CLINICAL ORAL IMPLANTS RESEARCH

Pablo Galindo-Moreno
Ana León-Cano
Inmaculada Ortega-Oller
Alberto Monje
Francisco O'Valle
Andrés Catena

Marginal bone loss as success criterion in implant dentistry: beyond 2 mm

Authors' affiliations:
Pablo Galindo-Moreno, Ana León-Cano, Inmaculada Ortega-Oller, Oral Surgery and Implant Dentistry Department, School of Dentistry, University of Granada, Granada, Spain
Alberto Monje, Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, USA
Francisco O'Valle, Department of Pathology, School of Medicine & IBIMER, University of Granada, Granada, Spain
Andrés Catena, Department of Experimental Psychology, School of Psychology, University of Granada, Granada, Spain

Corresponding author:
Dr *Pablo Galindo-Moreno*, DDS, PhD
C/ Recogidas
39 5º Izq, 18005 Granada
Spain
Tel.: +34 958 520658
Fax: +34 958 520658
e-mail address: pgalindo@ugr.es

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Abstract

Aim: The aim of this study was to analyze marginal bone loss (MBL) rates around implants to establish the difference between physiological bone loss and bone loss due to peri-implantitis.

Materials and methods: Five hundred and eight implants were placed in the posterior maxilla in 208 patients. Data were gathered on age, gender, bone substratum (grafted or pristine), prosthetic connection, smoking and alcohol habits, and previous periodontitis. MBL was radiographically analyzed in three time frames (5 months post-surgery and at 6 and 18 months post-loading). Nonparametric receiver operating curve (ROC) analysis and mixed linear model analysis were used to determine whether implants could be classified as high or low bone loser type (BLT) and to establish the influence of this factor on MBL rates.

Results: Marginal bone loss rates were significantly affected by BLT, connection type, bone substratum, and smoking. Bone loss rates at 18 months were associated with initial bone loss rates: 96% of implants with an MBL of >2 mm at 18 months had lost 0.44 mm or more at 6 months post-loading.

Conclusion: Implants with increased MBL rates at early stages (healing and immediate post-loading periods) are likely to reach MBL values that compromise their final outcome. Initial (healing, immediate post-loading) MBL rates around an implant of more than 0.44 mm/year are an indication of peri-implant bone loss progression.

The maintenance of peri-implant bone tissue is essential for the long-term success of dental implants. The most widely used parameters for measuring outcomes in implant dentistry are related to the implant, the peri-implant soft tissue, and the prosthesis, besides the subjective assessment of the patient (Papaspyridakos et al. 2012). These parameters are related to the tissue stability, which influences the progression of marginal bone loss (MBL) around healthy implants.

The criteria to define success in implant dentistry are under constant debate, but the achievement and maintenance of osseointegration are recognized as crucial factors, and MBL is therefore a key consideration. The loss of 2 mm of bone around the implant neck during the first year after functional loading has long been assumed normal by the dental community and has even been considered a successful outcome in some classifications and consensus statements (Albrektsson et al. 1986; Misch et al. 2008). However, tissue stability is expected at 1 year after placement, and a loss of more than 0.2 mm per year is regarded as undesirable (Albrektsson et al. 1986). Other authors have claimed that an MBL loss in the first year of 1.5 mm (Papaspyridakos et al. 2012), 1.8 mm (Roos-Jansaker et al. 2006),or 1.5–2 mm (Tarnow et al. 2000) represents a good outcome. An MBL of less than three threads has also proposed as success criterion (Fransson et al. 2005; Qian et al. 2012), despite the variability in inter-thread distances among different implant systems. Further research is required to resolve these discrepancies in the criteria for success, which have emerged from consensus statements and observational reports.

Marginal bone loss is known to be influenced by multiple phenomena (Albrektsson et al. 2012a,b), but some key questions remain unanswered. As noted above, MBL at 1 year post-loading is generally accepted

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(Albrektsson et al. 1986; Misch et al. 2008), but is not clear whether the biological "clock" that determines this event is prosthesis related, host related, implant related, or load dependent. Numerous studies have addressed this issue in recent years, clarifying some aspects and leading to improvements in implant design and protocols that have minimized this initial MBL. Nevertheless, the criteria for success utilized by many clinicians and researchers have remained unchanged since 1986.

The aim of this study was to examine the patient and clinical variables that might play key roles in the development of MBL. It was hypothesized that implants can be characterized as high or low bone losers, that is, that MBL progression rates are related to different individual and clinical features. The specific objectives of the study were to determine a cutoff point for discriminating between low and high bone loser types (BLTs), to examine whether a loss of 2 mm at 1 year post-surgery can be considered the threshold between normal and pathological bone loss, and to evaluate the impact of the implant type (high vs. low BLT) after controlling for other influential clinical and non-clinical factors.

Material and methods

Study population

All subjects were consecutively selected from a private practice pool. The inclusion criteria were age of 18–85 years, need for restoration of at least one teeth in the posterior maxilla, physical status of I or II according to the American Society of Anesthesiologists (ASA) classification system, absence of systemic diseases or conditions known to alter bone metabolism, stable periodontal condition, enrolment in a maintenance program, and the availability of records contained standardized digital orthopantomographs obtained after the implantation surgery (baseline), at the final restoration delivery, and at 6 and 18 months after functional loading. Exclusion criteria were a history of medical treatments known to modify bone metabolism and the presence of acute or chronic sinus pathology or any type of cancer or other major systemic disease. The study protocol was reviewed and approved by the ethical committee of the University of Granada for studies involving human subjects, and all patients signed their informed consent.

Two cohorts of patients undergoing implant surgery between January 2007 and January 2010 were selected in this retrospective study as a function of the bone availability in the posterior maxilla (Wang & Katranji 2008). The first cohort (Group 1) comprised the 106 patients with remnant alveolar crest bone height (RBH) >5 mm, which generally allows maxillary sinus augmentation to be performed with simultaneous implant placement; 262 implants were placed in these patients. The second cohort (Group 2) included the 102 subjects with adequate RBH for the conventional placement of implants with a length of ≥12 mm; 246 implants were placed in these patients.

Subjects received implants with an internal (Astra Tech AB, Mölndal, Sweden) or external (Microdent Implant System, Barcelona, Spain) implant-crown connection, with the corresponding differences in external micro/macro geometry.

Surgical and restorative procedures

All surgical procedures were conducted under local anesthesia (Ultracain®, Aventis Inc., Frankfurt, Germany). In group 1, sinus augmentation procedures were performed following the bone scraper technique as described elsewhere (Galindo-Moreno et al. 2007). All sinus cavities were grafted using autologous cortical bone in combination with anorganic bovine bone particles ranging from 250 to 1000 μm (Bio-Oss® – GeistlichPharma AG, Wolhusen, Switzerland) at a ratio of approximately 1 : 1. A conventional implantation protocol was followed for the implants inserted in the patients not requiring maxillary sinus augmentation (Group 2). All subjects were asked to comply with a pharmacological regimen of amoxicillin/clavulanic acid tablets (875/125 mg, TID for 7 days) or, if allergic to penicillin, clindamycin tablets (300 mg, TID for 7 days), and anti-inflammatory medication (Ibuprofen 600 mg, every 4–6 h as needed to a maximum of 3600 mg/day). Sutures were removed at 2 weeks after sinus surgery in Group 1 and at 1 week post-surgery in Group 2. The patients were then evaluated at 6- to 8-week intervals to follow up the postoperative healing. Trans-epithelial abutments were placed in a second surgical procedure after 5 months of healing, and implant-supported prostheses were delivered 4 weeks later. All definitive restorations were screw-retained fixed dentures. For the internal-connection implants, standardized uni-abutments (Astra Tech AB) were used to connect implants with the screwed restoration. UCLA type abutments were used for the same purpose in the external-connection implants (Microdent Implant System, Barcelona, Spain).

Radiographic evaluation of MBL

Standardized digital panoramic radiographs (Kodak ACR-2000; Eastman Kodak Company, Rochester, NY, USA) obtained at treatment planning, after implant surgery (baseline), at final restoration delivery (5 months post-implantation), and at 6 and 18 months after functional loading, were exported to a computer software program for further analysis (Dent-A-View v1.0; DigiDent, DIT, Nesher, Israel). The MBL was determined from linear measurements made by an independent calibrated examiner on each panoramic radiograph from the most mesial and distal point of the implant platform to the crestal bone. The magnification of the orthopantomographs was corrected using the clinical data (length and width) for each implant. Each linear measurement corresponding to the MBL was calibrated and re-calculated according to the radiographic image size by using a simple mathematical calculation.

The utilization of panoramic radiographic techniques could be considered a limitation, although they have been validated for this type of study (Harris et al. 2002; Angelopoulos et al. 2008). New technologies, such as cone beam computed tomography, would offer greater accuracy in radiographic MBL measurements and the possibility of performing a tridimensional analysis. However, it was ruled out for this study in order to avoid multiple exposures of the patients to radiation, as required by the ethical committee of our institution. Furthermore, although periapical radiographs have been described as the ideal technique for measuring peri-implant MBL (Albrektsson et al. 2012a,b), the limited standardization of intraoral radiographic techniques for the maxilla means that a bisector technique must be used, reducing the reproducibility of sequential radiographic images. In contrast, panoramic radiographs are performed using a repetitive standardized parallel technique, facilitating the reproducibility of radiological analyses.

Additional data recorded

Data were gathered for all patients on their age, gender, smoking, and alcohol consumption at study enrolment, history of periodontal disease, prosthetic connection type (internal or external), and the presence or absence of plaque at four sites/tooth, using the modified O'Leary plaque index (O'Leary et al. 1972). Patients were classified as non-smokers (0 cigarettes/day), mild smokers (1–10 cigarettes/day), or heavy smokers (>10 cigarettes/day) and were considered as alcohol consumers if their intake was >10 g/day (Galindo-Moreno et al. 2005).

A history of periodontal disease was defined by the presence of at least four sites with clinical attachment loss ≥3 mm (excluding third molars), which was assessed using a Michigan O probe (Hu-Friedy, Chicago, IL, USA).

Statistical analyses

Nonparametric receiver operating curves (ROC) were constructed for the MBL at 18 months to determine the cutoff for classifying an implant as low BLT or high BLT, using the kappa index. Monthly MBL rates were obtained to derive cutoffs at 5 months post-surgery (healing) and at 6 months post-loading. Three MBL rates (T1, T2, and T3) were computed in millimeters/month (mm/m). T1 rates were obtained by dividing the MBL at the healing interval (5 months post-surgery) by the number of months elapsed between the two surgical stages, T2 rates by dividing the difference between the MBL at 6 months post-loading and the MBL at healing by 6, the elapsed time in months, and T3 rates by dividing the difference between the MBL at 18 months and the MBL at 6 months post-loading by 12, the time elapsed between the two measurements in months. Descriptive statistics were computed. A linear mixed model was used to analyze mesial and distal T1, T2, and T3 rates, with the patients as clusters and the implant as unit of analysis (West et al., 2006); the BLT, aspect (mesial/distal), and measurement time (T1, T2, and T3) were considered as factors and the following variables as covariates: age, gender, smoking habits, alcohol intake, plaque, periodontitis, bone substratum (grafted or pristine), connection type (internal or external), location, implant length, and implant diameter. A scaled identity repeated covariance analysis was applied to minimize Schwarz's Bayesian information criteria (Cnaan et al., 1997). Mesial/distal measures were collapsed when no interactions were observed with the remaining factors. The crosstabs procedure for complex samples (Rao & Scott 1981, 1984) was used to test the association between T1, T2, and T3 cutoffs. The Bonferroni correction was applied to take account of the large number of potential predictors, establishing a 0.004 significance level per comparison.

Results

Discrimination between implants with high and low MBL

A total of 208 patients were enrolled in this study, including 508 implants. Tables 1 and 2 display the socio-demographic and clinical features of the study sample. The mean number of implants per patient was 1.72 (range: 1–6, median 2.0). Seven implants (two participants) were excluded from the analysis because of missing data on age (6 implants) or the 18-month follow-up (1 implant).

Table 1. **Frequencies for each level of the categorical factors**

Factor	Level	*n*	%
Bone substratum	Pristine	246	49.10
	Grafted	255	50.90
Location	Right	243	48.50
	Left	258	51.50
Connection	External	140	27.94
	Internal	361	72.06
Gender	Female	109	52.66
	Male	98	47.34
Alcohol	No	201	97.10
	Yes	6	2.90
Plaque Index	0	1	0.48
	1	115	55.56
	2	76	36.71
	3	15	7.25
Periodontitis	No	65	31.40
	Yes	142	68.60

Bone substratum, location, and type of connection frequencies are the number (percentage) of implants. gender, alcohol, plaque index, and periodontitis frequencies are the number (percentage) of patients.

Table 2. **Descriptive statistics for metric variables**

			Range	
	Mean (Median)	SEM	Min	Max
Age	52.669 (52.0)	0.47	23	84
Smoking (c/d)	7.390 (6.50)	0.42	0	40
Implant Diameter	4.331 (4.5)	0.02	3.3	5.8
Implant Length	13.810 (14.0)	0.06	10	16
MMBL Healing	0.170 (0.12)	0.014	0	1.81
DMBL Healing	0.211 (0.15)	0.026	0	1.88
MMBL 6 m	0.560 (0.37)	0.029	0	3.15
DMBL 6 m	0.645 (0.53)	0.030	0	3.62
MMBL 18 m	1.101 (1.07)	0.041	0	4.34
DMBL 18 m	1.212 (1.22)	0.044	0	5.89

SEM, standard error of the mean; MMBL, mesial marginal bone loss; DMBL, distal marginal bone loss; healing (5 months after surgery) 6 and 18 m after loading are the measurement time points in months. MBL is given for the three measurement time points in mm.

Receiver operating curve analysis (Fig. 1) indicated that the optimal cutoff value for categorizing implants as high BLT or low BLT was 1.325 mm at 18 months, according to the kappa index; the same cutoff value was used for both mesial and distal MBL. Accordingly, 260 implants were classified as high BLT and 241 as low BLT.

Factors involved in the MBL rate

Figure 2 shows the time course of absolute MBL values (left panel) and MBL rates as a function of the time since the interventions. The absolute MBL value increased as a function of time, independently of the mesial/distal aspect, whereas the MBL rate (right panel) showed a quadratic trend, with an increased MBL rate up to 6 months after functional loading followed by a return to similar rates to those during the healing period. Table 3 reports the descriptive

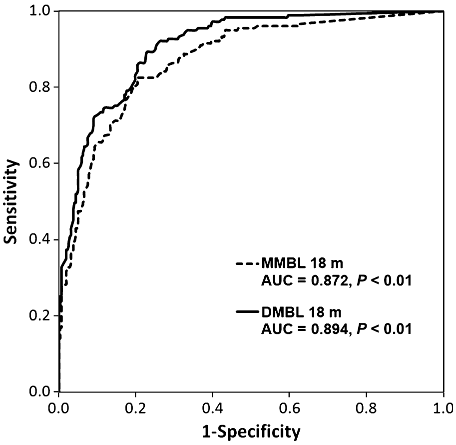

Fig. 1. Nonparametric receiver operating curve (ROC) analysis for mesial (MMBL) and distal (DMBL) marginal bone loss at 18 months. The areas under the ROC (AUC) are significant.

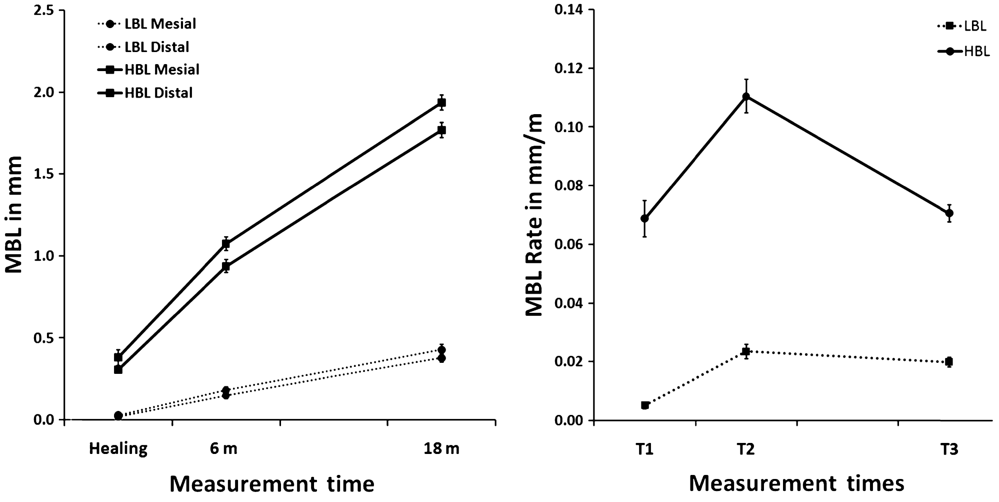

Fig. 2. Marginal bone loss values (left panel) and marginal bone loss rates (right panel) as a function of time. Healing time (T1, 5 months from surgery); T2 and T3 were measured at 6 and 18 months after functional loading.

Table 3. **Mean rates, standard errors, and median rates for the factors explaining the variance in the dependent variables at the three measurement times**

		T1	T2	T3
BLT	LOW BLT	0.005 (0.001) [0.000]	0.023 (0.002) [0.000]	0.020 (0.002) [0.011]
	HIGH BLT	0.069 (0.006) [0.046]	0.110 (0.006) [0.106]	0.071 (0.003) [0.065]
Connection	Internal	0.027 (0.003) [0.000]	0.056 (0.004) [0.031]	0.040 (0.002) [0.026]
	External	0.066 (0.001) [0.029]	0.100 (0.008) [0.100]	0.063 (0.003) [0.057]
PD	No PD	0.030 (0.004) [0.000]	0.058 (0.006) [0.028]	0.037 (0.003) [0.024]
	PD	0.042 (0.005) [0.000]	0.073 (0.004) [0.068]	0.050 (0.002) [0.040]
Bone	Graft	0.052 (0.006) [0.000]	0.072 (0.006) [0.062]	0.044 (0.003) [0.028]
	Pristine	0.023 (0.003) [0.000]	0.065 (0.005) [0.046]	0.049 (0.002) [0.044]
Gender	Male	0.039 (0.004) [0.000]	0.072 (0.005) [0.053]	0.043 (0.003) [0.033]
	Female	0.038 (0.006) [0.000]	0.065 (0.005) [0.062]	0.049 (0.003) [0.039]
Smoking		0.213 (0.045)	0.167 (0.045)	0.114 (0.045)
Age		0.083 (0.045)	0.019 (0.045)	0.067 (0.045)

Rates are expressed in mm/month.
BLT, bone loser type; PD, history of periodontitis; No PD, No history of periodontitis; T1, rate at 5 months after surgery; T2, rate at 6 months after functional loading; T3, rate at 18 months after loading. Standard errors of the mean are given in parentheses. Medians are given between square brackets. Pearson linear correlations are shown for smoking and age.

statistics for the three rates as a function of the main study factors.

The mixed linear model analysis yielded significant effects for BLT, $P < 0.001$, connection type, $P < 0.001$, time, $P < 0.001$, smoking, $P < 0.001$, and the interaction of BLT with time, $P < 0.001$. Periodontal status, $P = 0.049$, and mesial/distal aspect, $P = 0.032$, were marginally significant.

Analysis of the BLT × time interaction showed that the connection type, $P < 0.001$, and time, $P < 0.001$, were significant for the low BLT, with a lower MBL rate for internal (0.014 mm/m) vs. external (0.027 mm/m) connections. The Bonferroni-corrected comparison between times indicated that the rate was lower for T1 (0.005 mm/m) than for T2 (0.023 mm/m) or T3 (0.020 mm/m), which showed no difference between them. Connection, $P = 0.002$, smoking, $P = 0.001$, bone, $P = 0.001$, and time, $P < 0.001$, were significant for high BLT, again observing higher MBL rates for external (0.093 mm/m) vs. internal (0.077 mm/m) connections.

The MBL rate was higher with increased smoking consumption (0.0009 mm/cigarette), for grafted (0.091 mm/m) vs. pristine (0.075 mm/m) bone, and for T2 (0.111 mm/m) vs. T1 (0.069 mm/m) or T3 (0.071 mm/m). T1 rates were affected by the connection, $P < 0.001$, smoking, $P < 0.001$, bone, $P < 0.001$), and age, $P = 0.002$. T2 rates were influenced by the connection, $P < 0.001$, and marginally influenced by plaque, $P = 0.030$. T3 rates were influenced by the connection, $P < 0.001$, and marginally influenced by periodontitis, $P = 0.022$, and smoking, $P = 0.041$.

Relationship between MBL at 18 months and at earlier time points

Crosstab statistics for complex samples indicated that MBL values at T1 and T2 were significantly associated with those at T3, adjusted $F = 38.62$ (OR = 2.52) and adjusted $F = 189.07$ (OR = 9.21), respectively, $P < 0.001$; 74.20% of low BLT implants at T3 were low BLT at T2, while 76.5% of high BLT implants at T3 were also high BLT at T2. Moreover, 86.7% of low BLT implants at T3 were low BLT at T1, whereas 35.2% of high BLT at T3 were also high BLT at T1.

Factors influencing MBL rate changes

Mixed linear model analysis showed that differences between T2 and T1 rates were explained by smoking ($P = 0.035$), bone ($P = 0.012$), and age ($P = 0.044$), whereas differences between T3 and T2 rates were accounted for by connection ($P = 0.004$) and plaque ($P = 0.003$).

Complex samples crosstab indicated that implants with an MBL rate >0.0736 mm/m (0.44 mm MBL at 6 months) at T2 were much more likely to have an MBL of ≥2 mm at 18 months (OR = 9.39, 95% CI [6.67 13.24]). Thus, 74.5% of implants with MBL of <2 mm at 18 months had an MBL rate ≤0.0736 mm/m at T2, whereas 76.5% of those with MBL of ≥2 mm MBL at 18 months had a rate above this T2 cutoff value. The OR for an implant below the cutoff in T2 to show an MBL <2 mm at 18 months was 25.66 (95% CI [13.13 50.17]), and 96.1% of implants with MBL of ≥2 mm at 18 months had a T2 rate above the cutoff value.

Discussion

This study suggests that the appraisal of peri-implant MBL is clinically relevant and not merely an academic issue. MBL is influenced by numerous variables related to surgical trauma (Qian et al. 2012), prosthetic considerations (Cardaropoli et al. 2006), implant design (Canullo et al. 2010), bone substratum (Galindo-Moreno et al. 2013), patient habits (Galindo-Moreno et al. 2005), implant-abutment connection (Penarrocha-Diago et al. 2012; Monje et al. 2013), and the general health of the patients. Klinge described an MBL >2 mm at delivery of the prosthetic device in comparison with initial radiographs, in combination with bleeding on probing, as a "red flag" for the clinician to evaluate the need for an intervention to achieve peri-implant health (Klinge 2012).

The present results offer some important clues on this issue. It appears that the consideration of MBL rates rather than raw MBL data may improve the ability of clinicians to predict peri-implant disease. Although MBL is known to be triggered by multiple factors, including the type of connection, type of bone, gender, age, and periodontitis, this study has highlighted that the outcome at 18 months strongly depends on the BLT, which appears to be different for each implant. We also found that MBL is directly dependent on the features of each implant and patient. In other words, the definition of success or failure in implant dentistry requires an appraisal of the characteristics of the implant/patient, with each playing an important role in the prognosis. We also highlight that a patient with multiple implants of the same type can show an increased MBL in a few implants, but not in the remainder; thus, 17.5% of the patients in our sample showed some MBL in 78.5% of implants, but not in the remaining ones. Other variables that should be taken into account in evaluating implant success or failure include the type of occlusion or type of prosthesis, as previously reported (Isidor, 1996).

In the present study, MBL levels were mainly related to the type of connection, type of bone, and smoking habit. In relation to the bone substratum, MBL is produced around the neck of implants placed in native residual bone, but it has been noted that when the stiffness of a grafted area is less than that of the cancellous bone, high-level strain is primarily distributed at the crestal level, which may promote MBL. Hence, grafted areas should ideally have a similar or greater stiffness in comparison with the adjacent native bone for a correct distribution of loading forces by ensuring similar values of strain energy density among cortical and cancellous crestal bone and grafted bone (Cehreli et al. 2007; Inglam et al. 2010).

An important finding was that bone loss rates at 18 months were strongly associated with the initial bone loss rate. Results (ORs) indicated that higher T3 rates are much more likely in implants with elevated rates between T1 and T2. Almost all of the implants (96.1%) with MBL of >2 mm at 18 months had a high bone loss rate at T2 (defined as >0.0736 mm/m, 0.44 mm at 6 months). These findings suggest that the MBL rate immediately after restoration delivery may represent a clear risk indicator for implants to reach an MBL failure level over the medium or long term.

As noted in the Introduction, the most widely accepted success criteria establish 2 mm as the maximum acceptable MBL after 1 year of loading for considering an implant to be a success (Misch et al. 2008). Many authors have used this radiographic criterion to define peri-implantitis (Fransson et al. 2005; Jung et al. 2008; Koldsland et al. 2010). However, there is a lack of clarity on this definition among the dental community, and some proposals, such as the measurement of exposed implant threads, have increased confusion on this issue (Fransson et al. 2005). Hence, there is a need to evaluate not only the etiology but also the acceptable levels of peri-implant MBL in order to establish health or disease.

There remains a need to understand the factors that influence MBL, which remain highly controversial, and to distinguish between physiological and pathological losses. The majority of MBL appears during the interval between abutment connection and crown placement (Tarnow et al. 2000; Cardaropoli et al. 2006), supporting the concept of initial loss defined by Albrektsson et al. (1986). This theory is further supported by the present results, which show that MBL rates are insignificant from implant placement (T0) to T1 in comparison with those between T1 and T2 and become almost stable in the T2-T3 period (Fig. 2). These findings indicate that MBL is more related to the prosthetic phase than to the post-surgical bone healing and remodeling process, confirming that the biological width establishment is a crucial factor in preserving marginal bone level (Berglundh & Lindhe 1996).

According to other authors, the origin of MBL around endosseous implants may be either biomechanical (van Steenberghe et al. 1999) or microbial (Heitz-Mayfield 2008). There have been reports, mainly in the periodontology literature, that dental implants behave as natural dentition and that a process similar to periodontitis occurs around implants, generating peri-implantitis. This idea was supported by a recent finding of a higher MBL in patients with a history of periodontitis than in periodontally healthy subjects (Safii et al. 2010). In the present study, most of the implants with higher bone loss were found in a low proportion of the patients, similar to the pattern observed for periodontitis. However, the question remains whether the peri-implantitis is an infectious process or whether the contamination takes place after the tissue breakdown. One study associated the presence of cement in cemented-retained prostheses with localized inflammation and MBL (Wilson 2009) and found that uneventful healing could be achieved by removing the excess cement, indicating that the MBL in these cases was a foreign body reaction. Higher MBL rates around implants in patients with previous periodontal disease are not exclusively explained by a predisposition to infection. In fact, a history of periodontitis was not significantly related to the MBL in the present study, observing only marginal effects. Conversely, a higher MBL promotes bacterial colonization and a more rapid progression of peri-implantitis; hence, once than the initial lesion has taken place, the condition readily worsens.

It has conventionally been assumed that the peri-implant MBL at 1 year ranges between 1.6 and 2.0 mm (Tarnow et al. 2000; Cardaropoli et al. 2006), but a significant implant-dependent reduction in MBL has been reported (Norton 2004, 2006; Novaes et al. 2006). Laurell and Lundgren demonstrated a lower MBL at 5 years with some implant types than with others (Laurell & Lundgren 2011). Differences in the prosthetic connection for the same implant system (Penarrocha-Diago et al. 2012) or "platform-switching" have been shown to produce a marked reduction in peri-implant MBL (Canullo et al. 2012).

The present study showed that whatever the reason for an MBL loss of >0.44 mm at 6 months, there is a subsequent increase in the rate of MBL (Fig. 2). Hence, there is no need to wait for 1 year to determine the prognosis of implants, because initial MBL rates already reveal the likelihood of reaching MBL failure values. According to these findings, clinicians should employ all possible means to minimize early MBL around implants and establish a strict maintenance recall program, given the crucial role of this loss in the final outcome of oral rehabilitation.

Conclusions

- If the MBL is higher than the cutoff value of 0.44 mm at 6 months post-loading, MBL progression tends to be significantly higher, with an increased risk of implant failure.
- New success criteria should be developed based on MBL rates during time intervals rather than on the peri-implant MBL value after a given period of time; the evaluation of MBL rates may provide crucial information on the biological event faced by clinicians.

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