CLINICAL ORAL IMPLANTS RESEARCH

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Factors influencing severity of peri-implantitis

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Abstract

Objectives: To retrospectively assess the influence of potential risk factors, primarily smoking and a prior history of periodontitis, on the severity of peri-implantitis in patients referred for treatment of peri-implantitis.

Materials and methods: Among 98 patients referred for treatment of peri-implantitis, 34 patients fulfilled the inclusion criteria: one or several implants with peri-implant marginal bone loss ≥2 mm concomitant with bleeding and/or pus on probing. Information about health status, smoking habits, reason for tooth loss, and performed implant treatment were obtained from the patient charts and interviews. Moreover, a detailed extra- and intraoral examination was performed, including intraoral radiographs of all implants. Risk factors were evaluated by a two-way ANOVA at patient level.

Results: Smoking and a prior history of periodontitis were significant risk factors for increased severity of peri-implantitis. Furthermore, the presence of both smoking and a prior history of periodontitis did not further increase the severity of peri-implantitis, as compared to either of these two factors alone. Poor marginal fit of the suprastructure and extensive gingival imitations on implant-supported fixed full prostheses may also be potential risk factors.

Conclusions: The study indicated that smoking and a prior history of periodontitis were important risk factors for increased severity of peri-implantitis, while concomitant presence of these two risk factors did not further increase the severity of peri-implantitis, as compared to either of these two risk factors alone. Therefore, early diagnosis and adequate treatment of peri-implantitis are important in patients with a prior history of periodontitis and in smokers to minimize the risk of advanced peri-implantitis in conjunction with focus on known risk factors, including meticulous infection control before implant treatment and a systematic maintenance care program.

The prognosis of implant treatment has been addressed in several studies. Although it has been concluded within several systematic reviews that implant treatment in most cases is characterized by high survival of the implants as well as the suprastructures (Berglundh et al. 2002; Jung et al. 2012; Pjetursson et al. 2012), there is increasing focus on the occurrence of mechanical/technical and biological complications. Various risk factors of peri-implantitis have been described, including a prior history of periodontitis and smoking, as described in several published systematic reviews (Schou et al. 2006; Heitz-Mayfield 2008; Schou 2008; Heitz-Mayfield & Huynh-Ba 2009; Renvert & Persson 2009; Mombelli et al. 2012; Clementini et al. 2014). Previous research has mainly focused on the influence of a prior history of periodontitis and smoking on peri-implant bone loss and implant failure rather than on the occurrence and severity of peri-implantitis.

Peri-implantitis was defined at the 1st European Workshop on Periodontology in 1993 as inflammatory reactions with loss of supporting bone in the tissues surrounding a functioning implant (Albrektsson & Isidor 1994). The definition did not include specific clinical and radiological criteria of inflammation and bone loss, thus compromising detailed analyses of the influence of various risk factors of peri-implantitis. Recent consensus conference statement (Sanz & Chapple 2012) and systematic review (Heitz-Mayfield & Huynh-Ba 2009) indicate inadequately reporting of occurrence of peri-implantitis, variations in radiographic reference points for measuring peri-implant marginal

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bone loss, and varying definitions of implant success. Consequently, the present knowledge about potential risk factors influencing the peri-implantitis severity is inadequately described. Therefore, the aim of the present retrospective study was to evaluate the influence of a prior history of periodontitis and smoking, among other potential risk factors such as poor marginal fit of the suprastructure indicated by obvious radiographical or clinical detectable discrepancies between the margin of suprastructure/abutment/implant and also extensive gingival imitations on the severity of peri-implantitis in patients referred for treatment of peri-implantitis.

Material and methods

Inclusion criteria and patient characteristics

The patients were included from a total of 98 patients consecutively referred from November 1, 2008 to February 1, 2014 to the Section for Oral and Maxillofacial Surgery and Oral Pathology and the Section for Prosthetic Dentistry, Department of Dentistry, Health, Aarhus University, Denmark, for treatment of peri-implantitis.

The following inclusion criteria were applied: Presence of peri-implantitis defined as ≥2 mm peri-implant marginal bone loss (see later) concomitant with bleeding and/or pus on probing around one or more implants at the time of examination (Sanz & Chapple 2012). A total of 34 patients (18 women, 16 men) with a mean age of 38 years (range: 23–87 years) at the time of examination fulfilled the inclusion criteria. Consequently, a total of 64 patients were excluded due to bone loss <2 mm and/or lack of bleeding/pus on probing (21 due to bone loss <2 mm, 29 due to lack of bleeding/pus on probing, and 14 due to bone loss <2 mm combined with lack of bleeding/pus on probing). Information about patient characteristics and the performed implant treatment were obtained by structured patient interviews and review of patient charts (Table 1).

Briefly, 16 (47%) of the patients were smokers, and 17 (50%) lost their teeth due to periodontitis, while the remaining 17 (50%) had missing teeth due to other reasons (Caries, trauma, and congenitally missing teeth). Systemic disease, predominantly well regulated, was reported in 15 (44%) of the patients, mainly cardiovascular disease (9/26%). All patients with implant loss before referral had a prior history of periodontitis.

The performed implant treatment is summarized in Table 2. A total of 118 titanium implants were examined. Most of the patients were treated by dentists or oral and maxillofacial surgeons in private practice, while a minority was treated by dental students as part of their undergraduate dental curriculum at the Department of Dentistry, Health, Aarhus University, Denmark, under supervision by dentists and oral and maxillofacial surgeons, all with special knowledge within the field of oral implantology (Bonde et al. 2010, 2013). Most implants were placed in the maxilla (70/59%), and few patients were treated with more than six implants. The mean number of implants per patient was 3.5 (range: 1–12). In most patients, no bone regenerative procedure was performed. However, detailed information about the exact region of bone regeneration could not be obtained systematically from the patient charts. Most suprastructures were fixed, and the few overdentures were retained by either ball or bar attachments. The average time of function of the suprastructure was 6.1 years (range: 1–19 years). The patients have been included in various maintenance programs.

Table 1. **Summary of patient interviews**

		No.	%
Gender	Female	18	53
	Male	16	47
Reason for tooth loss	Periodontitis	17	50
	Caries	6	18
	Trauma	5	14
	Congenitally missing teeth	6	18
Smoking	Smokers and former smokers	16	47
	Non-smokers	18	53
Systemic disease	Diabetes	2	6
	Cardiovascular disease	9	26
	Osteoporosis	1	3
	Autoimmune disease	3	9
	No systemic disease	19	56
Implant loss before referral	Implant loss	5	15
	No implant loss	29	85

Table 2. **Summary of performed implant treatment**

		No.	%
Type of implant	Nobel Biocare – Brånemark	45	38
	Astra	16	14
	Straumann	6	5
	Ankylos	4	3
	Nobel Biocare – Replace	23	20
	Frialit	6	5
	Other	18	15
	Total	118	100
Implant site, maxilla	Central incisor	14	12
	Lateral incisor	10	8
	Canine	15	13
	Premolar	21	18
	Molar	10	8
	Total	70	59
Implant site, mandible	Central incisor	7	6
	Lateral incisor	4	3
	Canine	3	3
	Premolar	19	16
	Molar	15	13
	Total	48	41
No. of implants per patient*	Patients with 1–3 implants	21	62
	Patients with 4–6 implants	10	29
	Patients with ≥7 implants	3	9
Type of suprastructure	Single-tooth replacement	34	60
	Fixed partial prosthesis	11	19
	Fixed full prosthesis	8	14
	Overdenture	4	7

*Mean number of implants per patient was 3.5 (range: 1–12).

Clinical and radiographic examination

A detailed extra- and intraoral examination was performed. The assessment of all implants included (i) Plaque (yes, no), (ii) Deepest clinical probing depth measured to the nearest mm (six sites per implant), (iii)

Bleeding and/or pus on probing (yes, no), (iv) Fistula (yes, no), (v) Keratinized peri-implant mucosa (yes, no), (vi) Recession of the peri-implant mucosa (yes, no), (vii) Mobility of the implant (yes, no), (viii) Mechanical/technical complications (yes, no), and (ix) Poor marginal fit of suprastructure (yes, no). Moreover, diseases of the oral mucosa (yes, no) and clinical signs of xerostomia were assessed (yes, no). All clinical examinations were performed with fixed prostheses attached to the implants.

Intraoral radiographic images of all implants were taken with the parallel technique (Larheim & Eggen 1982) at the time of the clinical examination using a phosphor plate system (Digora® fmx, Soredex Orion Cooperation, Helsinki, Finland). The distance from a reference point to the most coronal bone in contact with the implant was measured mesially and distally parallel with the long axis of the implant on the radiographs taken at the time of the clinical examination using Image J Software (Research Services Branch, National Institute of Health, Bethesda, MD, USA). The reference point was defined as the implant–abutment connection for all 2-piece implants, while the border between the machined and rough implant surface was used for 1-piece implants. The peri-implant marginal bone loss was calculated after correction of magnification based on the known distance between implant threads. All measurements were performed by one examiner (MS).

Data analyses

Descriptive statistics were initially carried out. After initial testing of possible associations between the peri-implant marginal bone loss and various independent variables, a two-way analysis of variance with the peri-implant marginal bone loss as the dependent variable and smoking habits and reason for tooth loss as the independent variables was finally performed followed by an all pairwise multiple comparison procedure (Holm-Sidak method). Data were initially transformed using the logarithm function to obtain normality. The applicability of the two-way analysis of variance was tested using the Shapiro–Wilk normality test and the equal variance test. The statistical unit was the patient. For patients with more than one implant, a mean for each parameter was calculated from the registrations of all implants. The level of significance was 0.05. Data management including calculation of descriptive statistics was conducted in Excel (Microsoft, Redmond, WA, USA), while SigmaPlot 11 (Systat Software, San Jose, CA, USA) was used for the statistical analyses.

Results

The main clinical findings including descriptive statistics are summarized in Table 3. All implant-supported fixed full prostheses were characterized by extensive gingival imitations compromising adequate oral hygiene procedures (Fig. 1). All implant-supported single-tooth replacements and fixed partial prostheses except one mandibular fixed partial prosthesis were without gingival imitations and with no or limited plaque accumulation. A total of 68% of the implants were characterized by bleeding and/or pus on probing. In addition, probing depth of >5 mm was registered around 58% of the implants. Few fistulas were observed, all within the maxillary incisor and canine region. Most implants were surrounded by keratinized mucosa (83%), and recession was frequently seen (28%), predominantly in relation to implants in the mandibular incisor region (Fig. 2). Finally, poor marginal fit of the suprastructure was frequently observed (12%). Assessment of the peri-implant marginal bone level was possible at all implants. The mean peri-implant marginal bone loss is presented in Table 4 in relation to smoking habits and a prior history of periodontitis.

The two-way analysis of variance showed a significant interaction between smoking habits and reason for tooth loss in relation to peri-implant marginal bone loss ($P = 0.043$). The additional all pairwise multiple comparison procedures revealed when smoking habits were considered that peri-implant marginal bone loss was significantly more advanced in smokers than in non-smokers in the group of patients who lost their teeth due to other reasons than periodontitis ($P = 0.007$). In contrast, no significant association between smoking habits and peri-implant marginal bone loss was found among patients who had lost their teeth due to periodontitis ($P = 0.903$). Furthermore, when reason for tooth loss was considered no significant effect of tooth loss due to periodontitis was seen on the peri-implant marginal bone loss in the group of patients who smoked ($P = 0.306$), whereas tooth loss due to periodontitis was almost significantly associated with the peri-implant marginal bone loss in non-smoking patients ($P = 0.060$).

Table 3. **Summary of clinical examination**

		No.	%
Plaque	Yes	49	42
	No	69	58
Bleeding and/or pus on probing	Yes	80	68
	No	38	32
Most profound clinical probing depth*	0–3 mm	14	14
	3–5 mm	29	28
	>5 mm	60	58
Fistula	Yes	7	6
	No	111	94
Keratinized peri-implant mucosa	Yes	98	83
	No	20	17
Recession of peri-implant mucosa	Yes	33	28
	No	85	72
Implant mobility	Yes	6	5
	No	112	95
Poor marginal fit of suprastructure	Yes	14	12
	No	104	88
Mechanical/technical complication	Yes	1	1
	No	117	99
Xerostomia	Yes	2	6
	No	32	94
Disease of oral mucosa	Yes	4	12
	No	30	88

*Detailed registration of probing depth was not possible in some cases due to the design of the suprastructure.

Discussion

The aim of the present retrospective study was to assess the influence of various risk factors on the severity of peri-implantitis in patients referred for treatment of peri-implantitis. In these patients, smoking and/or a prior history of periodontitis were associated with a significantly increased (20%) peri-implant marginal bone loss as compared to non-smokers with tooth loss due to other reasons than periodontitis. Consequently, the present study indicated that smoking and a prior history of periodontitis were important risk factors for increased severity of peri-implantitis, while concomitant presence of these two risk factors did not further increase the severity of peri-implantitis, as compared to either of them alone.

The present retrospective study involved initially 98 patients referred for treatment of peri-implantitis. Assessment of the influence of various risk factors on peri-implantitis requires a strict definition of peri-implantitis. As described within the introduction, peri-implantitis was initially defined as inflammatory reactions with concomitant loss of supporting bone in the tissues surrounding a functioning implant (Albrektsson & Isidor 1994). Presence of a peri-implant marginal bone loss ≥2 mm concomitant with bleeding and/or pus on probing involving one or more implants at the time of examination was used in the present study as the criteria of peri-implantitis, in accordance with recent recommendations (Sanz & Chapple 2012).

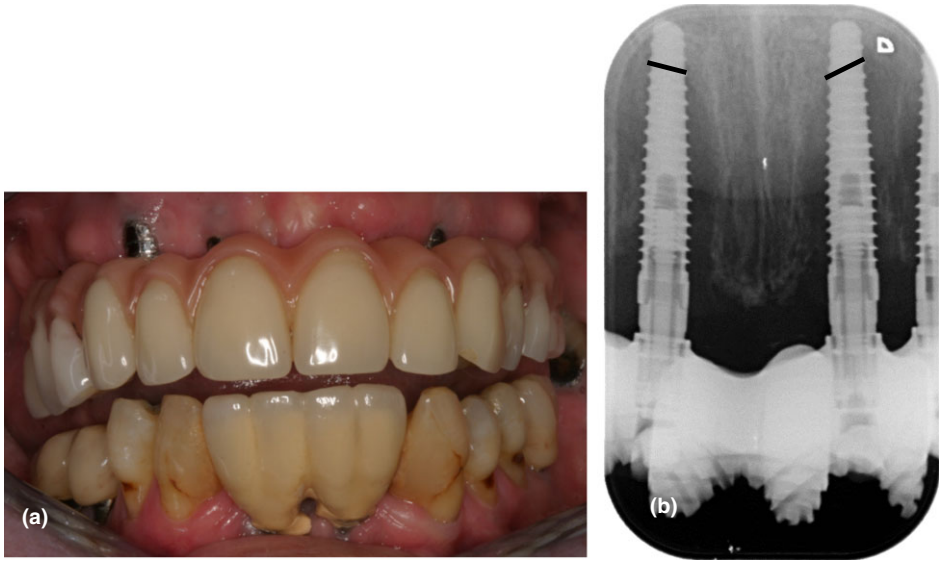

Fig. 1. A 60-year-old female smoker with tooth loss due to periodontitis. Implants were inserted 4 years before examination. (a) To create an esthetic acceptable full fixed prosthesis, extensive gingival imitations were made which compromised oral hygiene procedures. (b) Intraoral radiographic image of implants in the anterior maxilla. Extensive peri-implant marginal bone loss (lines) can be observed.

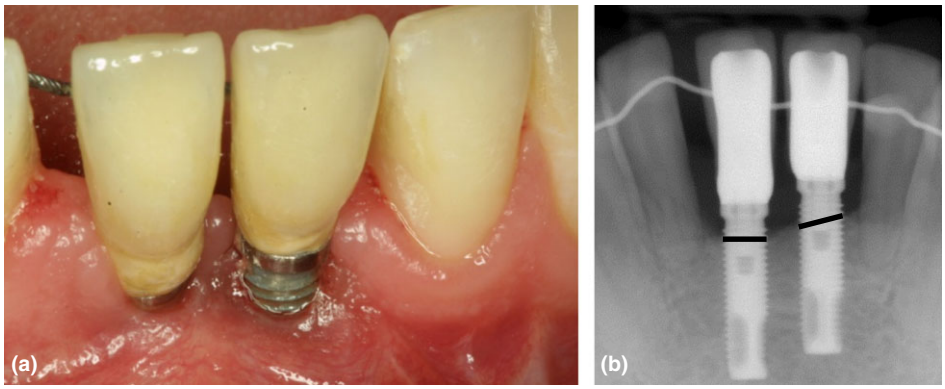

Fig. 2. A 23-year-old male non-smoker with congenitally missing mandibular central incisors. Implants were placed 3 years before examination. (a) Recession and absence of keratinized peri-implant mucosa can be seen. (b) Intraoral radiographic image revealed moderate peri-implant marginal bone loss (lines).

Table 4. **Compared peri-implant marginal bone loss**

	Category	Mean peri-implant marginal bone loss in mm (range)
Smoking habits	Smokers	5.3 (2–11.5)
	Non-smokers	3.5 (2–7.5)
Reason for tooth loss	Periodontitis	5.3 (2–9.8)
	Other reasons than periodontitis	3.8 (2–11.5)

Using these recently accepted inclusion criteria, a total of 34 patients were finally included. Consequently, 64 patients were excluded. The background of exclusion could be related to various factors. The used radiographic criteria addressed bone loss only mesially and distally. The bone loss buccally and lingually could only be assessed at a surgical intervention, which was not indicated in all cases. Therefore, presence of buccal bone loss could not be considered systematically. In addition, some patients were referred with peri-implant marginal bone loss without bleeding on probing at the time of examination or peri-implant.

Previous studies on risk factors of peri-implantitis have mainly focused on survival of the suprastructures, survival of the implants, and peri-implant marginal bone loss (for review, see Schou et al. 2006; Heitz-Mayfield 2008; Schou 2008; Heitz-Mayfield & Huynh-Ba 2009; Renvert & Persson 2009; Mombelli et al. 2012; Clementini et al. 2014). Few recent studies have addressed the occurrence of peri-implantitis defined by bleeding/pus on probing concomitant with well-defined criteria for peri-implant marginal bone loss (Koldsland et al. 2011; Renvert et al. 2014). Despite the limited study population, statistical analyses could be carried out using a two-way analysis of variance after logarithmic transformation.

The analyses were performed at patient level, because the implants cannot be considered as independent units due to the so-called cluster complication effect and the exposure of all implants within each patient by the same systemic risk factors (Jemt & Häger 2006). Therefore, assessment at implant level would from a statistical point of view not be appropriate (Sanz & Chapple 2012). The mean peri-implant marginal bone level at all implants, with and without peri-implantitis, was calculated and used to access the influence of smoking and tooth loss due to periodontitis on the severity of peri-implantitis. In other words, all patients with at least one implant affected by peri-implantitis were included, despite the presence of some implants without peri-implantitis in some patients.

The performed statistical analyses within the present study indicated that smoking was a significant risk factor for increased severity of peri-implantitis, especially in patients with non-periodontitis-associated tooth loss. Previously published systematic reviews have concluded that smokers have an increased risk of (i) Loss of the implants, (ii) Peri-implant marginal bone loss, and (iii) Occurrence of peri-implantitis (Klokkevold & Han 2007; Heitz-Mayfield 2008; Heitz-Mayfield & Huynh-Ba 2009; Mombelli et al. 2012; Clementini et al. 2014).

It has been concluded within several systematic reviews that patients with tooth loss due to periodontitis are characterized by a significantly increased risk of (i) Loss of the suprastructures, (ii) Loss of the implants, (iii) Peri-implant marginal bone loss, and (iv) Occurrence of peri-implantitis (for review, see Schou et al. 2006; Heitz-Mayfield 2008; Schou 2008; Heitz-Mayfield & Huynh-Ba 2009; Renvert & Persson 2009; Mombelli et al. 2012). However, it has not previously been addressed in detail whether peri-implantitis is more severe in periodontitis patients as compared to non-periodontitis patients, although previous studies have addressed the peri-implant marginal bone loss. The results of present study indicate that within the group of non-smokers, patients with tooth loss due to periodontitis are characterized by increased severity of peri-implantitis as compared to patients with non-periodontitis-associated tooth loss.

It has recently been concluded in a systematic review that the combination of a prior history of periodontitis and smoking seems to further increase the risk of implant loss, peri-implant marginal bone loss, and peri-implantitis as compared to smokers and periodontitis patients, respectively (Heitz-Mayfield & Huynh-Ba 2009). Therefore, in accordance with the present study, two-way analyses are needed to assess to influence of smoking and tooth loss due to periodontitis as risk factors. The present study indicated that the concomitant presence of smoking and a prior history of periodontitis did not further increase the severity of peri-implantitis, as compared to either of these two risk factors alone. However, these results must be interpreted cautiously due to the relatively small study population.

It was not possible in detail to evaluate the influence of several potential risk factors influencing the severity of peri-implantitis, including implant overload, plaque, systemic disease, medication, type of implant, implant region, type of suprastructure, poor marginal fit of suprastructure, presence of extensive gingival imitations, absence of keratinized peri-implant mucosa, absence of a systematic maintenance program, disease of the oral mucosa, clinical signs of xerostomia, and lack of buccal bone (Fig. 3.), mainly due to the limited number of included patients. It has previously been described that limited accessibility to proper oral hygiene was associated with peri-implantitis (Serino & Ström 2009). In addition, excess cement has been associated with peri-implantitis (Korsch et al. 2013, 2014), while poor marginal fit of the suprastructure has not previously been described as a significant risk factor. In the present study, only one case of excess cement was identified (Fig. 4), while poor marginal fit was often observed. Fistulas were frequently observed without concomitant peri-implant marginal bone loss in patients with congenitally missing teeth and optimal oral hygiene, why these patients were excluded from the study. Further studies addressing these potential risk factors are needed before final conclusions can be made. Finally, only one case with extensive peri-implant marginal bone loss concomitant with implant fracture was observed (Fig. 5).

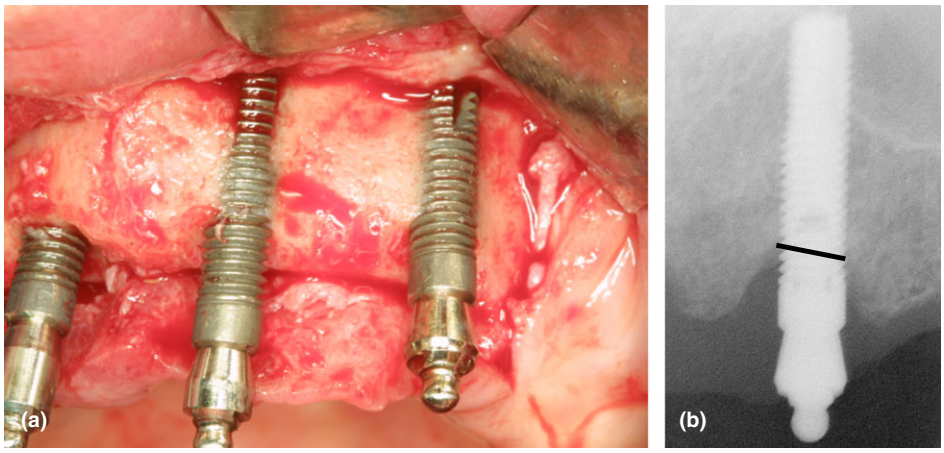

Fig. 3. A 58-year-old female smoker with tooth loss due to periodontitis. Implants were placed 8 years before examination. (a) Extensive lack of buccal bone was observed. (b) Intraoral radiographic image of the right implant revealed moderate peri-implant marginal bone loss (line).

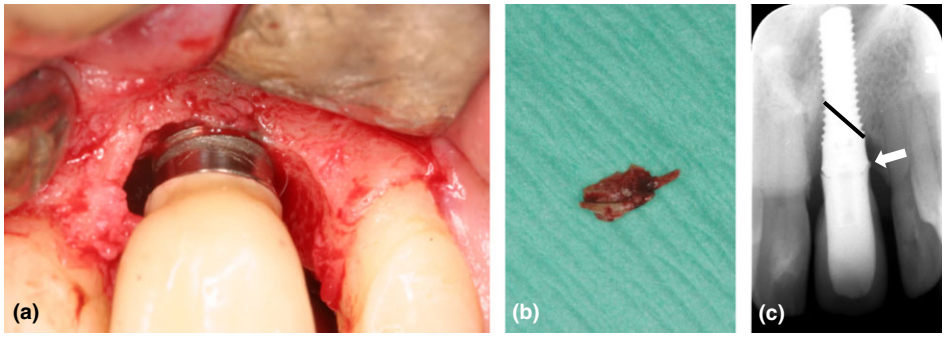

Fig. 4. A 35-year-old male non-smoker with loss of the left maxillary central incisor due to trauma. The implant was placed 8 years before examination. (a) A peri-implant marginal bone defect was observed after removal of excess cement and granulation tissue. (b) A large piece of excess cement was identified during the surgical procedure. (c) Intraoral radiographic image showed poor marginal fit of implant crown, excess cement (arrow), and extensive peri-implant marginal bone loss (line).

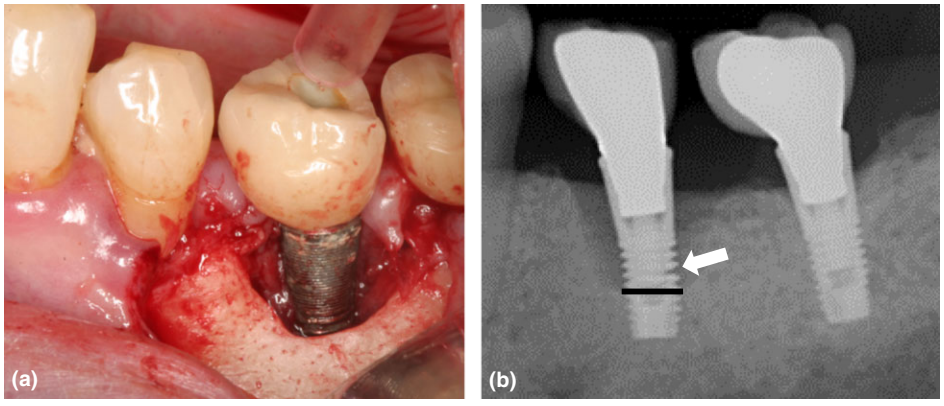

Fig. 5. A 56-year-old smoker with tooth loss due to periodontitis. (a) The implant in the left mandibular second premolar region had extensive peri-implant marginal bone loss concomitant with implant fracture. (b) The intraoral radiographic image confirmed fracture of implant (arrow) and extensive peri-implant marginal bone loss (line).

Conclusions

The present study indicated that a prior history of periodontitis and smoking were important risk factors for increased severity of peri-implantitis, while concomitant presence of these two risk factors did not further increase the severity of peri-implantitis, as compared to either of them alone. Therefore, early diagnosis and adequate treatment of peri-implantitis are important in patients with a prior history of periodontitis and in smokers to minimize the risk of advanced peri-implantitis in conjunction with focus on

known risk factors, including meticulous infection control before implant treatment and a systematic maintenance care program.

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