Impact of Implant and Site Characteristics on the Pattern of Bone Loss in Peri-implantitis

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Purpose: To assess the pattern of bone loss in peri-implantitis in partially edentulous patients and relate patient and implant/site characteristics that may influence such patterns. Materials and Methods: In this retrospective study, the records of partially edentulous patients with dental implants were stratified according to sex, age, smoking, and diabetes. Implants were stratified according to site, number of years in function, presence of adjacent implants, diameter, bone-grafted site, and implant platform. All these variables were obtained from previous periodontal charts and radiographs. The implants were then classified into two main groups: (1) bone loss as defined by the presence of progressive marginal bone change found on radiographs at least 12 months following prosthesis placement compared to a baseline with a threshold ≥ 2 threads of bone loss; and (2) no bone loss as defined by no detected bone change or bone level change with a threshold < 2 threads. The bone loss group was further divided into three subgroups according to pattern: vertical, horizontal, and combined. Descriptive analyses were applied to assess the frequency of the pattern of bone loss (horizontal, vertical, and combined). A statistical regression model was used to find if there was a significant correlation between patient/implant characteristics and the pattern of bone loss. Results: A total of 304 charts with 540 implants met the inclusion criteria. One randomly selected implant per patient through Microsoft Excel software was included in this study. Of these, 157 (51.6%) of examined charts were men and 147 (48.4%) were women. The patients’ mean age was 63.9 ± 11.4 years (range: 27 to 85 years) at implant placement, and implants had been in function for 12 to 120 months (median: 37 months). The percentage of implants that had bone loss was 24.7% (75 out of 304). The pattern of bone loss was 65%, 22%, and 13% for vertical, horizontal, and combined, respectively. Implants that had been placed in surgically bone-grafted sites had increased odds of vertical bone loss with either narrow or wide implants (OR = 2.5 [P = .04] and 3.1 [P = .01], respectively). The presence of adjacent implants had significantly (P = .003) increased odds of horizontal bone loss (OR = 5.1). Conclusion: Approximately one-quarter of dental implants (24.7%) developed bone loss beyond normal physiologic remodeling. Vertical bone loss around single implants was the most common pattern (65%), particularly around implants placed in bone-grafted sites with odds ratio of 2.5 for narrow implants vs 3.1 for wide implants. In the presence of adjacent implants, the odds of horizontal bone loss was 5.1 (P = .003). Int J Oral Maxillofac Implants 2019;34:1475–1481. doi: 10.11607/jomi.7434

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The popularity of dental implants has increased as a method to restore missing teeth in edentulous and partially edentulous patients. Implants are a highly predictable treatment with a 98% survival rate. This high survival rate does not take into account the health status of the implant and its surrounding tissues. Tissue surrounding dental implants is susceptible to disease; it can develop inflammatory reactions such as peri-implant mucositis and peri-implantitis.

In a consensus report from the American Academy of Periodontology and European Federation of Periodontology 2018, clinical investigators defined peri-implantitis as “plaque-associated pathological condition occurring in tissues around dental implants, characterized by inflammation in the peri-implant mucosa and subsequent progressive loss of supporting...
bone. In contrast, peri-implant mucositis was defined as "an inflammatory lesion of the soft tissues surrounding an endosseous implant in the absence of loss of supporting bone or continuing marginal bone loss." Lindhe and Meyle found that peri-implantitis occurs between 28% and 56% of the time. Another more recent cross-sectional study reported 11.3% to 47.1% prevalence of peri-implantitis. With an aging population and increased use of dental implants, it is expected that many patients will develop peri-implantitis, which would negatively contribute to the systemic health of the patients.

Periodontitis and peri-implantitis share similar etiology and clinical manifestations. The rate of progression of bone loss, however, is more rapid around implants in comparison to natural teeth. Patterns of bone loss in peri-implantitis have not been compared to that occurring in periodontitis, which might be correlated with the progressive bone loss in peri-implantitis.

Risk factors associated with peri-implantitis have been extensively studied, but factors associated with the pattern of bone loss in peri-implantitis have not been investigated. The purpose of the present study was to assess the prevalence and pattern of bone loss in peri-implantitis at least 1 year following restoration, as well as to relate certain patient/implant characteristics that may influence the pattern of bone loss.

MATERIALS AND METHODS

This was a retrospective chart review study. The study protocol was approved by the Institutional Review Board (IRB # 2017-1975), Cleveland, Ohio.

Eligible records were identified through an electronic search at Case Western Reserve University School of Dental Medicine for dental implants placed between 2010 and 2016. Included records met the following study criteria: (1) age > 18 years; (2) partially edentulous; (3) single and/or multiple adjacent implants; (4) presence of periapical or bitewing radiographs taken at the time of prosthesis placement as a baseline, and at least 1 year later; and (5) implants with diagnostic images that show clear demarcation between implant threads were considered for the study. The exclusion criteria were as follows: (1) splinted implants, (2) previously treated peri-implantitis, and (3) patients diagnosed with osteoporosis or undergoing bisphosphonate therapy.

Data from patients’ charts included: age, sex, presence of diabetes, self-reported current smoking, and date of implant prosthesis placement. Data from patients’ charts and radiographs included: implant site, ie, maxillary anterior, maxillary posterior, mandibular anterior, mandibular posterior; implant diameter (wide ≥ 4.3 mm, narrow < 4.3 mm); presence of adjacent implant; presence of grafted site (any bone graft material used before or during implant placement); implant platform (platform matched vs platform switched); presence of bone loss (as defined by the presence of progressive marginal bone change found on radiographs at least 12 months following prosthesis placement compared to a baseline with a threshold of ≥ 2 threads of bone loss) (Fig 1). In the presence of bone loss, the pattern of bone loss was classified as follows: vertical: base of the defect is located apical to surrounding bone; horizontal: bone is perpendicular to the implant surface; combined: one side horizontal and one side vertical (Fig 2).

Implants were placed and restored by multiple operators in the CWRU School of Dental Medicine Clinics following the implant manufacturer protocol supervised by experienced faculty. Only two implant systems were used: Straumann Roxolid SLA bone level implants and NobelReplace tapered implants with TiUnite Collar. All implants were restored with delayed loading, and none of the implants were provisionalized.

For analysis, two variables, implant diameter and presence of grafted site, were combined into a single, four-level variable: the levels were narrow implant in native bone, narrow implant in grafted bone, wide implant in native bone, and wide implant in grafted bone.
Radiographs (periapical or bitewing) were evaluated by one examiner (A.S.) after having been calibrated by three experienced periodontists (N.B., P.R., A.P.). Interexaminer and intraexaminer determination of pattern of bone loss showed 100% agreement. Radiographic images were compared at the time of implant restoration with radiographs taken at least 12 months following prosthesis placement.

Data Analysis
The appropriate descriptive statistics (means, frequencies, percentages) were calculated for each study variable. Patient and implant characteristics were examined by the outcome of measured bone loss. Chi-squared tests or Fisher exact tests were used to compare the distribution of study variables according to bone loss pattern (vertical, horizontal, or combined). Multinomial logistic regression was used to model patterns of bone loss as a function of the study variables. Independent variables were included in the model based on the significance of the bivariate tests of association. The combined variables of implant diameter and grafted site were retained in the model. The odds ratios and their 95% confidence intervals were generated from the regression model. The critical value for all tests was set at 5% (alpha = .05).

RESULTS
Out of 757 charts reviewed, 304 charts with 540 implants met the inclusion criteria. One randomly selected implant per patient through Microsoft Excel software was included in this study. Of these, 157 (51.6%) of examined charts were men and 147 (48.4%) were women. The patients’ mean age was 63.9 ± 11.4 years (range: 27 to 85 years) at implant placement, and implants had been in function for 12 to 120 months (median: 37 months). A small percentage of patients self-reported current smoking (4.9%) or having diabetes (8.9%), as shown in Table 1.

Overall, 75 (24.7%) out of 304 of the implants had bone loss. Many implants (n = 167, 54.9%) were in the mandibular posterior, while most implants (n = 216, 71.1%) were not adjacent to another implant. A majority of the implants (n = 282, 92.8%) were platform matched, characterized as narrow (n = 190, 62.5%), and placed in augmented bone (n = 170, 55.9%), as shown in Table 2. Bone loss was further categorized into vertical, horizontal, and combined bone loss. The
most common pattern was vertical (n = 49, 65%), then horizontal (n = 16, 22%), with combined bone loss as the least common (n = 10, 13%), as shown in Fig 3.

No patient characteristics, such as sex, smoking, and diabetes were statistically associated with any pattern of bone loss (Fig 4). When implant and implant site characteristics were examined in relation to the pattern of bone loss, only the presence of an adjacent implant was statistically associated with horizontal bone loss (P = .01) (Fig 5).

From the regression model, the bone-augmented site increased the odds of vertical bone loss for a narrow implant placed in a grafted site (P = .04) and also a wide implant placed in a grafted site (P = .01; OR = 2.5 and 3.1, respectively), compared to the narrow implant placed in native bone. In addition, the presence of adjacent implants significantly increased the odds of horizontal bone loss (OR = 5.1, P = .003), as shown in Table 3.
DISCUSSION

Irrespective of the long-term survival rate of dental implants, the success rate is essential to the health status and the general outcome of the dental implant. Implants with any degree of detectable bone loss following initial bone remodeling after implant placement should be diagnosed as peri-implantitis. With respect to this definition, the present study indicates that 24.7% of the osseointegrated implants have peri-implantitis.

This study classified the pattern of bone loss in peri-implantitis into three categories: vertical, horizontal, and combined. Vertical bone loss is seen more frequently in peri-implantitis, contrary to the case of natural teeth, where the most common pattern of bone loss in periodontitis is horizontal. Schwarz et al surgically evaluated the pattern of bone loss in peri-implantitis and reported that the most common pattern of bone loss is circumferential. In the present study, only two-dimensional radiographic images were used to note the vertical pattern of bone loss that actually may in many cases clinically represent a circumferential defect. The vertical pattern of bone loss is an indication of possible rapid progression of bone loss. Rams et al found the risk of disease progression in periodontitis to be significantly higher with vertical rather than horizontal bone loss. The risk of bone loss in peri-implantitis is greater compared with natural teeth. Attached gingiva composed of epithelial and connective tissue around natural teeth provides a protective barrier not only against inflammation but also against traumatic restorative injuries. The long junctional epithelium around a dental implant may not provide adequate protection against mechanical trauma, so rapid disease progression in peri-implantitis is seen more frequently than with natural teeth.

The present study revealed significant association between a vertical pattern of bone loss and grafted sites when wide- or narrow-diameter implants are present. Such an outcome therefore favors native bone over grafted bone, and might suggest that a narrow implant placed in a native bone site may be a better choice than a wider-diameter implant with a bone graft in that same native bone site.

In this study, the presence of two or more adjacent implants is associated with a horizontal pattern of bone loss rather than around single implants. This relationship is of concern, especially in the esthetic zone, when the interdental papillae do not fill the interproximal space. Tarnow et al reported that 3 mm of interimplant distance is necessary to prevent horizontal bone loss around implants.

In the present investigation, all factors regarding the patient (age, sex, controlled diabetes) and implant (site, number of years in function, diameter, platform) characteristics were not significantly associated with a pattern of bone loss. However, previous studies report contradictory findings.

This study revealed that 75.3% of the implants had no bone loss. Considering this, it was questioned whether some of these implants had any detrimental factors that could, but did not, cause bone loss. It was detected that some implants were healthy, but had one or multiple detrimental factors. It is possible that some implants with only one detrimental factor are not “compromised” enough to develop bone loss, while others, in a similar state, might. Such an outcome could be explained by different thresholds being needed to cause an “imbalance” to initiate a detrimental inflammatory change. This could vary from one patient to another based on the inflammatory level and by the host response. Albretsson et al surmised that dental implant osseointegration may be a foreign

<table>
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<th>Implant characteristics</th>
<th>Vertical</th>
<th>Horizontal</th>
<th>Combined</th>
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<tr>
<td></td>
<td>Odds ratio*</td>
<td>95% CI</td>
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</tr>
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<td>Adjacent implant</td>
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<td>0.6, 2.4</td>
<td>.6</td>
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<tr>
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<td></td>
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<tr>
<td>Narrow-grafted</td>
<td>2.5</td>
<td>1.0, 6.1</td>
<td>.04**</td>
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<tr>
<td>Wide-native</td>
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<td>0.8, 7.1</td>
<td>.13</td>
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<tr>
<td>Wide-grafted</td>
<td>3.1</td>
<td>1.2, 7.8</td>
<td>.01**</td>
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*Outcome reference category is no bone loss.
**Significant.
body equilibrium or “balance” that results in stable implant function. In this scenario, an implant “imbalance” then may occur either early or late in the process with the timing being caused by the host response to one or more, or some combination of, detrimental factors. Each “imbalance” might have a different impact on a certain implant. For example, an early imbalance could end with implant failure, whereas a late one may regain equilibrium despite some bone resorption. Whether or not this concept is valid is obviously open to further research.

Intrinsic methodologic study limitations should be noted. The protocol of implant placement (delayed vs immediate) as well as the implant position in relation to the bone crest were not included in this study. Also, the type of fixed prosthetic restoration (screw-retained vs cement-retained) was not evaluated since most of the chart cases reviewed did not have this information. The maintenance protocol of CWRU dental clinics for patients following implant placement varied between 3 months and 12 months based on patients’ systemic and periodontal conditions. However, the compliance of those patients was not thoroughly documented, and it was decided not to be included in this study.

Although this clinical study was based on a retrospective chart review, it is possible to provide practical clinical recommendations for practitioners. Approximately one-fourth of dental implants have bone loss beyond normal physiologic remodeling. Dentists should be cognizant of this fact when recommending dental implants at the expense of treatable natural teeth. Also, relative to the findings about horizontal bone loss between two adjacent implants, this study suggests that perhaps the better alternative when two adjacent implants are needed and where interproximal space is less than 3 mm is a single implant with cantilever. Since the risk of vertical bone loss in peri-implantitis is high, implant patients should have routine periodontal supportive therapy.

CONCLUSIONS

Bone loss beyond normal physiologic remodeling was detected in 24.7% of dental implants. The most common pattern around single implants was vertical bone loss (65%), predominantly around implants placed in bone-grafted sites with odds ratio of 2.5 (P = .04) for narrow implants vs 3.1 (P = .01) for wide implants. In the presence of adjacent implants, the odds of horizontal bone loss is 5.1 (P = .003).

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REFERENCES


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