilsan Hospital, Goyang, Korea
[2]Department of Periodontology, Research Institute of Periodontal Regeneration, Yonsei University College of Dentistry, Seoul, Korea

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*Correspondence:
Young-Taek Kim
Department of Periodontology, National Health Insurance Service Ilsan Hospital, 100 Ilsan-ro, Ilsandong-gu, Goyang 10444, Korea.
Email: youngtaek@nhimc.or.kr
Tel: +82-31-900-0625
Fax: +82-0303-3448-7138

ORCID iDs
Sung-Bae Lee [iD]
https://orcid.org/0000-0002-6618-3263
Bo-Ah Lee [iD]
https://orcid.org/0000-0003-3586-4928
Seong-Ho Choi [iD]
https://orcid.org/0000-0001-6704-6124
Young-Taek Kim [iD]
https://orcid.org/0000-0002-5132-5783

Author Contributions
Conceptualization: Young-Taek Kim; Formal analysis: Sung-Bae Lee; Funding acquisition: Young-Taek Kim; Investigation: Sung-Bae Lee, Bo-Ah Lee; Methodology: Sung-Bae Lee, Young-Taek Kim; Validation: Seong-Ho Choi;

ABSTRACT

Purpose: This study aimed to determine the long-term outcomes after peri-implantitis treatment and the factors affecting these outcomes.

Methods: This study included 92 implants in 45 patients who had been treated for peri-implantitis. Clinical data on the characteristics of patients and their implants were collected retrospectively. The change in the marginal bone level was calculated by comparing the baseline and the most recently obtained (≥3 years after treatment) radiographs. The primary outcome variable was progression of the disease after the treatment at the implant level, which was defined as further bone loss of >1.0 mm or implant removal. A 2-level binary logistic regression analysis was used to identify the effects of possible factors on the primary outcome.

Results: The mean age of the patients was 58.7 years (range, 22–79 years). Progression of peri-implantitis was observed in 64.4% of patients and 63.0% of implants during an observation period of 6.4±2.7 years (mean±standard deviation). Multivariable regression analysis revealed that full compliance to recall visits (P=0.019), smoking (P=0.023), placement of 4 or more implants (P=0.022), and marginal bone loss ≥4 mm at baseline (P=0.027) significantly influenced the treatment outcome.

Conclusions: The long-term results of peri-implantitis treatment can be improved by full compliance on the part of patients, whereas it is impaired by smoking, placement of multiple implants, and severe bone loss at baseline. Encouraging patients to stop smoking and to receive supportive care is recommended before treatment.

Keywords: Dental implants; Peri-implantitis; Recurrence; Retrospective studies; Treatment outcome

INTRODUCTION

Peri-implantitis is a biological complication of osseointegrated dental implants, defined as inflammation in the peri-implant connective tissue and progressive loss of the bone supporting the implants [1]. Peri-implantitis has reportedly been found in 12%–43% of implants and 28%–56% of analyzed individuals [2]. The increasing use of implant-based restorations to replace teeth has made peri-implantitis a major problem for both clinicians and patients.

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Supervision: Seong-Ho Choi, Young-Taek Kim;
Writing - original draft: Sung-Bae Lee, Bo-Ah
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Seong-Ho Choi, Young-Taek Kim.

Peri-implantitis has been investigated for a relatively short period, and various therapies have been proposed. Treatments for peri-implantitis are based on both non-surgical and surgical concepts that resemble those applied for periodontal treatment. Non-surgical therapies include submucosal decontamination using hand instruments, ultrasonic devices, air abrasive powders, lasers, and antimicrobial agents. Similarly, surgical treatments include various forms of open-flap debridement combined with lasers, antimicrobials, implantoplasty, and bone grafting with or without a barrier membrane. Although most of these protocols have been reported to be effective in resolving peri-implantitis, there is still no consensus regarding the most effective procedure (gold standard) for treating peri-implantitis [3-5].

Under these circumstances, knowledge of prognostic factors could help clinicians select appropriate methods to treat peri-implantitis. A retrospective study wherein most patients (81.6%) were followed for up to 3 years found that early disease development was significantly associated with treatment failure [6]. Lagervall and Jansson [7] reported that severe periodontitis, severe bone loss around the implant, poor oral hygiene, and low compliance reduced the likelihood of treatment success over a follow-up period of 26±20 months (mean±standard deviation). Another study in which the follow-up lasted 12 months observed that the experience of the surgical team, the amount of peri-implant bone loss at baseline, and smoking significantly affected the treatment outcome [8]. However, a limitation of those studies is that they considered only short-term outcomes.

The present retrospective study aimed to determine the long-term outcomes after peri-implantitis treatment and the factors affecting these outcomes.

MATERIALS AND METHODS

Study population
This retrospective study investigated patients who were diagnosed with peri-implantitis between August 2007 and May 2017 at the Department of Periodontology, National Health Insurance Service (NHIS) Ilsan Hospital, Goyang, Korea. Peri-implantitis was defined as the presence of bleeding on probing (BOP) and probing pocket depth >5 mm, combined with radiographic peri-implant bone loss >2 mm [9]. This study excluded patients who did not receive interventions for various reasons, including missed appointments, refusal of treatment, or systemic conditions. Patients whose implants were removed immediately after diagnosis without any treatment were also excluded. Some patients with peri-implantitis received multiple treatments for the same implant during the investigation period. In this case, the most recent treatment was included in this study. Only patients satisfying the following criteria were included: (1) radiographs available from ≥3 years after treatment, (2) receiving rehabilitation with implant-supported fixed prostheses, and (3) treated with non-surgical or surgical treatment without grafting of any regenerative materials (**Figure 1**). The time of the clinical examination before treatment was set as the baseline. This study was approved by the Institutional Review Board (approval number: NHIMC 2018-07-025) of the NHIS Ilsan Hospital. This study followed the Strengthening the Reporting of Observational studies in Epidemiology guidelines.

Treatment protocol

Peri-implantitis was treated by experienced periodontists with non-surgical or surgical protocols 2–4 weeks after full-mouth ultrasonic supragingival scaling. Surgical therapy was considered the first choice of treatment for infected implants. However, when patients declined invasive procedures, non-surgical therapy was administered.

Non-surgical therapy was accompanied by submucosal mechanical debridement using ultrasonic devices, hand curettes, and rotary brushes (I-brush® or T-brush®, Neobiotech, Seoul, Korea). Local minocycline (Minocline®, DongKook Pharma, Seoul, Korea; or Periocline®, Sunstar, Osaka, Japan) was administered in the peri-implant pocket. Meanwhile, surgical treatment involved open flap access to the implant surface, which was decontaminated using ultrasonic devices, hand curettes, and rotary brushes (I-brush® or T-brush®, Neobiotech). No resective bone surgery was done. Local minocycline (Minocline®, DongKook Pharma; or Periocline®, Sunstar) was injected into the surgical site after the flap was sutured to its original position. Systemic antibiotics were prescribed for 3–7 days, and sutures were removed 7–10 days after treatment.

In the maintenance phase, full-mouth ultrasonic debridement was performed every 3–6 months, depending on the patient's oral hygiene. Local minocycline (Minocline®, DongKook Pharma; or Periocline®, Sunstar) was applied adjunctively to residual pockets around the teeth and implants. However, in patients with poor compliance, the intervals between visits were often more than 6 months, and sometimes no visits were made for several years.

Assessment of radiographic marginal bone level

Standardized digital panoramic radiographs taken by radiologic technologists at the NHIS Ilsan Hospital were collected. The patient's head was aligned in a proper 3-dimensional position, with the Frankfort plane parallel to the floor and the midsagittal plane perpendicular to the floor. Radiographic assessments were performed by a single calibrated investigator (Sung-Bae Lee) using the measuring function in the PACS viewer system (Centricity® Enterprise Web V3.0, GE Healthcare, Barrington, IL, USA). The distance from the top of the intraosseous part of an implant to the most crestal bone level was measured in millimeters at the mesial and distal aspects of the diseased implants. A higher value for
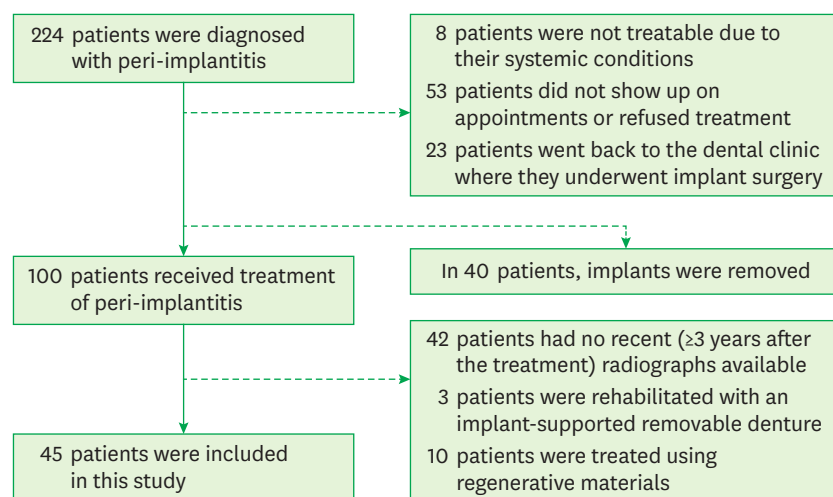

Figure 1. Flow diagram of patient inclusion and exclusion.

the mesial and distal aspects was chosen. The value was calibrated to correct distortion error using the known implant length and the measured length in the radiograph. This process was conducted once more after a 1-week interval. These pairs of measurements showed an intraclass correlation coefficient (ICC) of 97% and a mean measurement error of 0.35±0.35 mm. Finally, the mean value of the 2 measurements was set as the representative value of marginal bone loss (MBL). The severity of peri-implantitis was categorized into 3 groups depending on the baseline MBL (<3 mm, ≥3 mm and <4 mm, or ≥4 mm). The change in MBL was determined by comparing the baseline and latest radiographs.

Treatment outcome

The primary outcome was a progression of peri-implantitis after treatment, which was defined as an additional MBL of >1.0 mm or implant removal between the baseline and the most recent visit.

Clinical data

The dental records of the study population were screened retrospectively by another investigator (Bo-Ah Lee), who was blinded to the radiographic assessment. Data were collected on sex; age; systemic disease (hypertension and diabetes mellitus); patients' self-reported smoking history (non-smoker, ex-smoker, or smoker); history of periodontitis (history of receiving root planing or periodontal flap surgery); observation period (between the times when baseline and latest radiographs were taken); the number of implants infected and placed; location of the implant; type of implant-abutment connection (platform matching, platform switching, or transmucosal); microthread design; prosthesis type (single or splinted); treatment type; presence or absence of BOP at recall visits; and patient compliance. Patient compliance was classified as full compliance (100% attendance at recall visits), erratic compliance (returning to receive supportive care for more than 50% of the appointments), and non-compliance (attending fewer than 50% of the supportive care sessions) [10]. Discontinuation of maintenance for at least 2 years was also considered to indicate non-compliance. Attendance was defined as a visit within a 1-month range from the scheduled date.

Statistical analysis

Data were collected from 2 levels with a hierarchical structure, in which the patient and implant levels were higher and lower, respectively. The progression of peri-implantitis at the implant (lower) level was set as the primary outcome. This approach enabled 2-level binary logistic regression with a random-intercept model to be used for the analysis. The parameters were estimated using a second-order penalized quasi-likelihood procedure. Continuous variables were dichotomized using mean or clinically relevant values. Univariable 2-level logistic regression was applied to each factor. Only variables showing a P value of <0.10 in the univariable analyses were included in the multivariable 2-level logistic regression analysis. None of the included variables displayed a multicollinearity problem with a variance inflation factor of >5. Multilevel logistic regression analyses were performed using a specialized software package for fitting multilevel models (MLwiN version 2.36, Centre for Multilevel Modelling, University of Bristol, Bristol, UK). ICC calculation for the radiographic measurements and assessment of multicollinearity among variables were performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Statistical significance was set at $P<0.05$.

RESULTS

Of the 224 patients diagnosed with peri-implantitis, 124 who did not receive therapy for peri-implantitis and 55 who did not meet the inclusion criteria were excluded. Consequently, this study included 92 implants in 45 patients (23 men and 22 women) aged 58.7±11.2 years (age range, 22–79 years) (**Figure 1**). The characteristics of the patients and their implants are presented in **Tables 1** and **2**, respectively. The patients were observed for 6.4±2.7 years (range, 3.0–11.9 years). The number of infected implants per patient varied, with 19 patients (42.2%) having only 1 affected implant, while the others had multiple implants.

The treatment outcomes of peri-implantitis during the observation period are shown in **Table 3**. Even after peri-implantitis was treated, the disease progressed in 58 of 82 (63.0%) implants and 29 of 45 (64.4%) patients. The absence of BOP was observed in 26 of 92 (28.3%) implants and in 11 of 45 (24.4%) patients. Excluding the removed implants, 65 remaining implants showed mean additional MBL of 1.04±1.94 mm during the observation period.

Multilevel logistic regression analyses were performed to determine the factors that influenced treatment outcomes. The results of the univariable and multivariable multilevel logistic regression analyses are presented in **Table 4**. Among the potential factors selected in the univariable analyses, full compliance, smoking, placement of ≥4 implants, and baseline MBL ≥4 mm were found to be significant. The treatment outcomes were more satisfactory in fully compliant patients than in non-compliant patients (P=0.019), whereas they did

Table 1. Characteristics of the patients

Characteristic	Value
No. of patients	45 (100.0)
Sex	
Female	22 (48.9)
Male	23 (51.1)
Age (yr)	58.7±11.2 (22–79)
<60	25 (55.6)
≥60	20 (44.4)
Systemic disease	
Hypertension	16 (35.6)[a]
Diabetes mellitus	7 (15.6)[a]
Patient compliance	
None	16 (35.6)
Erratic	19 (42.2)
Full	10 (22.2)
Smoking status	
Non-smoker	32 (71.1)
Ex-smoker	5 (11.1)
Smoker	8 (17.8)
History of periodontitis	34 (75.6)
No. of implants placed	
<4	17 (37.8)
≥4	28 (62.2)
No. of implants infected	
1	19 (42.2)
≥2	26 (57.8)
Infected/placed implants	
<0.5	18 (40.0)
≥0.5	27 (60.0)
Observation period (yr)	6.4±2.7 (3.0–11.9)

Values are presented as number (%) or mean±standard deviation (range).
[a] Six patients had both diseases simultaneously.

Table 2. Characteristics of the implants

Characteristic	Total
No. of implants	92 (100.0)
Implant location	
Maxilla	45 (48.9)
Mandible	47 (51.1)
Anterior	8 (8.7)
Posterior	84 (91.3)
Baseline MBL (mm)	
<3	31 (33.7)
≥3 and <4	27 (29.3)
≥4	34 (37.0)
I-A connection	
Transmucosal	26 (28.3)
Platform matching	42 (45.7)
Platform switching	24 (26.1)
Microthread design	23 (25.0)
Prosthesis type	
Single	8 (8.7)
Splinted	84 (91.3)
Treatment type	
Non-surgical	39 (42.4)
Surgical	53 (57.6)

Values are presented as numbers (%).
MBL: marginal bone loss, I-A connection: implant-abutment connection.

Table 3. Treatment outcomes during the observation period

Treatment outcomes	Implants (n=92)
Recurrence of peri-implantitis	
No	34 (37.0)
Yes	58 (63.0)
Bone loss >1.0 mm	31 (33.7)
Implant removal	27 (29.3)
No BOP at last visit	26 (28.3)
Mean MBL change (mm)	1.04[a]±1.94 (n=65)[b]

Values are presented as number (%) or mean±standard deviation.
BOP: bleeding on probing, MBL: marginal bone loss.
[a]Positive value represents additional marginal bone loss.
[b]Twenty-seven removed implants were not considered.

not differ significantly between erratic compliers and non-compliant patients (P=0.58). Additionally, the treatment results were more favorable in non-smokers than in smokers (P=0.023), while they did not show significant differences between non-smokers and ex-smokers (P=0.94). Patients with ≥4 implants were more likely to have additional MBL than those with <4 implants (P=0.022). Implants with a baseline MBL <3 mm showed more favorable treatment outcomes than those with a baseline MBL ≥4 mm (P=0.027), while there was no significant difference compared to the implants with a baseline MBL ≥3 mm and <4 mm (P=0.07). The proportions of progression of peri-implantitis after treatment according to the 4 significant factors above are presented in **Figure 2**.

DISCUSSION

This retrospective study investigated the long-term outcomes after peri-implantitis treatment and evaluated the factors influencing the results. Progression of peri-implantitis after treatment was defined as the primary outcome in this study. It was found that 63.0% of the treated implants in the 45 patients showed disease progression over an observation period

Table 4. Results of the 2-level binary logistic regression analyses

Characteristic	Univariable		Multivariable	
	OR (95% CI)	*P*	OR (95% CI)	*P*
Sex				
Female	Reference			
Male	1.29 (0.40–4.15)	0.67		
Age (yr)				
<60	Reference			
≥60	0.91 (0.28–2.96)	0.87		
Hypertension	2.21 (0.57–8.59)	0.25		
Diabetes mellitus	1.23 (0.23–6.48)	0.81		
Patient compliance				
None	Reference		Reference	
Erratic	0.79 (0.22–2.77)	0.71	0.69 (0.19–2.55)	0.58
Full	0.12 (0.03–0.56)	0.007[a]	0.15 (0.03–0.77)	0.019[b]
Smoking status				
Non-smoker	Reference		Reference	
Ex-smoker	0.97 (0.19–4.82)	0.97	0.93 (0.16–5.49)	0.94
Smoker	7.78 (1.47–41.06)	0.02[a]	6.36 (1.35–30.03)	0.023[b]
History of periodontitis	2.28 (0.57–9.12)	0.24		
No. of implants placed				
<4	Reference		Reference	
≥4	5.65 (1.68–18.98)	0.005[a]	4.44 (1.23–16.05)	0.022[b]
Infected/placed implants				
<0.5	Reference			
≥0.5	0.81 (0.22–2.90)	0.74		
Implant location				
Maxilla	Reference			
Mandible	0.58 (0.19–1.73)	0.33		
Anterior	Reference			
Posterior	1.35 (0.21–8.73)	0.75		
Baseline MBL (mm)				
<3	Reference		Reference	
≥3 and <4	3.39 (0.89–12.89)	0.07[a]	3.99 (0.90–17.81)	0.07
≥4	4.20 (1.10–15.94)	0.04[a]	5.15 (1.20–22.07)	0.027[b]
I-A connection				
Transmucosal	Reference			
Platform matching	0.32 (0.07–1.51)	0.15		
Platform switching	0.32 (0.06–1.83)	0.20		
Microthread design	0.70 (0.18–2.79)	0.62		
Prosthesis type				
Single	Reference		Reference	
Splinted	9.32 (1.16–74.85)	0.04[a]	2.82 (0.31–25.89)	0.36
Treatment type				
Non-surgical	Reference		Reference	
Surgical	2.77 (0.89–8.61)	0.08[a]	1.11 (0.34–3.64)	0.86

MBL: marginal bone loss, I-A connection: implant-abutment connection, CI: confidence interval, OR: odds ratio.
[a]Variables showing *P*<0.10 in the univariable analysis were included in the multivariable analysis.
[b]*P*<0.05 in the multivariable analysis was considered significant.

of 6.4±2.7 years. The long-term risk of progression tended to be lower in fully compliant patients, whereas it was higher in smokers and those who had ≥4 implants. Implants with ≥4 mm of initial MBL showed a higher long-term risk of progression than implants with an initial MBL of <3 mm.

This study revealed that peri-implantitis progressed after treatment in 63.0% of implants and 64.4% of implants. BOP was absent in 28.3% of the implants and 24.4% of the patients. The treatment outcomes were relatively disappointing. Other retrospective studies reported success rates of 45.3% [6] and 69% [7], which are more favorable outcomes than those found
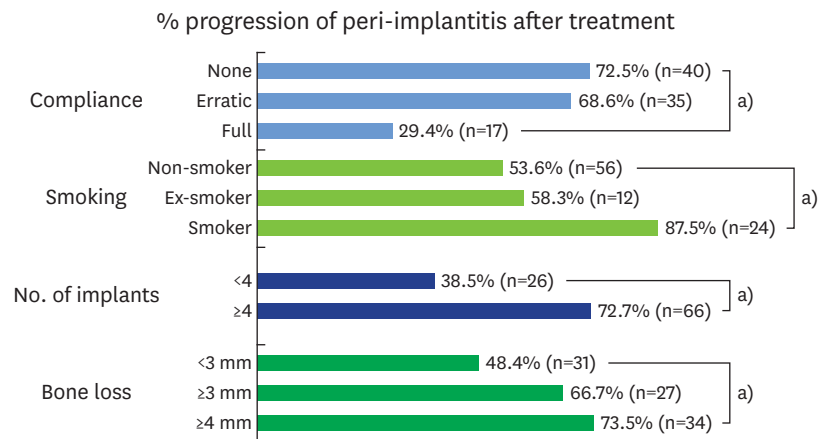
% progression of peri-implantitis after treatment

Figure 2. Percentage of cases where peri-implantitis progressed after treatment according to the 4 significant influencing factors (patient compliance, smoking status, the number of implants placed in a patient, and marginal bone loss at baseline). 'n' is the number of implants in each category.
[a)]Statistically significant difference ($P<0.05$).

in the present study. This discrepancy might be due to the longer mean observation period (6.4 years) and the lower level of patient compliance (with full compliance observed in only 22.2% of patients) in the present study compared to those studies.

Compliance is necessary for patients to adhere to supportive therapy. The importance of supportive therapy has been emphasized to maintain outcomes after peri-implantitis treatment [11]. In a 5-year follow-up study, patients were in a recall system every 6 months after receiving resective surgical treatment for peri-implantitis [12]. Those authors reported that peri-implant conditions were well maintained in most patients. This result is similar to that of another 5-year follow-up study, in which regular supportive care was applied after anti-infective surgical treatment in implants with peri-implantitis [9]. These results are consistent with those of the present study, which showed a significant correlation between full compliance and treatment outcome. However, the proportion of fully compliant patients was low in the current study. A recent systematic review found that compliance with supportive therapy was unsatisfactory [13], with the authors reporting that the most frequent reason for a lack of compliance was being provided with inadequate information and motivation. Therefore, it is important to motivate patients to comply with supportive therapy before treating peri-implantitis.

In the current study, smoking showed significant adverse effects on treatment results, which is consistent with previous reports that smoking affected the treatment outcomes in implants with peri-implantitis [6,8,14]. Smoking is a well-established risk factor for periodontitis [15] and has negative effects on outcomes after periodontal treatment [16-18]. Similarly, smoking has been suggested to be a risk factor for peri-implantitis [19], although strong evidence is not yet available [1,20,21]. Thus, as is the case with periodontitis, it can be expected that smoking will adversely affect the outcomes after therapy for peri-implantitis. Moreover, the present study found that treatment outcomes did not differ significantly between non-smokers and those who had stopped smoking. Considering that smoking cessation has been reported to result in additional improvements in periodontal indices after periodontal therapy [22], it can be expected to have a similar effect on the treatment of peri-implantitis. Thus, smoking cessation should be included as part of peri-implantitis treatment.

Patients with ≥4 implants were observed to have a significantly elevated risk of post-treatment peri-implantitis progression in this study. A history of periodontitis is strongly associated with the development of peri-implantitis [1]. The patients suffered from multiple tooth loss, which was probably due to periodontitis, considering their age. Some studies reported that periodontitis was the main reason for tooth extraction in middle-aged and elderly individuals [23-25]. In this study, 4 or more implants were placed in 23 of 34 (67.4%) patients with a history of periodontitis and in 5 of 11 (45.5%) patients without a history of periodontitis. Moreover, placement of ≥4 implants had a significant association with the development of peri-implantitis in a previous study [26]. Those authors also used a history of periodontitis to explain the results. Therefore, a history of periodontitis seems to have influenced the treatment outcomes of peri-implantitis. However, the history of periodontitis itself did not appear to be a significant factor in this study. A reason for this might be that most patients (75.4%) in the present study had a history of periodontitis; thus, the statistical analysis did not demonstrate its influence.

Implants with MBL of ≥4 mm had a significantly higher odds ratio for progression than those with MBL of <3 mm. Some studies have reported that the treatment outcomes of peri-implantitis can be impaired by the presence of severe peri-implant bone loss. Lagervall and Jansson [7] reported a significantly lower success rate after peri-implantitis therapy in patients with severe MBL around the implants (exceeding one-third of the implant length). Moreover, another study found that increasing amounts of bone loss at treatment were correlated with a decreasing success rate of peri-implantitis treatment [8]. This finding, in addition to the fact that the progression of peri-implantitis accelerates over time [27], suggests the importance of early detection and intervention for peri-implantitis to improve the prognosis of implants. Meanwhile, reconstructive surgery can be performed to improve the prognosis of implants with deep bony defects. In the present study, reconstructive surgery was not considered for implants with ≥4 mm of MBL due to various reasons, such as the presence of 1- or 2-wall intrabony defects, insufficient access to the implant surface, and/or poor plaque control. A recent consensus report documented that the procedure could be considered in implants with a ≥3-mm depth of intrabony defects, 3- or 4-wall defects, and the presence of keratinized mucosa [28]. When indicated, the procedure showed long-term stable treatment results of reduced pocket depth and radiographic bone fill [29,30]. However, it should be noted that these results were observed in well-motivated and compliant patients. Therefore, both patient- and site-related factors should be evaluated prior to reconstructive surgery.

There was no significant difference between the treatment results of non-surgical and surgical therapy in the present study (P=0.86). It has been believed that a surgical approach would be better for resolving peri-implantitis than a non-surgical approach [5,31]. A surgical approach has the advantage of providing direct access to the implant surface for decontamination. The treatment results of access flap surgery, a surgical modality performed in the present study, have been reported in some studies. Leonhardt et al. [14] observed successful results in 58% of treated implants during a 5-year follow-up period. In addition, Heitz-Mayfield et al. [9] reported that 53% of treated implants showed successful outcomes at a 5-year time point. The authors stated that successful outcomes could be achieved when the treatment was followed by regular supportive therapy. The patients in this present study were characterized by a low level of compliance. Thus, surgical treatment would not have made any significant difference in their long-term treatment outcomes compared to non-surgical treatment.

This study has several limitations. First, some factors related to implant surgery, such as implant surface type, bone substitutes grafted, or loading period, were not considered. Information on these factors was unavailable in 47 implants (51.1%) because implant surgery was performed at other dental clinics. Confounding of these factors may be a remaining issue. Second, while periapical radiographs have been the standard for assessing the peri-implant bone level, only panoramic radiographs were available for most patients. However, panoramic radiography has been reported to be as reliable as intraoral radiographs for determining the point of bone attachment to implant threads and accurate for measuring vertical dimensions in implant dentistry [32,33]. These findings indicate that digital panoramic radiography can provide reliable data on the peri-implant bone level.

Within the limitations of this retrospective study, the long-term prognosis after treating peri-implantitis could be improved by full patient compliance, while it can be impaired by smoking, the placement of multiple implants, and severe bone loss at baseline. Sufficient information about the benefits of smoking cessation and regular supportive care should be provided before treating peri-implantitis.

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