Changes in Crestal Bone Levels for Immediately Loaded Implants

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Purpose: *The authors' objective was to measure crestal bone level change in subjects with immediately loaded implants and to identify risk factors associated with changes in bone level.* ***Materials and Methods:*** *A retrospective cohort study design was used. The sample comprised subjects who had had endosseous implants placed and immediately loaded between July 2001 and July 2003. Demographic, health status–related, anatomic, implant-specific, prosthetic, and surgical variables were examined. The primary outcome variable was change in crestal bone level over time. Appropriate uni-, bi-, and multivariate statistics were computed.* ***Results:*** *The sample comprised 174 subjects who received 347 immediately loaded implants. The mean duration of radiographic follow-up was 6.9 ± 4.0 months, respectively. Mean changes in radiographic bone level were −0.5 mm and −0.6 mm on the mesial and distal surfaces, respectively, after a mean of 6.9 months of radiographic follow-up. Using least squares methods, it was estimated that radiographic bone levels would be −1.0 mm and −0.8 mm on the mesial and distal surfaces, respectively, at 12 months. The multivariate model revealed that radiolucency at or adjacent to implant site was associated with an increased risk of crestal bone loss (odds ratio, 1.88; 95% CI, 1.00 to 3.60). Twelve months after placement, 92.5% of implants had had ≤ 1.5 mm of crestal bone loss.* ***Discussion:*** *The results of this study were comparable to the results of other studies comparing immediate loading to delayed loading. Further research to estimate long-term changes in crestal bone loss and to identify risk factors for bone loss with immediate loading is recommended.* ***Conclusion:*** *This study suggests that crestal bone level changes with immediately loaded implants were within the recommended range for 92.5% of the evaluated implants. The mandible showed a higher risk for crestal bone loss compared to the maxilla.* Int J Oral Maxillofac Implants 2006;21:253–261

Key words: *crestal bone levels, dental implants, immediate loading, multivariate models, retrospective cohort studies, risk factors*

To ensure successful osseointegration of dental implants, a standard treatment recommendation has been to avoid loading implants for 3 to 6 months after placement.[1,2] The rationale for delayed loading was that premature loading could result in fibrous tissue encapsulation rather than bone regeneration.[3,4] Functional loading immediately after implant placement can result in micromotion of the implant. According to Brunski,[5] micromotion of more than 100 μm should be avoided, since this could cause the wound to undergo fibrous repair instead of osseous regeneration. The required duration of undisturbed healing, however, was empirically based and has not been verified experimentally.[6]

Recently, the concept of loading implants immediately after placement has become increasingly popular. According to 1 source, an implant is considered "immediately loaded" if full occlusal load is placed on the implant through a fixed or removable prosthesis, provisional or permanent, within 72 hours after placement.[7] Several investigators have reported that immediately loaded implants, placed in good quality bone, were clinically equivalent to implants man-

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aged using a standard or delayed loading protocol.[8–10] Benefits of immediate implant loading include shortened overall treatment time and reduction in the number of surgical sessions. Furthermore, the patient is provided with a fixed provisional prosthesis immediately after implant placement. The theoretical cost is increased risk of implant failure.

In addition to osseointegration, other criteria used to evaluate implant success include lack of mobility, absence of persistent infection, lack of pain, and absence of peri-implant radiolucency.[11–13] One criterion for success includes changes in crestal bone levels, ie, mean crestal bone loss of ≤ 1.5 mm in the first year of function and < 0.2 mm annually in subsequent years.[11,12] Factors hypothesized to be associated with crestal bone loss include surgical trauma upon the periosteum and bone,[14] the size of the microgap between the implant and the abutment,[15] bacterial colonization of the implant sulcus,[16] biological width,[17] and biomechanical factors related to loading.[18]

The purpose of this study was to measure changes in crestal bone levels over time and to identify risk factors associated with increased rates of bone loss in a sample of subjects with immediately loaded implants. It was hypothesized that the rate of bone loss in the first 12 months after implant placement for immediately loaded implants would be < 1.5 mm. Furthermore, it was hypothesized that there would be at least 1 risk factor associated with increased rates of crestal bone loss and that this factor would be something the clinician could modify to enhance the outcome. The specific primary aim of this study was to measure mesial and distal crestal bone levels immediately after implant placement and longitudinally until the subjects' last visit or implant removal. Secondly, the aim was to identify risk factors associated with increased rates of crestal bone loss using multivariate modeling techniques.

MATERIALS AND METHODS

Study Design and Sample

Using a retrospective cohort study design, a sample was derived from the population of subjects who had Bicon implants (Bicon, Boston, MA) placed by practitioners at the Implant Dentistry Centre at Faulkner Hospital (IDC-FH), Boston, Massachusetts, between July 2001 and July 2003. All subjects who had implants placed and immediately loaded were eligible for inclusion in the study. Implants were defined as "immediately loaded" if a functional, fixed provisional prosthesis was placed on the implant on the same day as implant placement. Exclusion criteria included insufficient documentation in the clinical record or insufficient imaging, ie, lack of digital imaging.

Study Variables

The predictor variables, ie, clinical exposures or clinical risk factors, have been reviewed in detail elsewhere[14,19] and are briefly summarized here. The predictor variables were grouped into the following categories:

- **Demographics:** These included the subject's age and gender at the time of implant placement.
- **Health Status:** Current tobacco use status and medical conditions associated with wound healing were recorded.
- **Anatomy:** The anatomic variables included *(1)* implant location, ie, maxilla or mandible, anterior or posterior; *(2)* dentition status, ie, partially or fully edentulous; *(3)* bone quality (types 1 to 4); and *(4)* implant relationship to other dentoalveolar structures.[20] Bone quality was determined at the time of implant placement upon examination of the contents of the flutes of a 3.5-mm reamer extracted from the osteotomy. Type 1 bone was defined as compact, nearly bloodless bone that completely filled the flutes of the reamer. Bone quality was classified as type 4 when little or no bone filled the flutes of the reamer. Intermediate grades were classified as either type 2 or type 3 bone. The number of root canal–treated teeth at an implant site, number of teeth with periapical radiolucencies adjacent to an implant, and location of any previous root canals were also recorded.
- **Implant-Specific Variables:** These variables included implant diameter (3.5 to 6 mm), implant length (5.7 to 11 mm), well size (2 to 3 mm), and implant coating (grit-blasted acid etched, titanium plasma sprayed [TPS], hydroxyapatite [HA]).
- **Prosthetic Variables:** The primary prosthetic variable was the total size of the prosthesis, which was defined by the number of units (implants, natural teeth, and pontics) in the span of the prosthesis. This variable was subdivided into 3 categories: *(1)* total number of natural teeth involved within the span of the temporary prosthesis, *(2)* the total number of pontic units within the span of the temporary prosthesis, and *(3)* the total number of implants supporting the temporary prosthesis.
- **Surgical Variables:** Surgical variables included the use of dentoalveolar reconstructive procedures to enhance the recipient site (eg, autologous or allogeneic bone grafting, sinus lifting, or barrier membranes) and the timing of implant placement rela-

tive to tooth extraction. Implant placement timing was classified based on the time when the implant was placed in relation to tooth extraction. There were 3 categories: *(1)* "immediate," defined as implant placement at the time of extraction; *(2)* "early delayed," defined as implant placement 6 to 8 weeks after tooth extraction, and *(3)* "prolonged delayed," defined as implant placement ≥ 3 months after tooth extraction.

For each implant, the date of implant placement, dates of follow-up visits, dates of all radiographs obtained, and date of implant removal (if applicable) were recorded.

The primary outcome variable, which was a continuous variable, was change in crestal bone level over time relative to immediate postoperative status. Change in crestal bone level was measured in millimeters by comparing the immediate postoperative radiographs to the most recent radiographs available for review. A negative number implied bone loss over time. A positive number suggested an increase in bone levels over time. The secondary outcome variable was binary and was defined as change in bone levels ≤ 1.5 mm during the first year or > 1.5 mm during the first year.

Changes in bone levels over time were estimated by direct measurements on nonstandardized, digital periapical radiographs by 2 examiners (RHY and MSE). Magnification was not a known or repeatable factor for intraoral images in this study. To make calibrated measurements, an object of known size, eg, an implant, must be placed in the image in the same plane as the area to be measured. The length (mm) of the implant was measured on the digital radiographs from the implant-abutment interface to the apex of the implant (Fig 1). Next, the distance between the observed crestal bone level and the implant-abutment interface was measured at the mesial and distal implant surfaces. The actual implant length was known based on manufacturing standards. To adjust the measurements for magnification error, the following equation was used to determine the corrected crestal bone levels: Corrected crestal bone level = Measured crestal bone level × (actual implant length ÷ measured implant length).

Data Analysis

A database was created using Microsoft Excel (Microsoft, Redmond, WA). SAS PC version 8 (2001) (SAS Institute, Carey, NC) statistical software was used for data and statistical analysis. Descriptive statistics were computed for all study variables. Kaplan-Meier analysis was computed for time-to-event (survival) data.[21]

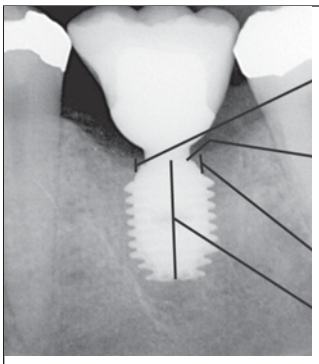

Fig 1 Direct measurements on a Bicon immediately loaded implant using a nonstandardized digital periapical radiograph.

For the purpose of estimating changes in bone levels at 12 months, bone level changes for all implants were plotted on a graph. A line that best fit using the least squares method across the scattered plot was drawn and extrapolated linearly to estimate the bone level changes at 12 months and associated 95% confidence intervals were computed.

Some subjects had more than one implant, producing correlated observations. To adjust for clustered, correlated observations, generalized estimating equations (GEE) regression analysis was applied to identify risk factors associated with crestal bone loss. Potential risk factors for increased crestal bone loss were identified using the bivariate GEE regression model and were considered potential predictor variables if $P \leq .15$. Variables meeting this criterion were included in the multivariate clustered GEE regression model to identify variables statistically associated ($P \leq .05$) with the outcome in addition to the 3 biologic important predictors: age at implant placement, gender, and radiographic follow-up time.

To determine intraexaminer reliability, each examiner measured and remeasured a set of 25 random implants. The measurements were made 2 months apart. To determine interexaminer reliability, each examiner measured the set of 25 random implants that was measured by the other examiner. Kappa statistics were used to compute intra- and interexaminer reliability. The intraexaminer kappa coefficients were 0.84 and 0.92 (excellent agreement). The interexaminer kappa coefficient was 0.76 (excellent agreement).

Table 1 Descriptive Statistics

Variable	n or k	%
Gender (n = 174)		
Male	90	51.7
Female	84	48.3
Tobacco use		
Yes	15	8.7
No	158	91.3
Anatomic		
Jaw location (k = 347)		
Maxilla	282	81.3
Mandible	65	18.7
Anteroposterior location (k = 347)		
Anterior	183	52.7
Posterior	164	47.3
Jaw and anteroposterior location (k = 347)		
Anterior maxilla	156	45.0
Posterior maxilla	124	35.7
Anterior mandible	28	8.1
Posterior mandible	39	11.2
Dentition status (k = 347)		
Partially edentulous	323	93.1
Completely edentulous	24	6.9
Bone quality (n = 118)		
Type 1	5	4.2
Type 2	13	11.0
Type 3	44	37.3
Type 3–4	3	2.5
Type 4	53	44.9
RCT tooth at implant site (k = 242)	106	43.8
Implant site adjacent to RCT teeth (k = 347)		
None	270	77.8
1	61	17.6
2	16	4.6
Radiolucency at or adjacent to implant site (k = 347)		
None	295	85.0
Implant site	22	6.3
Adjacent tooth	19	5.5
Implant site and adjacent tooth	11	3.2
Implant-specific		
Implant diameter (k = 347)		
3.5 mm	28	8.1
4.0 mm	31	8.9
4.5 mm	133	38.3
5.0 mm	131	37.8
6.0 mm	24	6.9
Implant length (k = 347)		
5.7 mm	8	2.3
8 mm	251	72.3
11 mm	88	25.4
Implant coating (k = 346)		
Grit-blasted acid etched	7	2.0
TPS	25	7.2
HA	314	90.8
Implant well size (k = 347)		
2 mm	59	17.0
3 mm	288	83.0
Prosthetics*		
Total units (k = 347)		
2	1	0.3
3	113	32.6
4	66	19.0
5	37	10.7
6	69	19.9
7	5	1.4
8	25	7.2
9	9	2.6
10	11	3.2
11	5	1.4
12	3	0.9
13	3	0.9
Natural teeth† (k = 347)		
0	38	11.0
1	48	13.8
2	258	74.4
3	3	0.9
Pontics (k = 347)		
0	304	87.6
1	21	6.1
2	10	2.9
3	10	2.9
4	2	0.6
Implants (k = 347)		
1	106	30.6
2	73	21.0
3	51	14.7
4	60	17.3
5	5	1.4
6	4	1.2
7	7	2.0
8	23	6.63
9	9	2.6
10	5	1.4
11	1	0.3
13	3	0.9
Dentoalveolar reconstruction procedure at implant site (k = 347)		
Yes	39	11.2
No	308	88.8
Timing of implant placement (k = 347)		
Immediate	306	88.2
Early delayed	17	4.9
Prolonged delayed	24	6.9

*No. of implants, natural teeth, and pontics within the span of the prosthesis.
†No. within the span of the prosthesis.
k = no. of implants; RCT = root canal–treated.

RESULTS

Between July 2001 and July 2003, 229 subjects had 478 immediately loaded implants placed. Fifty-five subjects (24.0%) having 131 (27.4%) implants placed were excluded because of inadequate imaging or incomplete preoperative or follow-up information. The final sample was composed of 174 subjects with

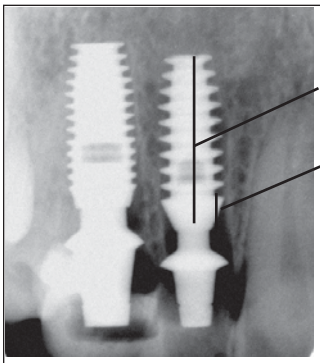

Fig 2a Measurement of crestal bone level at time of implant placement. Transitional shouldered abutment during immediate loading of implant.

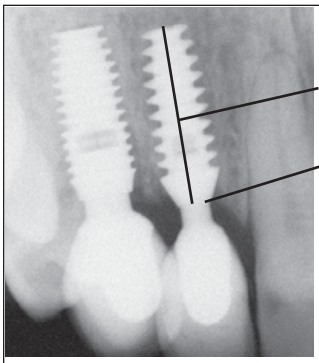

Fig 2b Measurement of crestal bone level 10 months after implant placement. Final restoration with an integrated abutment crown.

Table 2a Changes in Crestal Bone Levels Over Time

	k	%
Bone loss on mesial surface (k = 299)	153	51.2
Bone loss on distal surface (k = 292)	161	55.1
Bone loss on mesial or distal surface (k = 292)	198	67.8
Success rate on binary outcome scale (bone loss ≤ 1.5 mm at 12 months) (k = 347)	321	92.5
Failure rate on binary outcome scale (bone loss > 1.5 mm at 12 months) (k = 347)	26	7.5

Table 2b Change in mm in Radiographic Bone Level and Estimated Crestal Bone Loss at 12 Months

	Mean	SD	Range	95 % CI
Mean change on mesial surface (k = 299)	−0.5	1.5	−6.0 to 3.6	
Mean change on distal surface (k = 292)	−0.6	1.4	−5.8 to 1.9	
Estimated crestal bone loss at 12 mo*				
Mesial (k = 299)	−1.0	0.4		−1.8, −0.3
Distal (k = 292)	−0.8	0.3		−1.4, −0.1

* Estimated using least squares method.

347 implants placed and loaded on the same day. The mean duration of clinical follow-up time was 9.8 months ± 5.4 months (range, 0.1 to 24.6 months). The mean duration of radiographic follow-up time was 6.9 ± 4.0 months (range, 0.4 to 18.4 months).

Demographic study variables are summarized in Table 1. The mean age of the subjects ± SD at the time of implant placement was 53.9 ± 15.8 years (range, 15 to 86 years; 51.7% men and 48.3% women). Tobacco use was reported by 8.7% of subjects. The majority of implants were placed in the maxilla (81.3%), and more than half were placed in an anterior position (52.7%). Most implants (93.1%) were placed in partially edentulous subjects, while 6.9% were placed in fully edentulous subjects. Most implants were placed in either type 3 (37.3%) or type 4 (44.9%) quality bone. Almost half (43.8%) of the implant sites were at tooth locations that were previously root canal–treated, and 22.2% of implant sites were adjacent to at least 1 root canal–treated tooth. Of the 347 implants placed, most implants (85.0%) did not have a periapical radiolucency adjacent to an implant site. The mean survival time of the implants was 9.4 ± 5.4 months (range, 0.1 to 24.6 months). Three hundred twenty-three implants survived, for a survival rate of 93.1%.

Table 2 summarizes the changes in crestal bone levels over time. Overall, 67.8% of implants had evidence of crestal bone loss during the study period. On average, 51.2% and 55.1% of implants lost bone on the mesial and distal surfaces, respectively. Overall, the mean changes in radiographic bone levels were –0.5 ± 1.5 mm and –0.6 ± 1.4 mm on the mesial and distal implant surfaces, respectively. Five implants

Table 3 Bivariate Analysis of Factors Associated with Changes in Bone Levels (in mm)

	n or k	P
Demographic variables		
Mean age	174	.59
Gender (Female)	174	.07
Health-status variables		
Tobacco use	173	.77
Anatomic variables		
Jaw	347	.46
Location	347	.71
Dentition status	347	.07
Bone quality	118	.72
RCT tooth at implant site	242	.76
Implant site adjacent to RCT tooth	347	.37
Radiolucency at or adjacent to implant site	347	.04
Implant-specific variables		
Diameter	347	.22
Length	347	.66
Coating	346	.43
Well size	347	.80
Prosthetic variables		
Total units	347	.53
Total natural teeth	347	.36
Total pontic units	347	.49
Total implant units	347	.63
Surgical variables		
Augmentation	347	.54
Timing of implant placement	347	.91

Table 4 Multivariate Clustered GEE Regression Model (Adjusted) Associated with Changes in Bone Levels (in mm)

Exposure	OR estimate	95% CI	P
Age (per year increase)	1.00	0.99 to 1.02	.88
Gender (female)	1.55	0.91 to 2.64	.10
Dentition status (fully edentulous)	0.50	0.24 to 1.05	.07
Radiolucency at or adjacent to implant site	1.88	1.00 to 3.60	.05
Radiographic follow-up time (per month increase)	1.07	1.01 to 1.15	.04

OR = odds ratio.

gained > 2 mm of bone on the mesial surface (see Figs 2a and 2b for examples of bone gain). Based on the least squares method, the estimated changes in crestal alveolar bone at 12 months on the mesial and distal surfaces were –1.0 ± 0.4 mm (95% CI, –1.8, –0.3) and –0.8 ± 0.3 mm (95% CI, –1.4, –0.1), respectively. During the first 12 months, 321 (92.5%) immediately loaded implants lost ≤ 1.5 mm of crestal bone, the level of bone loss required for success according to the criteria of Albrektsson and associates.[11]

Table 3 summarizes bivariate clustered GEE analyses used to identify association between individual study variables and crestal bone loss measured in millimeters. Gender (P = .07), dentition status (P = .07), and radiolucency at or adjacent to implant site (P = .04) were considered candidate variables for inclusion in a multivariate model. In the adjusted multivariate model (Table 4), radiolucency at or adjacent to implant site (OR, 1.88; 95% CI, 1.00 to 3.60; P = .05) and radiographic follow-up time in months (OR, 1.07; 95% CI, 1.01 to 1.15; P = .04) were statistically associated with crestal bone loss.

Table 5 summarizes bivariate clustered GEE analyses used to identify associations between individual study variables and crestal bone loss categorized as a binary variable, ie, ≤ or > 1.5 mm at 12 months. Implant location (maxilla or mandible) (P = .01), radiolucency at or adjacent to implant site (P = .14), and total natural teeth (P = .13) were considered candidate variables for inclusion in this multivariate model, as well as age and gender, which were important biologic variables. In the adjusted multivariate model (Table 6), implant location, ie, mandible versus maxilla, was statistically associated with crestal bone loss > 1.5 mm at 12 months (OR = 4.26; 95% CI, 1.70 to 10.68; P = .002). This finding suggests that, holding all other variables constant, implants placed in the mandible are 4.26 times more likely to experience crestal bone loss greater than 1.5 mm during the first year after immediate loading when compared to implants placed in the maxilla.

DISCUSSION

The early investigations of Brånemark led to the establishment of an osseointegration protocol recommending a load-free postoperative healing period of 3 to 4 months for the mandible and 4 to 6 months for the maxilla.[22] The concept of unloaded healing has been challenged during recent years. Modifications of implant shape and surface characteristics have suggested that it may be possible to restore implants predictably and safely with shorter healing times.[23]

Crestal bone loss in this study was within the generally accepted conventional limits for standard delayed loading protocols. Mean crestal bone loss of 0.9 to 1.6 mm during the first year of function[24–26] for the delayed loading protocol has generally been considered acceptable, ie, successful. A 15-year study reported by Adell and associates[27] indicated that alveolar bone loss during the first year after abutment connection averaged 1.2 mm and 0.1 mm annually afterward for both the mandible and the maxilla. Several other studies using the delayed loading protocol have produced similar results. A retrospective study using submerged Brånemark System

implants (Nobel Biocare, Göteborg, Sweden) reported a mean annual bone loss of 0.8 mm after 1 year in function and 0.1 mm during the second year.[28] Bragger and colleagues reported a median bone loss of 0.7 mm for both the mesial and distal surfaces using nonsubmerged implants (Straumann, Waldenburg, Switzerland).[29]

Several studies have reported comparing crestal bone loss using the immediate loading protocol to delayed loading. Schnitman and colleagues[30] found no difference in bone level changes over a 7-year period between immediately loaded and submerged adjacent implants. Two other studies also found no significant differences between the 2 groups. In a prospective study comparing 39 delayed and 39 immediately loaded implants with overdentures using the Brånemark System, Chiapasco and associates[31] reported a median bone loss of 0.7 mm after 12 months and 1.5 mm after 24 months for immediately loaded implants. Median bone loss after 12 and 24 months for delayed loading was 0.8 mm and 1.2 mm, respectively.[31] In another comparison study of 88 immediately loaded implants and 30 implants loaded after a delay by Randow and colleagues, mean bone losses of 0.4 mm for immediate loading and 0.8 mm for delayed loading over an 18-month follow-up period were reported.[32] The most likely explanation for this difference was that a more reproducible radiographic technique was used for the immediately loaded implants.[31] However, 1 study did find a significant difference between immediately loaded and unloaded implants. In a prospective study evaluating 14 immediately loaded Frialit-2 (Friadent, Mannheim, Germany) implants and 28 unloaded implants, mean values of bone level changes 6 months postoperatively were 0.9 mm and 0.33 mm, respectively.[33] The changes in crestal bone level after immediate loading using the Bicon implant system appear to be comparable to immediate loading using other implant systems.

Multivariate analysis of crestal bone loss measured in millimeters suggested that radiolucencies at or adjacent to implant sites increase the risk of crestal bone loss. Implant sites with radiolucencies may be sites of periodontal pathogens that may infect or contaminate the implant sites. More studies are needed to determine the correlation between this variable and increased risk for crestal bone loss.

When crestal bone loss was treated as a binary outcome variable, the results suggested that the mandible has a higher risk for crestal bone loss adjacent to immediately loaded implants during the first year when compared to the maxilla. Past studies have shown greater bone loss in the maxilla using the delayed loading protocol.[34] In this study, the majority of immediately loaded implants (80.7%) were placed in the maxilla. Case selection is an important factor for the success of immediately loaded implants. Further studies are needed to determine the correlation between jaw and increased risk for bone loss.

The findings of this study revealed a range of –6.0 mm to 3.6 mm of change in radiographic bone level on the mesial implant surface and a range of –5.8 mm to 1.9 mm on the distal implant surface. A clinical study of 310 Astra dental implants (Mölndal, Sweden) placed in the edentulous mandible showed that male

Table 5 Bivariate Analysis of Factors Associated with Estimated Changes in Bone Levels > 1.5 mm at 12 mo

	n or k	*P*
Demographic variables		
Mean age	174	.99
Gender (Female)	174	.46
Health-status variables		
Tobacco use	173	.17
Anatomic variables		
Jaw location	347	.01
Anteroposterior location	347	.34
Dentition status	347	.28
Bone quality	118	.72
RCT tooth at implant site	242	.67
Implant site adjacent to RCT tooth	347	.28
Radiolucency at or adjacent to implant site	347	.14
Implant-specific variables		
Diameter	347	.52
Length	347	.38
Well size	347	.17
Prosthetic variables		
Total units	347	.55
Total natural teeth	347	.13
Total pontic units	347	.39
Total implant units	347	.21
Surgical variables		
Augmentation	347	.52
Timing of implant placement	347	.47

Table 6 Multivariate Clustered GEE Regression Model (Adjusted) Associated with Changes in Bone Levels > 1.5 mm at 12 mo

Exposure	OR estimate	95% CI	*P*
Age (per year increase)	1.00	0.97 to 1.03	.98
Gender (female)	1.55	0.62 to 3.88	.35
Implant location (mandible)	4.26	1.70 to 10.68	.002
Radiolucency at or adjacent to implant site	2.10	0.78 to 5.59	.14
Total natural teeth (per unit increase)	1.81	0.89 to 3.65	.10
Radiographic follow-up time (per month increase)	0.95	0.87 to 1.04	.24

OR = odds ratio.

subjects gained 0.1 mm of bone at 1 year after abutment connection.[35] In this study, 5 (1.7%) implants gained ≥ 2 mm of bone on the mesial surface.

The clinical failure rate (explantation) of almost 7% was based on the Kaplan-Meier analysis. The absolute "failure rate," ie, the percentage of implants that had > 1.5 mm of bone loss at 1 year, was 7.5%. Since Albrektsson criteria were more strict in terms of success and the Kaplan-Meier analysis accounted for the overall survival time, which could be more than 1 year of the follow-up, it makes sense that the absolute failure rate would be higher than the clinical failure rate.

Study limitations include the retrospective design, the use of a single center for implant placement, and missing records or incomplete information. Retrospective cohort studies rely on complete data entered into the patient's history. Retrospective cohort studies have less validity than randomized prospective clinical trials because of the possibility of selection bias and confounding factors. In this study, the radiographs were read consistently by 2 examiners. All of the radiographs were digitized and calibrated, which may have resulted in magnification errors. To ensure the reliability of the radiographic measurements, kappa statistics were computed. Another limitation of this study was the different time points at which the subjects returned for radiograph follow-up. This made it difficult to standardize the absolute amount of crestal bone loss for comparison at specific time points.

CONCLUSION

This study measured crestal bone level changes in immediately loaded implants and identified risk factors associated with increased risk for bone loss. Results suggest that crestal bone loss in immediate loading using the Bicon implant system may be comparable to crestal bone loss in immediate loading using other implant systems. In this study, 92.5% of evaluated implants met Albrektsson and associates' criterion regarding bone loss,[11] and the mandible showed a higher risk for crestal bone loss when compared to the maxilla.

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