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Influence of marginal bone loss on peri-implantitis: Systematic review of literature

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Abstract

Background: The marginal bone of dental implants is subjected to slight load modifications over time, conditioning implant survival. Objective: Perform a systematic review of the literature analyzing the factors that contribute to marginal bone loss (MBL) and the subsequent development of peri-implantitis.

Material and Methods: Bibliographic research in the databases PubMed, Medline and Scopus between 2010 and 2018 was performed. The inclusion criteria were articles published in the last 10 years and that were in English or Spanish, that were carried out on humans, that were cohort studies, that included cases and controls or that used randomized clinical trials. Exclusion criteria removed articles that contained clinical cases, case series or systematic reviews.

Results: A total of 90 articles were analyzed that examined all the factors reported in the literature, such as idiosyncratic factors, toxic habits, systemic drugs and implant characteristics (diameter, length, type surface, implant connection, implant design and type of platform at the moment of the prosthetic load). Discussion: Patient characteristics and associated pathologies must be taken into account when assessing MBL. MBL in all dental implants can be considered independent of the type of prosthetic rehabilitation and the moment of load; this was emphasized. The MBL is smaller in dental implants with rough surfaces, switch platforms and infracrestal localization, as they are of multifactorial origin.

Conclusions: All the reviewed articles maintain a common criterion regarding the concept and measurement of the MBL and highlighting the importance of radiodiagnosis for quantification. Longterm prospective studies with unified criteria are needed to reduce bias by identifying the most relevant factors in MBL.

Key words: *Marginal bone loss, dental implant, peri-implantitis.*

Introduction

Rehabilitation through dental implants has a long history. Recently, the analysis and relevance of bone remodeling shows that rehabilitation occurs from the moment of dental implant placement and the osseointegration process and from the implant's subsequent prosthetic rehabilitation and submission to masticatory loads, as well as the conservation and modification of the soft tissues that surround dental implants to achieve adequate function (1).

The study of these variables begins with Albrektsson *et al.* 1986 (2) and continues with Misch *et al.* 2008 (3), who showed how remodeling of the bone surrounding the crestal area of the implant takes place during the first year after implant placement. A loss of up to 2 mm of bone around the neck has been considered to be normal. However, the subsequent remodeling of the surrounding bone must continue be evaluated, since it can ultimately lead to the loss of the dental implant.

To assess a dental implant's success, different criteria have been described, some of which are still valid today: absence of peri-implant radiolucency, absence of mobility, annual bone loss of less than 0.2 mm after the first year and absence of pain, infection and paresthesias (2). However, new criteria have been incorporated in an attempt to establish scales of implant quality by establishing groups: Group I includes optimal health conditions, Group II includes satisfactory health with stable implants and a history of clinical problems, Group III includes those who have implants with compromised health and Group IV implants are considered failures (3).

Many factors that may influence marginal bone loss (MBL) have been described in the scientific literature: systemic factors of the patient (patient's baseline pathology, toxic habits), local factors (history/presence of periodontal disease, poor oral hygiene, quality and bone quantity) and characteristics of the implant (surface, diameter, length and morphology) (4-8).

This systematic review aimed to examine previous articles published in the scientific literature that examine which factors contribute to MBL and the development of peri-implantitis.

Material and Methods

This work has been carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) statement published in 2009 (9). The PI-CO question was asked: What factors influence the initial MBL after the placement of a dental implant and its progression over time? To answer this, a bibliographic search was carried out using PubMed, Medline and Scopus databases and was limited to works published during 2010-2018. The keywords used for the search were "Marginal bone loss," "dental implant" and "peri-implantitis."

The inclusion criteria for the research literature were articles published in the last 10 years and that were in English or Spanish, that were carried out on humans and that included the following types of studies: cohort studies, cases and controls or randomized clinical trials.

Exclusion criteria removed articles that contained clinical cases, case series or systematic reviews.

All the information was obtained from the articles selected by one of the authors (ACG). The variables included general information, such as the author, year of publication, type of study, sample size, number of patients evaluated and number of implants placed. Specific variables included the definition used by the authors for MBL, which types of radiography were used for the analysis of MBL, which factors were evaluated in the study and the results obtained.

Results

A systematic research of the PubMed database was carry out with the following research strategies:

1. ((marginal[All Fields] AND ("bone diseases, metabolic"[MeSH Terms] OR ("bone"[All Fields] AND "diseases"[All Fields] AND "metabolic"[All Fields]) OR "metabolic bone dis-eases"[All Fields] OR ("bone"[All Fields] AND "loss"[All Fields]) OR "bone loss"[All Fields])) AND ("peri-implantitis"[MeSH Terms] OR "peri-implantitis"[All Fields] OR "pe-riimplantitis"[All Fields])) AND ((Clinical Trial[ptyp] OR Observational Study[ptyp] OR Con-trolled Clinical Trial[ptyp]) AND "2008/12/01"[PDat]: "2018/11/27"[PDat] AND "hu-mans"[MeSH Terms] AND (English[lang] OR Spanish[lang])). A total of 61 articles were found, of which, after reading the title and summary, 36 were excluded for not complying with the established inclusion criteria; 13 articles were selected (Fig. 1).

2. ((marginal[All Fields] AND ("bone diseases, metabolic"[MeSH Terms] OR ("bone"[All Fields] AND "diseases"[All Fields] AND "metabolic"[All Fields]) OR "metabolic bone dis-eases"[All Fields] OR ("bone"[All Fields] AND "loss"[All Fields]) OR "bone loss"[All Fields])) AND ("dental implants"[MeSH Terms] OR ("dental"[All Fields] AND "implants"[All Fields]) OR "dental implants"[All Fields] OR ("dental"[All Fields] AND "implant"[All Fields]) OR "dental implant"[All Fields])) AND ((Clinical Trial[ptyp] OR Observational Study[ptyp] OR Controlled Clinical Trial[ptyp]) AND "2008/12/01"[PDat]: "2018/11/27"[PDat] AND "humans"[MeSH Terms] AND (English[lang] OR Spanish[lang])). A total of 619 articles were obtained, and after reading the title and abstract, 82 articles were selected (Fig. 2).

After the analysis of the articles obtained from both research attempts, five repeated articles were found, resulting in 90 articles being analyzed.

The articles included in the systematic review of the lite-

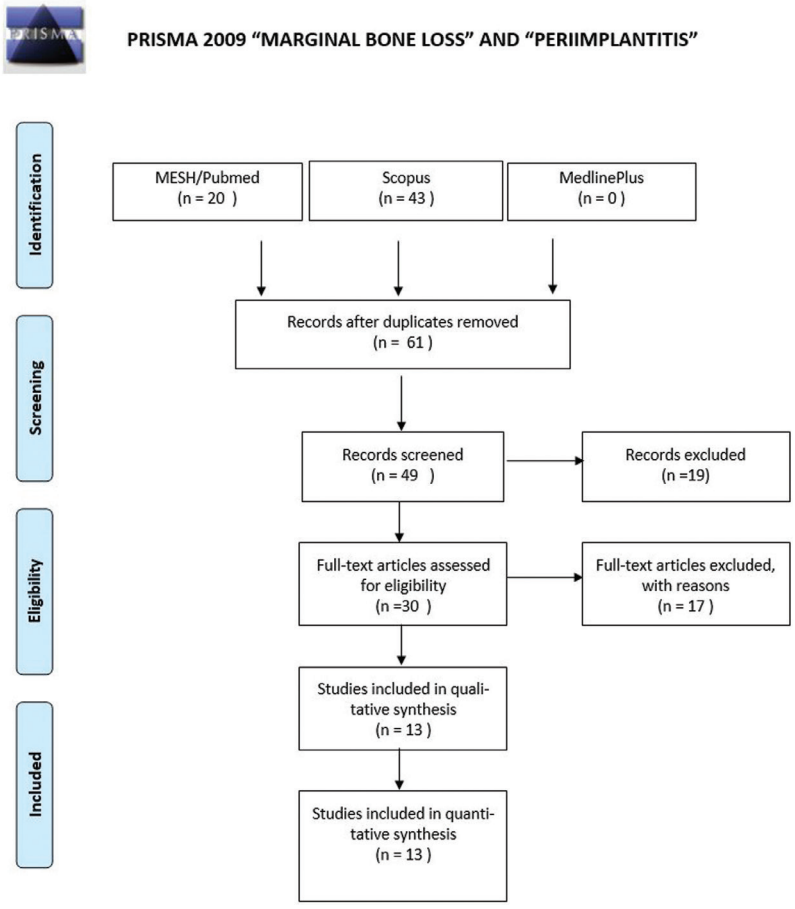

Fig. 1: Flowchart with the keywords "marginal bone loss" and "peri-implantitis."

rature with the research topic of "marginal bone loss and peri-implantitis" and with the research "marginal bone loss and dental implant" can be observed in Table 1, 1 continue, 1 continue-1-18.

Discussion

Peri-implantitis was initially described as an infection with pathological changes in the peri-implant tissues (10). Subsequently, different criteria have been defined for its diag-nosis: bleeding, probing depth of higher than 5 mm, exposure of 3 turns or more of the implant's surface (11) or radiographic observation of MBL, which is defined as bone lost around the crestal area of the dental implant (12).

-MBL Concept

Several authors defined MBL as the position of the marginal bone based on the position of the crestal bone that is in contact with the implant compared to the more coronal crestal reference point of the implant. Therefore, the MBL measured radiographically mesially and distally would be the vertical distance from the crestal reference point of the implant to the first contact with the bone with the implant at the axial level and is measured parallel to it (13).

The dimensional stability of the tissues is analyzed one year after the prosthetic load of the implant, since during the first year, different authors establish MBL limits of 1.5-2 mm (14), determining a single value of 1.8 mm (15) against the 1.5 mm subsequently established (16). Some authors suggested that after the first year, an MBL greater than 0.2 mm per year can take place (2).

-MBL Diagnostic Tests

For the proper assessment of MBL around dental implants, it is essential to go through complementary diagnostic tests (3). Among the most important radiological tests, we observed the panoramic radiography or orthopantomography and the periapical radiography; these tests will only allow researchers to measure the proximal (mesial and distal) MBL of the implant vertically (3). On the other hand, the conical beam tomography (CBCT) offers us transversal cuts, giving us the possibility to obtain a threedimensional evaluation of the MBL and measure the MBL of the vestibular and lingual area of the implant aside from being able to obtain values in the horizontal sense (17). In addition, with respect to axial tomography, the exposure time, radiation dose and economic cost are reduced (18). However, only 4 of the 90 included studies used cone beam tomography, and 8 of them resorted to

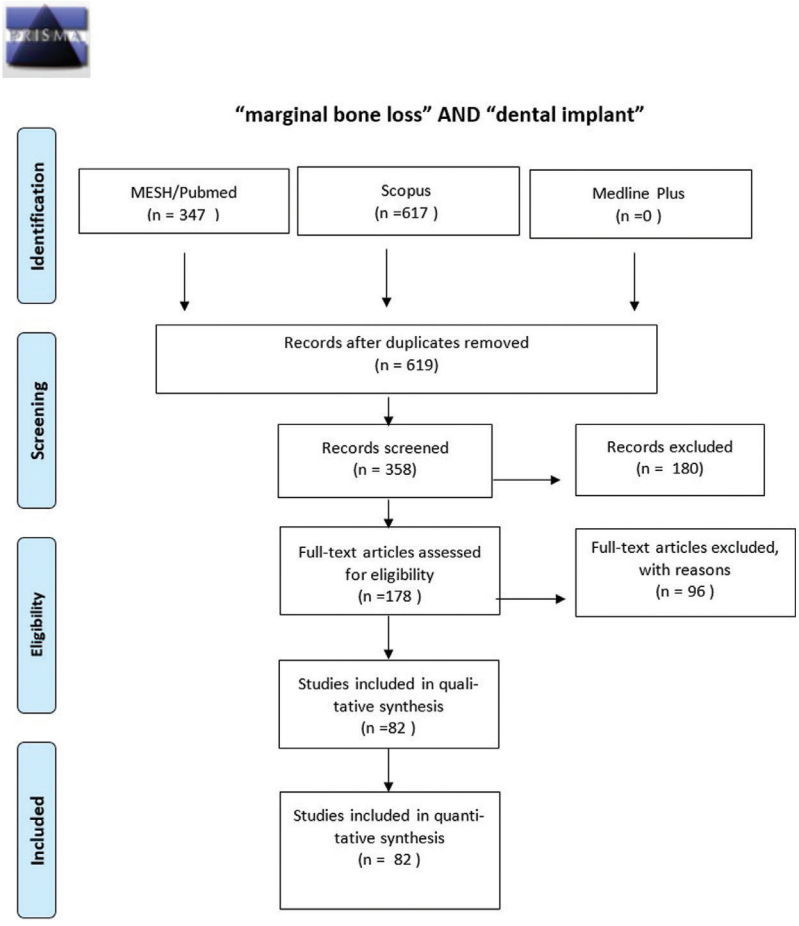

Fig. 2: Flowchart with the keywords "marginal bone loss" and "dental implant."

panoramic radiography, whereas the vast majority carried out periapical radiographs of the implants by performing a parallel technique with the help of positioners (Table 1, 1 continue, 1 continue-1-18).

-MBL Quantification

When quantifying MBL, some authors used different software (19) and even used magnifying glasses to be more exhaustive with the measurement (20). All the studies included in this review expressed this MBL quantitatively in millimeters, except for the study performed by Corcuera *et al.* 2016 (21), in which Lagervall and Jansson's classification was used (22). This classification gives grade 0 if there is no MBL, grade 1 when the loss is equal to or less than 1/3 of the length of the implant, grade 2 if the loss is greater than 1/3 but less than 2/3 of the length of the implant and grade 3 if it suffers 2/3. Corcuera *et al.* 2016 made a modification to this classification, incorporating a grade 4 that includes implants that were unsuccessful or non-surviving (21).

-MBL Influential Epidemiological Factors

The main idiosyncratic patient factors recorded in the studies reviewed were age, gender, toxic habits and systemic pathology (osteoporosis, osteopenia, Interleukin-1b levels), in addition to the medication administered (bisphosphonates) (23-27).

Few studies focused on assessing MBL and highlighted the presence of systemic pathology, including a patient's medication and/or their toxic habits. Although greater MBL has been observed in smoking patients, independently of the type of implant rehabilitation, MBL sometimes duplicates these results independently of the type of implant rehabilitation applied (28). Sayardoust *et al.* 2017 (25) indicated that MBL was higher in the mechanized implants of smoking patients at 90 days, with a higher expression of the proinflammatory cytokine IL-6 and a lower expression of the osteogenic and osteocalcin gene. Predictors of MBL are reflected in smoking, bleeding as a result of probing at 90 days, an expression of factor 1 alpha and an expression of proinflammatory cytokine at 90 days (25).

Corcuera *et al.* 2017 (21) concluded that patients with Down syndrome have significantly higher MBL ($p < 0.001$) if one implant per patient is selected ($p < 0.05$). They also observed a greater loss of implants, especially in those with greater MBL ($p < 0.01$). In the case group, an increase in MBL ($p < 0.05$) and greater implant loss ($p < 0.01$) was also observed with age.

Table 1: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Author *et al.* year	Reference	Study type	Sample size	Criteria used to define MBL	Radiography	Evaluated variables	Results
Corcuera-Flores et al. 2017	Four years of survival and marginal bone loss of implants in patients with Down syndrome and cerebral palsy. Clin Oral Investig. 2017 Jun;21(5):1667-1674	Retrospective	19 patients 172 implants	MBL in thirds (Lagervall and Jansson's proposed radiological classification; does not specify program used).	OPG	Implant length Medical pathology (Down syndrome vs. cerebral palsy)	MBL was significantly higher in all samples ($p < 0.001$). MBL ($p < 0.05$) and implant loss ($p < 0.01$) increased with age. The three-unit fixed dental prosthesis showed higher MBL ($p < 0.05$). Down syndrome had a higher MBL than cerebral palsy (entire sample: $p < 0.0001$; one implant per patient: $p < 0.05$). All patients with Down syndrome saw some damage to bone support (entire sample: $p < 0.0001$; one implant per patient: $p < 0.05$). Implant loss occurred only in Down syndrome patients ($p < 0.00001$).
Cooper et al. 2016	Comparison of Marginal Bone Changes with Internal Conus and External Hexagon Design Implant Systems: A Prospective, Randomized Study. Int J Periodontics Restorative Dent. 2016 Sep-Oct;36(5):631-42	Prospective	45 patients 93 implants	MBL in mm (does not specify program used)	Intraoral Rx with paralyzer (parallel technique)	MBL Implant connection. Interproximal papilla level	The mean marginal bone level change from implant placement to 3 years was -0.25 ± 0.60 mm and -0.5 ± 0.93 mm for internal conus design implants and external hex design implants, respectively. The change recorded from permanent restoration to 3 years was a gain of 0.31 ± 0.41 mm versus 0.04 ± 0.51 mm for ICI and EXI implants, respectively ($P < .05$).
Mendoza-Azpur et al. 2016	Assessment of Marginal Peri-implant Bone-Level Short-Length Implants Compared with Standard Implants Supporting Single Crowns in a Controlled Clinical Trial: 12-Month Follow-Up. Int J Periodontics Restorative Dent. 2016 Nov/Dec;36(6):791-795.	Clinical trial	82 patients	MBL in mm measured with ImageJ software (NIH)	Intraoral Rx (parallel technique)	Type of implant (shorts vs. conventional) Soft tissue stability	A statistically significant difference was found in favor of the standard-length implants after 12 months, with greater gingival recession around the implant; however, bone loss in the short implants did not exceed 0.53 mm. The treatment with 5.5- to 7-mm-length implants is as reliable as treatment with 10- or 12-mm-length implants.
Koutouzis et al. 2015	The Effect of Interimplant Distance on Peri-Implant Bone and Soft Tissue Dimensional Changes: A Nonrandomized, Prospective, 2-Year Follow-Up Study. Int J Oral Maxillofac Implants. 2015 Jul-Aug;30(4):900-	Prospective	30 patients 60 implants	MBL in mm measured with MiPacs, Medicor Imaging	Intraoral Rx with parallelizer (Dentsply Rinn; parallel technique)	Marginal and midproximal bone loss between implants	There were no statistically significant differences in marginal and midproximal bone crest loss between the different groups at any time.

Table 1 continue: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Türk et al. 2013	Marginal bone loss of two implant systems with three different superstructure materials: a randomised clinical trial. J Oral Rehabil. 2013 Jun;40(6):457-63	Clinical trial	33 patients 77 implants	MBL in mm measured with software (RAIN v:12.27)	Intraoral Rx with parallelizer (parallel technique)	Implant system Prosthetic material	Prosthetic materials were found to have greater effect (β = 0.575, P = 0.015) on crestal bone loss than implant systems (P > 0.05). The porcelain fused to base metal alloy restorations showed higher crestal bone loss than noble metal alloy-based restorations (P = 0.003) at 3 months, (P = 0.038), at 6 months and (P = 0.00) at 12 months; however, the crestal bone loss differences between noble metal alloy and zirconia were not significant (P = 0.629) at 3 months, (P = 0.974) at 6 months and (P = 1) at 12 months.
Bressan et al. 2017	The influence of repeated abutment changes on peri-implant tissue stability: 3-year post-loading results from a multicentre randomised controlled trial. Eur J Oral Implantol. 2017;10(4):373-390	Clinical trial	80 patients 128 implants	MBL in mm measured with Scion Image (Scion Corporation, Frederick, MD, USA) software	Intraoral Rx with parallelizer (parallel technique)	Implant location (I,C, PM, M). Implant diameter Postextraction implants Unitary crown or bridges	Mean peri-implant MBL 3 years after loading was 0.07 (0.18) mm for the definitive abutment group and 0.50 (0.93) mm for the repeated abutment changes group (difference = 0.43 mm; CI 95%: 0.13, 0.74; P = 0.007).
Pisoni et al. 2016	Flapless Versus Traditional Dental Implant Surgery: Long-Term Evaluation of Crestal Bone Resorption. J Oral Maxillofac Surg. 2016 Jul;74(7):1354-9	Prospective	40 patients 69 implants	MBL in mm (does not specify program used)	Rx does not specify	Surgical technique with or without flap MBL	No statistical differences were found in peri-implant bone resorption between the 2 groups (open flap surgery vs. flapless surgery) at the basal, implant loading and 3-year control recordings.
Abtahi et al. 2016	Randomised trial of bisphosphonate-coated dental implants: Radiographic follow-up after five years of loading. Int J Oral Maxillofac Surg. 2016 Dec;45(12):1564-1569.	Clinical trial	32 patients 56 implants	MBL in mm Measured with diagnostic imaging (Sectra PACS; Sectra AB, Linko¨ping, Sweden)	Intraoral Rx with parallelizer (parallel technique)	Bisphosphonate treatment	The median MBL for control implants was found to be 0.70 mm, which is less than usually reported in the literature. The bisphosphonate-coated implants showed even less resorption (median 0.20 mm). The median difference within each pair of implants after 5 years of use was 0.34 mm (95% confidence interval 0.00-0.75 mm; P=0.04).
Gultekin et al. 2013	Clinical evaluation of marginal bone loss and stability in two types of submerged dental implants. Int J Oral Maxillofac Implants. 2013 May-Jun;28(3):815-23.	Clinical trial	27 patients 104 implants	MBL in mm Measured with software (Iluma DVT soft- ware, IMTEC Imaging)	TAC	Implant design Implant platform design Implant stability (insertion torque)	One year after loading, mean crestal bone loss was 0.35 ± 0.13 mm for test implants and 0.83 ± 0.16 mm for control implants, showing a significant difference. Primary stability was significantly higher in the test group (TG) than in the CG, but this difference disappeared after 3 months of healing prior to loading.

Table 1 continue-1: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Khorsand et al. 2016	Effect of Microthread De-sign on Marginal Bone Lev-el Around Dental Implants Placed in Fresh Extraction Sockets. Implant Dent. 2016 Feb;25(1):90-6	Clinical trial	30 patients 41 implants	MBL in mm mea-sured with Trophy 2000 software (Tro-phy windows access software; Paris, France)	Intraoral Rx with parallelizer (parallel technique)	Implant length Implant location (I, C, PM, M) Implant design	At month 3, the microthread groups have been associated with more MBL than the CG (P = 0.04). At months 6 and 12, both groups had comparable bone levels (P = 0.21).
Lee et al. 2016	A Long-Term Prospec-tive Evaluation of Mar-ginal Bone-Level Change Around Different Implant Systems. Int J Oral Maxil-lofac Implants. 2016 May-Jun;31(3):657-64	Prospective	54 patients 135 implants	MBL in mm mea-sured with UTHSCSA Image Tool (version 3.00 for Windows, University of Texas Health Sci-ence)	Intraoral Rx (parallel technique)	Implant system Implant surface Unitary crown or bridges	The rough-surface implants and the machined coronal aspect implants did not exhibit statistically significantly different MBL, whereas the microthreaded coronal aspect implants exhibited significantly less MBL (P = .0015).
Schincaglia et al. 2016	Marginal Bone Response Around Immediate- and Delayed-Loading Implants Supporting a Locator-Retained Mandible Over-denture: A Randomized Controlled Study Int J Oral Maxillofac Implants. 2016 Mar-Apr;31(2):448-58	Clinical trial	30 patients 60 implants	MBL mm measured with Image J, version 1.42, National Insti-tutes of Health)	Intraoral Rx (parallel technique)	Moment of implant loading (immediate or deferred) Implant stability (insertion torque) Implant length	A statistically significant difference was observed at 12 months, with less radiographic bone loss in the immedi-ately implants group. Insertion torque and implant length were not correlated with radiographic bone loss. Also, no difference in frequency of maintenance visits and prosthetic complications was reported between the groups.
Elsyad et al. 2016	Circumferential bone loss around splinted and non-splinted immediately loaded implants retaining mandibler overdentures: A random-ized controlled clinical trial using cone beam-computed tomography. J Prosthet Dent. 2016 Nov;116(5):741-748	Clinical trial	30 patients 60 implants	MBL mm Measured with On-Demand3DApp Soft-ware; CyberMed Inc	CBCT	MBL Prosthetic rehabilita-tion (overdenture in implants splinted with bar or without splinting)	Vertical bone loss and horizontal bone loss increased significantly at 3 years after insertion (T3) compared with 1 year (T1) for both groups (P < .005). After 3 years, vertical bone loss was 1.36 ± 0.57 mm and 1.0 ± 0.44 mm and horizontal bone loss was 0.88 ± 0.48 mm for with ball attachment (BA) and 0.77 ± 0.53 mm for bar attachment (RA). At T1 and T3, a BA had more significant vertical bone loss than an RA (P < .001), while horizontal bone loss did not differ signifi-cantly between groups. For both groups, a significant difference was found in vertical bone loss and horizontal bone loss between implant sites (P < .001).

Table 1 continue-2: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Slot et al. 2016	Maxillary overdentures supported by four or six implants in the anterior region: 5-year results from a randomized controlled trial. J Clin Periodontol. 2016 Dec;43(12):1180-1187	Clinical trial	50 patients 250 implants	MBL in mm	Intraoral Rx with parallelizer (parallel technique)	Hybrid prosthesis on 4 or 6 implants (number of implants)	In patients with functional complaints of their maxillary denture, bar-supported overdentures on four implants in the anterior maxillary region were not inferior to overdentures supported by six implants after 5 years of function. Clinical function was good, with no difference in clinical parameters between the groups.
Negri et al. 2014	The effect of age, gender, and insertion site on marginal bone loss around endosseous implants: results from a 3-year trial with premium implant system. Biomed Res Int. 2014;2014:369051	Clinical trial	252 patients 632 implants	MBL in mm measured with OsiriX Imaging Software	OPG	Age Gender Implant location (maxilar o mandible) Implant diameter	Overall MBL was 0.8 mm ± 0.03 (mean ± SEM). Higher MBL was observed around implants in the maxilla than in the mandible ($P < 0.007$). A relationship between implant diameter and MBL ($P < 0.0001$) was observed in male and, more limitedly, female patients. Older patients had higher MBL in the maxilla, but not in the mandible ($P < 0.0001$). MBL progressively increased with age in male patients, but reached a peak in the 50- to 60-year age group in the female subset ($P < 0.001$).
Fernández-Formoso et al. 2012	Radiographic evaluation of marginal bone maintenance around tissue-level implant and bone-level implant: a randomised controlled trial. A 1-year follow-up. J Oral Rehabil. 2012 Nov;39(11):830-7.	Clinical trial	54 patients 114 implants	MBL in mm measured with NHI Image	Intraoral Rx (parallel technique)	Implant platform design	Mean of bone loss with platform-switching implants was -0.01 mm, and the mean of bone loss with standard platform implant was 0.42 mm. Outcomes of this study indicated that the platform-switching design could preserve the crestal bone levels to the 1-year follow-up. There was a statistically significant difference in MBL.
Ma et al. 2010	Marginal bone loss with mandibler two-implant overdentures using different loading protocols and attachment systems: 10-year outcomes. Int J Prosthodont. 2010 Jul-Aug;23(4):321-32.	Retrospective	106 patients 212 implants	MBL in mm measured with x7 magnification, using a peak magnifying glass (which had a scale in tenths of a millimeter)	Intraoral Rx with parallelizer (parallel technique)	Implant surface Attachments (ball retainers vs. locator)	Annual MBL progressed at low levels after the first year with episodes of bone loss and gain. There was stability in marginal bone levels over the long term, with the majority of remodeling occurring during the first year of function. Roughened implant surfaces may be beneficial during the early remodeling period. The amount of MBL in the first year of loading differed significantly by loading protocol and implant surface, whereas the attachment system had only a minor influence.

Table 1 continue-3: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Hof et al. 2014	Impact of insertion torque and implant neck design on peri-implant bone level: a randomized split-mouth trial. Clin Implant Dent Relat Res. 2014 Oct;16(5):668-74	Clinical trial	21 patients 84 implants	MBL in mm; does not specify program used	Intraoral Rx (parallel technique)	Implant stability (insertion torque) Implant design Interleukin-1b levels	No significant influence of insertion torque or implant neck design on peri-implant bone level was found. Protein levels of interleukin-1β in the peri-implant crevicular fluid revealed no difference between both insertion torque groups and different neck designs.
Song et al. 2009	Comparative analysis of peri-implant marginal bone loss based on microthread location: a 1-year prospective study after loading. J Periodontol. 2009 Dec;80(12):1937-44	Prospective	20 patients 40 implants	MBL in mm; does not specify program used	Intraoral Rx with parallelizer (parallel technique)	Implant design	The average bone loss was 0.16 (SD: 0.19) mm in the group with microthreads placed at the implant top and 0.30 (SD: 0.22) mm in the group with microthreads placed 0.5 mm below the implant top after 1 year of functional loading. The paired t test revealed a significant difference in crestal bone loss between groups A and B in individual patients (P = 0.004). No significant differences were found between the two groups for the gingival parameters.
Froum et al. 2017	Survival Rates and Bone and Soft Tissue Level Changes Around One-Piece Dental Implants Placed with a Flapless or Flap Protocol: 8.5-Year Results Int J Periodontics Restorative Dent. 2017 May/Jun;37(3):327-337	Retrospective	52 patients 108 implants	MBL in mm; measured with Image-Pro Insight version 8.0.4, Media Cybernetics	Intraoral Rx (parallel technique)	Surgical technique with or without flap Implant and abutment one piece	Analysis suggested decreasing mean levels of bone loss with time (P < .001). Moreover, there was 0.8-1.0 mm of bone loss through year 1.5, which decreased to 0.3 mm at 8.5 years (P < .05). There was no statistically significant difference in probing pocket depth (PPD) or bleeding on probing over time. Similar mean levels of PPD were found in flap and flapless groups (mean [SD] = 2.4 [0.3] and 2.2 [0.4] mm, respectively [P = .18]), as well as similar rates of BoP (22.8% vs. 17.9%, respectively).
Aimetti et al. 2015	Soft tissue and crestal bone changes around implants with platform-switched abutments placed nonsubmerged at subcrestal position: a 2-year clinical and radiographic evaluation. Int J Oral Maxillofac Implants. 2015 Nov-Dec;30(6):1369-77	Retrospective	40 patients 58 implants	MBL in mm measured with Image J software	Intraoral Rx (parallel technique)	Implant location (maxilar o mandible) Bone quality (2 or 3) Number of implants	From implant insertion to the 2-year follow-up, the mean bone loss was 0.32 ± 0.37 mm. No significant differences related to sex, implant site and bone density were observed.

Table 1 continue-4: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Toljanic et al. 2016	Immediate Loading of Implants in the Edentulous Maxilla with a Fixed Provisional Restoration without Bone Augmentation: A Report on 5-Year Outcomes Data Obtained from a Prospective Clinical Trial. Int J Oral Maxillofac Implants. 2016 Sep-Oct;31(5):1164-70	Clinical trial	51 patients 306 implants	MBL in mm measured with x7 magnification and using software (Il- lustrator CS, Adobe Systems)	Intraoral Rx (parallel technique)	Implant diameter Implant location	Forty subjects with 232 implants returned for the final follow-up appointment, representing a 5-year implant survival proportion of 93% with a mean MBL of 0.44 ± 1.25 mm for this group
Giacomel et al. 2017	Comparison of Marginal Bone-Level Changes of Immediately Loaded Implants, Delayed Loaded Non-submerged Implants, and Delayed Loaded Submerged Implants: A Randomized Clinical Trial. Int J Oral Maxillofac Implants. 2017 May/ Jun;32(3):661-666	Clinical trial	15 patients 45 implants	MBL in mm measured with Cliniview 10.2.2 software (Instrumentarium	Intraoral Rx (parallel technique)	Implant location (submerged or not submerged) Moment of implant loading (immediate or deferred)	In the 9-month period following the implants, no statistically significant differences were found between immediately and delayed loaded implants or between submerged and nonsubmerged implants in bone level changes in patients with partial posterior mandibular edentulism.
Thoma et al. 2014	Prospective randomized controlled clinical study comparing two dental implant systems: demographic and radiographic results at one year of loading. Clin Oral Implants Res. 2014 Feb;25(2):142-9	Clinical trial	60 patients 151 implant	MBL in mm measured with Image J; National Institutes of Health, Bethesda, MD, USA	Intraoral Rx (parallel technique)	Implant design (implant and abutment one piece or two pieces)	The changes in mean marginal bone levels on the implant level amounted to -0.05 mm (SD ± 0.32 mm) (2 piece) and to -0.27 mm (± 0.52 mm) (1 piece). Patient-level values were -0.06 mm (± 0.37 mm) (2 piece) and -0.25 mm (±0.35 mm) (1 piece). These differences between the groups reached statistical significance on the patient level with less bone loss in the 2-piece group ($P < 0.05$).
Vigolo et al. 2015	Clinical evaluation of marginal bone-level change around multiple adjacent implants restored with splinted and nonsplinted restorations: a 10-year randomized controlled trial. Int J Oral Maxillofac Implants. 2015 Mar-Apr;30(2):411-8.	Clinical trial	44 patients 132 implants	MBL in mm (does not specify program used)	Intraoral Rx (parallel technique)	Prosthetic rehabilitation	At 10 years, the splinted group showed a mean of 1.2 mm (interquartile range: 0.2 mm) of bone loss; the nonsplinted group showed 1.3 mm (interquartile range: 0.2 mm). A significant difference in bone loss was seen between the two groups. However, the difference of 0.1 mm was not considered clinically meaningful.

Table 1 continue-5: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Bechara et al. 2017	Short (6-mm) dental implants versus sinus floor elevation and placement of longer (≥10-mm) dental implants: a randomized controlled trial with a 3-year follow-up. Clin Oral Implants Res. 2017 Sep;28(9):1097-1107	Clinical trial	53 patients 90 implants	MBL in mm measured with software (Scion Image; Scion, Frederick, MD, USA)	OPG	Implant length Regeneration (maxillary sinus lift or not).	At 3 years, the sinus floor elevation with simultaneous placement of standard-length (≥ 10-mm) implants (CG) had a significantly higher mean ISQ than the short (6-mm) implants (TG) (72.4 vs. 71.6, P = 0.004). Mean MBL was significantly higher in the CG than in the TG, both at 1 year (0.14 mm vs. 0.21 mm, P = 0.006) and at 3 years (0.20 mm vs. 0.27 mm, P = 0.01). A few complications were reported. Surgical time and cost were significantly higher in the CG than in the TG (P < 0.0001).
Elsyad et al. 2012	Marginal bone loss adjacent to conventional and immediately loaded two implants supporting a ball-retained mandibler overdenture: a 3-year randomized clinical trial. Clin Oral Implants Res. 2012 Apr;23(4):496-503	Clinical trial	36 patients 60 implants	MBL in mm measured with software (MxLiteView, version 1.24 DICOM viewer)	CBCT	Moment of implant loading (immediate or deferred) Implant length Implant diameter	After a 3-year follow-up period, the immediate-loading group recorded more significant vertical bone loss at distal and labial sites than the conventional-loading group, and no significant differences in horizontal bone loss between the groups were observed. The probing depths at the distal and labial sites in the immediate loading group were higher than in the conventional loading group.
Temmerman et al. 2017	An open, prospective, non-randomized, controlled, multicenter study to evaluate the clinical outcome of implant treatment in women over 60 years of age with osteoporosis/osteopenia: 1-year results. Clin Oral Implants Res. 2017 Jan;28(1):95-102.	Clinical trial	48 patients 148 implants	MBL in mm measured with software (Illustrator CS; Adobe Systems Inc., San Jose, CA, USA)	Intraoral Rx (parallel technique)	Bone density (osteoporosis osteopenia vs. healthy)	The overall MBL alteration on a subject's level was -0.04 ± 0.27 mm (osteoporosis group: −0.17 ± 0.30 mm; CG: 0.04 ± 0.23 mm). No statistically significant differences were found between groups.
Canullo et al. 2016	Implant Abutment Cleaning by Plasma of Argon: 5-Year Follow-Up of a Randomized Controlled Trial. J Periodontol. 2016 Apr;87(4):434-42	Clinical trial	30 patients 30 implants	MBL in mm measured with Autocad 2006, v.Z54.10, Autodesk, San Rafael, CA.	Intraoral Rx with parallelizer (parallel technique)	Implant location (I,C,PM)	A statistically higher mean MBL occurred in the CG (cleaning protocol by steaming) compared with the TG (plasma of argon treatment) at 6, 24 and 60 months after crown connection. Nevertheless, intragroup comparisons during the entire follow-up demonstrated a statistically significant mean MBL in the CG but not in the TG.

Table 1 continue-6: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Galindo-Moreno et al. 2017	Clinical and radiographic evaluation of early loaded narrow-diameter implants: a 5-year follow-up of a multicenter prospective clinical study. Clin Oral Implants Res. 2017 Dec;28(12):1584-1591	Clinical trial	69 patients 97 implants	MBL in mm (does not specify the program used)	No radiographic method specified	Implant location (anterior zone) Implant diameter (narrow)	The implants' marginal bone levels did not differ statistically after the 1-year follow-up visit.
Piao et al. 2009	Marginal bone loss around three different implant systems: radiographic evaluation after 1 year. J Oral Rehabil. 2009 Oct;36(10):748-54	Prospective	54 patients 135 implants	MBL in mm measured with UTHSCSA Image Tool (version 3Æ00 for Windows)	Intraoral Rx with parallelizer (parallel technique)	Type of implant (Branemark, Restore, Hexplant) Implant surface	At 1 year, significant differences in MBL were recorded for the three groups ($P < 0.0001$). The rough surface with microthread implants had a mean crestal bone loss of 0.42 ± 0.27 mm; the rough surface implants had 0.81 ± 0.27 mm; the hybrid surface implants had 0.89 ± 0.41 mm. Within this study's limitations, a rough surface with microthreads at the coronal part of the implant maintained the marginal bone level against functional loading better than implants without these two features.
Zuffetti et al. 2016	A 10-year report from a multicentre randomised controlled trial: Immediate non-occlusal versus early loading of dental implants in partially edentulous patients. Eur J Oral Implantol. 2016;9(3):219-230.	Clinical trial	52 patients 52 implants	MBL in mm measured with Scion Image (Scion Corporation, Maryland, USA) software	Intraoral Rx with parallelizer (parallel technique)	Moment of implant loading (immediate or deferred) Implant location	At 10 years, there was a statistically significant recession ($P < 0.001$) of the vestibular soft tissues from the baseline (the final restorations were delivered 8 months after implant placement) at the immediately (0.38 mm) and early (0.25 mm) loaded implants. No statistically significant differences existed in terms of peri-implant bone (difference = 0.08 mm, 95% CI: −0.49 to 0.65; $P = 0.49$) and soft-tissue level changes (difference = 0.07 mm, 95% CI: −0.48 to 0.62; $P = 0.469$) between the two groups at 10 years after loading.
Kadkhodazadeh et al. 2013	Radiographic evaluation of marginal bone levels around dental implants with different designs after 1 year. Acta Odontol Scand. 2013 Jan;71(1):92-5	Prospective	25 patients 75 implants	MBL in mm (does not specify program used)	Intraoral Rx with parallelizer (parallel technique)	Implant design (cylindrical, conical)	After 12 months, significant differences were recorded in the amount of alveolar bone loss recorded between the cylindrical and conical implants ($p < 0.05$). The mean crestal bone loss was 0.88 ± 0.43 mm for the cylindrical, 0.61 ± 0.34 mm for the conical contact and 0.54 ± 0.27 mm for the SPI element implants.

Table 1 continue-7: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Felice et al. 2014	A comparison of two dental implant systems in partially edentulous patients: 1-year post-loading results from a pragmatic multicentre randomised controlled trial. Eur J Oral Implantol. 2014 Winter;7(4):397-409.	Clinical trial	64 patients 144 implants	MBL in mm measured with Scion Image (Scion Corporation, Frederick, MD, USA) software	Intraoral Rx with parallelizer (parallel technique)	Implant design Type of implant Bone quality Implant length Implant diameter Implant location Bone regeneration or not Surgical technique with or without flap	Marginal bone level changes were not statistically significant different for Way Milano compared to Kentron implants at 4 months (−0.16 mm, 95% CI −0.30, 0.01; P = 0.0606) and at 1 year (−0.09 mm, 95% CI −0.26, 0.09; P = 0.3407) after loading.
Vigolo et al. 2012	Cemented versus screw-retained implant-supported single-tooth crowns: a 10-year randomised controlled trial. Eur J Oral Implantol. 2012 Winter;5(4):355-64.	Clinical trial	18 patients 36 implants	MBL in mm (does not specify program used)	Intraoral Rx with parallelizer (parallel technique)	Prosthetic rehabilitation (cemented or screwed) Keratinized gum	There was no evidence of a significant difference in the clinical behavior of the peri-implant marginal bone or of the peri-implant soft tissues when cemented or screw-retained single-tooth implant restorations were provided.
Esposito et al. 2017	Do repeated changes of abutments have any influence on the stability of peri-implant tissues? One-year post-loading results from a multicentre randomised controlled trial. Eur J Oral Implantol. 2017;10(1):57-72.	Clinical trial	80 patients 80 implants	MBL in mm measured with Scion Image (Scion Corporation, Frederick, MD, USA) software.	Intraoral Rx with parallelizer (parallel technique)	Implant location Bone regeneration or not Implant length Implant diameter Prosthetic rehabilitation (unitary crown or not) Postextraction implant or not	The mean peri-implant MBL at 1 year after loading was 0.06 (0.12) mm for the definitive abutment group and 0.23 (0.49) mm for the repeated abutment changes group (difference = −0.16; CI 95%: -0.33, −0.00; P = 0.046).
Koutouzis et al. 2013	The effect of healing abutment reconnection and disconnection on soft and hard peri-implant tissues: a short-term randomized controlled clinical trial. Int J Oral Maxillofac Implants. 2013 May-Jun;28(3):807-14	Clinical trial	16 patients 21 implants	MBL in mm measured with ImageJ, version 1.39F (U.S. National Institutes of Health)	Intraoral Rx with parallelizer (parallel technique)	Implant location (PM or M) Definitive implant abutment vs. healing abutment	The mean MBL at 6 months was 0.13 mm for the permanent abutment group and 0.28 mm for the group with the healing abutment. The present study indicates that implants receiving a final abutment during the implant placement exhibited minimal MBL and were similar to implants subjected to abutment disconnection and reconnection twice. Two disconnection and two reconnection of the abutment did not cause negative dimensional changes in the peri-implant mucosa.

Table 1 continue-8: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Ter-Gunne et al. 2016	Immediate and Early Loading of Two-Implant-Supported Mandibler Overdentures: Three-Year Report of Loading Results of a Single-Center Prospective Randomized Controlled Clinical Trial. Int J Oral Maxillofac Implants. 2016 Sep-Oct;31(5):1110-6.	Clinical trial	40 patients 40 implants	MBL in mm measured with ImageJ software (v1.47, National Institutes of Health)	Intraoral Rx with parallelizer (parallel technique)	Moment of implant loading (immediate or deferred)	The mean radiographic MBL between the baseline and the 3-year follow-up was 0.35 ± 0.63 mm for immediately loaded implants and 0.31 ± 0.96 mm for early loaded implants. The difference between the two groups was not statistically significant (P = .26).
Borgonovo et al. 2012	Multiple teeth replacement with endosseous one-piece yttrium-stabilized zirconia dental implants. Med Oral Patol Oral Cir Bucal. 2012 Nov 1;17(6):e981-7.	Retrospective	8 patients 29 implants	MBL in mm measured with software program (CorelDraw 10; Corel Corp and Coral Ltd, Ottawa, Canada)	Intraoral Rx with parallelizer (parallel technique)	Implant length Implant diameter Implant location Implant material (zirconia vs. titanium)	Radiographic measurements of MBL did not exceed 1.6 mm during the first year of loading, and further MBL was minimal and not significant 1 to 4 years after surgery. This peri-implant bone preservation may be associated with the absence of a micro-gap between the fixture and the abutment, as zirconia dental implants are one-piece implants. Moreover, zirconia is characterized by high biocompatibility and accumulates significantly fewer bacteria than titanium.
Patil et al. 2014	Comparison of two different abutment designs on marginal bone loss and soft tissue development. Int J Oral Maxillofac Implants. 2014 May-Jun;29(3):675-81.	Prospective	26 patients 52 implants	MBL in mm (does not specify program used)	Intraoral Rx with parallelizer (parallel technique)	Implant locations Implant length Implant diameter Implant abutment	A titanium abutment with a circumferential curved design adds no benefit to soft tissue's development or to the preservation of marginal bone compared to a conventional straight abutment design for restoring single-tooth implants in the esthetic zone.
Pohl et al. 2017	Short dental implants (6 mm) versus long dental implants (11-15 mm) in combination with sinus floor elevation procedures: 3-year results from a multicentre, randomized, controlled clinical trial. J Clin Periodontol. 2017 Apr;44(4):438-445.	Clinical trial	101 patients 137 implants	MBL in mm (does not specify program used)	Intraoral Rx with parallelizer (parallel technique)	Implant length (short vs. conventional) Regeneration (maxillary sinus lift or not)	Plaque accumulation and bleeding on probing at a 3-year follow-up showed no difference between the groups except for PPD (p = 0.035).
Barone et al. 2016	The Effect of Insertion Torque on the Clinical Outcome of Single Implants: A Randomized Clinical Trial. Clin Implant Dent Relat Res. 2016 Jun;18(3):588-600.	Clinical trial	116 patients 116 implants	MBL in mm (does not specify program used)	Intraoral Rx with parallelizer (parallel technique)	Implant stability (insertion torque) Implant location	The findings suggested that implants inserted with high IT (≥50 Ncm) in healed bone ridges showed more peri-implant bone remodeling and buccal soft tissue recession than implants inserted with a regular IT (<50 Ncm) (p < 0.001).

Table 1 continue-9: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Rocha et al. 2016	Effect of platform-switching on crestal bone levels around implants in the posterior mandible: 3 years results from a multicentre randomized clinical trial. J Clin Periodontol. 2016 Apr;43(4):374-82	Clinical trial	63 patients 135 implants	MBL in mm measured with ImageJ 1.44	Intraoral Rx with parallelizer (parallel technique)	Bone quality Implant platform design	From surgery to 36 months, the mean bone loss was 0.28 ± 0.56 mm for the platform-switching group and 0.68 ± 0.64 mm for the platform-matching group. A statistically significant difference was found between groups (p = 0.002) with an estimate of 0.39 mm (0.15-0.64, 95% CI) in favor of platform-switching.
Hadzik et al. 2018	The Influence of the Crown-Implant Ratio on the Crestal Bone Level and Implant Secondary Stability: 36-Month Clinical Study. Biomed Res Int. 2018 May 16;2018:4246874.	Clinical trial	30 patients 30 implants	MBL in mm (does not specify program used)	Intraoral Rx with parallelizer (parallel technique) and CBCT	Ratio implant/crown Implant length	The MBL was low for short and conventional implants at 0.34 ± 0.24 mm and 0.22 ± 0.46 mm, respectively. No significant correlation was found between the C/I ratio and secondary stability or between the C/I ratio and the MBL.
Canullo et al. 2010	Platform-switching and marginal bone-level alterations: the results of a randomized-controlled trial. Clin Oral Implants Res. 2010 Jan;21(1):115-21	Clinical trial	31 patients 80 implants	MBL in mm measured with Autocad 2006, version Z 54.10, Autodesk, San Rafael, CA, USA	Intraoral Rx with parallelizer (parallel technique)	Implant crown adjustment (mismatch level)	A radiographic evaluation showed a mean bone loss of 0.99 mm (SD = 0.42 mm) for the 4.3 mm platform diameter, 0.82 mm (SD = 0.36 mm) for the 4.8 mm platform diameter and 0.56 mm (SD = 0.31 mm) for the 5.5 mm platform diameter. These values were statistically significantly lower (P < 0.005) than the control platform diameter of 3.8 mm (1.49 mm, SD = 0.54 mm). Marginal bone level alterations could relate to the extent of implant and abutment mismatching. The marginal bone levels were better maintained at implants restored according to the platform-switching concept.
Moergel et al. 2016	Radiographic evaluation of conical tapered platform-switched implants in the posterior mandible: 1-year results of a two-center prospective study. Clin Oral Implants Res. 2016 Jun;27(6):686-93.	Prospective	24 patients 52 implants	MBL in mm measured with ImageJ	Intraoral Rx with parallelizer (parallel technique)	MBL after prosthetic loading Implant connection Implant platform design	Internal conical connection implants with platform-switching abutments presented a high success rate and enhanced or preserved marginal bone levels after 1 year of loading.

Table 1 continue-10: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Becker et al. 2013	Prospective clinical trial evaluating a new implant system for implant survival, implant stability and radio-graphic bone changes. Clin Implant Dent Relat Res. 2013 Feb;15(1):15-21.	Clinical trial	66 patients 10 implants	MBL in mm mea-sured with ImageJ	Intraoral Rx with parallelizer (parallel technique)	Implant diameter Implant location Bone quality Implant stability	Between examinations, there was an average -0.6 mm of bone loss, which was statistically significant (p = 0.03). On average, 4.0-mm-wide implants lost 0.1 mm of bone when compared with 5-mm-wide implants. These differences were insignificant (p = 0.86). Bone loss was adjusted for implant length, and tooth position and there were small, but clini-cally insignificant changes. Five-milli-meter-wide implants lose 0.2 mm more than 4.0-mm-wide implants (p = 0.7). Maxillary incisors lose the least amount of bone at 0.152 mm (p = 0.33).
Cochran et al. 2009	A prospective multicenter 5-year radiographic evalu-ation of crestal bone levels over time in 596 dental implants placed in 192 patients. J Periodontol. 2009 May;80(5):725-33.	Prospective	192 patients 596 implants	MBL in mm (does not specify program used)	Intraoral Rx with parallelizer (parallel technique)	Type of implant Implant design (solid screw or hollow cylinder) Prosthetic restoration (single or multiple) Implant length	Clinically significant marginal bone remodeling occurred between the implant placement and the final prosthesis place-ment around one-stage non-submerged titanium implants with a titanium plas-ma-sprayed surface. Subsequent to that, bone loss observed around implants up to 5 years postloading was minimal.
Ryu et al. 2016	Early loading of splinted im-plants supporting a two-unit fixed partial denture in the posterior maxilla: 13-month results from a randomized controlled clinical trial of two different implant sys-tems. Clin Oral Implants Res. 2016 Aug;27(8):1017-25	Clinical trial	30 patients 60 implants	MBL in mm (does not specify program used)	Intraoral Rx with parallelizer (parallel technique)	Implant stability (insertion torque) Implant design Bone quality Implant location	Both groups exhibited no stability dip during the early phase of healing. The average MBL from the baseline of im-plant placement for the control and ex-perimental groups was 0.38 and 0.45 mm after 4 weeks and 0.98 and 0.61 mm after 13 months, respectively.
Mumcu et al. 2012	The influence of healing type on marginal bone levels of implants supporting mandibler overdentures: a randomized clinical study. Indian J Dent Res. 2012 Jul-Aug;23(4):514-8	Clinical trial	48 patients 96 implants	MBL in mm mea-sured with software program CorelDraw 11.0 (Corel Corporation and Coral Ltd., Ot-tawa, Canada)	OPG	Healing period (im-plant submerged or not)	The MBL of the implants at 6 months was found to be significantly higher in the submerged healing group (P < 0.05). No statistically significant relation was found between the MBL of implants left to submerged healing and that of im-plants left to non-submerged healing in the other follow-up periods.

Table 1 continue-11: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Palaska et al. 2016	Influence of placement depth and abutment con-nection pattern on bone remodeling around 1-stage implants: a prospective randomized controlled clini-cal trial. Clin Oral Implants Res. 2016 Feb;27(2):e47-56.	Clinical trial	81 patients 105 implants	MBL in mm mea-sured with DSR (VixWin; Gendex Dental System)	Intraoral Rx with parallelizer (parallel technique)	Implant location (crestal vs. subcrest-al) (M, PM) Implant connection (Morse type or not)	The mean (± SE) peri-implant bone loss was recorded as follows. Group 1 (sub-crestal, screwed tapered internal connec-tion): 0.68 ± 0.07 mm; group 2 (crestal, screwed and tapered internal connection): 0.79 ± 0.06 mm; group 3 (subcrestal internal conical seal connection): 0.49 ± 0.06 mm; and group 4 (crestal, internal conical seal connection): 0.40 ± 0.07 mm. The statistical analysis revealed significant differences in bone resorption between groups with different abutment connections.
Veis et al. 2010	Evaluation of peri-implant marginal bone loss using modified abutment connec-tions at various crestal level placements. Int J Periodon-tics Restorative Dent. 2010 Dec;30(6):609-17.	Prospective	282 implants	MBL in mm mea-sured with AxioVision 4.6.3, Carl Zeiss	Does not specify the radiographic method used	Implant location (crestal, sub and supracrestal) Implant platform design	Statistically significant differences were found between subgroups in both straight and platform-switched categories. The only non-statistically significant differ-ence (P = .341) arose when comparing the supracrestal and subcrestal locations in the straight abutment connection group. The platform-switched group exhibited significantly less bone loss (P = .046) only in subcrestal locations. The platform-switched concept was not beneficial during the overall comparison, but it was for the subcrestal location of the abutment connection. The crestal placement of the implant-abutment con-nection raised the marginal bone resorp-tion in straight and platform-switched abutments.

Table 1 continue-12: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Cehreli et al. 2010	Spontaneous early exposure and marginal bone loss around conventionally and early-placed submerged implants: a double-blind study. Clin Oral Implants Res. 2010 Dec;21(12):1327-33	Retrospective	46 patients 103 implants	MBL in mm measured with (ImageJ 1.32j, NIH, Bethesda, MD, USA	Intraoral Rx with parallelizer (parallel technique)	Postextraction implants or not Provisional prosthetic or not	The MBL in the early-placed group (Group 2) was higher than in the conventionally placed group (Group 1) in patients with or without interim prosthesis ($P < 0.05$). The use of interim prosthesis did not increase the MBL in Group 1, but it led to a higher MBL in Group 2. The percentage of nonexposed implants in Group 1 was higher than in Group 2 ($P = 0.007$, odds ratio = 7). Group 1 implants had an 11.5 times greater plaque index score of 0 than those in Group 2 ($P = 0.031$, odds ratio = 11.5). The differences between the MBL with regards to CSE scores of 0 and 1–4 was significant for both sides in Group 2 and the mesial side in Group 1 ($P < 0.05$).
Tealdo et al. 2014	Immediate versus delayed loading of dental implants in edentulous patients' maxillae: a 6-year prospective study. Int J Prosthodont. 2014 May-Jun;27(3):207-14	Prospective	49 patients 260 implants	MBL in mm (does not specify program used)	Intraoral Rx with parallelizer (parallel technique)	Moment of implant loading (immediate or deferred)	Significantly less bone loss occurred in the immediately loaded implants (mean: 1.62 mm) compared with the control delayed implant loading (mean: 2.44 mm) over the study's 6-year follow-up period.
Karabuda et al. 2011	Stability, marginal bone loss and survival of standard and modified sand-blasted, acid-etched implants in bilateral edentulous spaces: a prospective 15-month evaluation. Clin Oral Implants Res. 2011 Aug;22(8):840-9.	Prospective	22 patients 96 implants	MBL in mm measured with software (Diagora for Windows, Sooredex, Tuusula, Finland)	OPG	Implant surface (SLA or SLA modified: sandblasting and acid)	At the loading stage, modSLA implants showed a significantly lower MBL (0.18 ± 0.05 mm) than SLA implants (0.22 ± 0.06 mm; $P = 0.002$). In the loading stage, the RFA value of the modSLA implants (60.42 ± 6.82) was significantly higher than that of both implant types in the surgical stage (55.46 ± 8.29 and 56.68 ± 8.19) and after 1 (56.08 ± 7.01 and 55.60 ± 9.07) and 3 weeks of healing (55.94 ± 5.95 and 55.40 ± 6.50 for SLA and modSLA implants, respectively).
Tallarico et al. 2016	Dental implants treatment outcomes in patient under active therapy with alendronate: 3-year follow-up results of a multicenter prospective observational study Clin Oral Implants Res. 2016 Aug;27(8):943-9	Prospective	40 patients 98 implants	MBL in mm measured with DFW 2.8 for Windows, Soredex, Tuusula, Finland	Intraoral Rx with parallelizer (parallel technique)	MBL after biphosphonate intake	Oral bisphosphonate therapy did not appear to significantly affect implant survival and success in cases with an accurate treatment time selection, minimally invasive surgical approach and constant follow-up.

Table 1 continue-13: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Felice et al. 2016	Posterior jaws rehabilitated with partial prostheses supported by 4.0 x 4.0 mm or by longer implants: One-year post-loading results from a multicenter randomised controlled trial. Eur J Oral Implantol. 2016 Spring;9(1):35-45.	Clinical trial	150 patients 240 implants	MBL in mm measured with OsiriX (Pixmeo Sarl, Bernex, Switzerland) software	Intraoral Rx with parallelizer (parallel technique)	Implant length Implant stability (insertion torque)	No statistically significant differences in bone level changes between short and long implants occurred for 1 year (mean difference = 0.038 mm; 95% CI: −0.068 to 0.138; P = 0.198).
Lee et al. 2016	A Two-Year Evaluation of a Sloped Marginal Contour Implant System Placed in Healed Sites. Int J Oral Maxillofac Implants. 2016 Nov/Dec;31(6):1423-1428.	Retrospective	14 patients 18 implants	MBL in mm (does not specify program used)	Intraoral Rx with parallelizer (parallel technique)	Implant location Implant stability (insertion torque)	No statistical difference were found related to implant location or implant stability.
Vercruyssen et al. 2014	Implant- and patient-centred outcomes of guided surgery, a 1-year follow-up: An RCT comparing guided surgery with conventional implant placement. J Clin Periodontol. 2014 Dec;41(12):1154-60.	Clinical trial	59 patients 314 implants	MBL in mm measured with imageJ software (National Institutes of Health)	Intraoral Rx with parallelizer (parallel technique)	Bone quality Implant length Implant diameter Surgical technique (guided or conventional)	At a 1-year follow-up, no difference could be found between the implant and patient outcome variables of guided or conventional implant treatment.
Esposito et al. 2015	Dental implants with internal versus external connections: 1-year post-loading results from a pragmatic multicenter randomised controlled trial. Eur J Oral Implantol. 2015 Winter;8(4):331-44.	Clinical trial	200 patients 327 implants	MBL in mm measured with UTHSCSA Image Tool 3.0 software (The University of Texas Health Science Center, Texas, USA)	Intraoral Rx with parallelizer (parallel technique)	Implant connection (internal vs. external) Implant length Implant diameter Implant location (I, C,PM,M) Bone density	Within the limitations given by the difference in neck design and platform-switching between external connection and internal connection implants, preliminary short-term data (1-year post-loading) did not show any statistically significant differences between the two connection types,
Jung et al. 2016	Evaluation of a one-piece ceramic implant used for single-tooth replacement and three-unit fixed partial dentures: a prospective cohort clinical trial. Clin Oral Implants Res. 2016 Jul;27(7):751-61.	Clinical trial	60 patients 71 implants	MBL in mm (does not specify program used)	Intraoral Rx with parallelizer (parallel technique)	Implant length Implant diameter Implant location (maxilla or mandible)	The mean MBL from the implant insertion to the 1-year follow-up after the final prosthetic restoration was 0.78 mm, with a standard deviation of 0.79 mm. After 1 year, the difference was significant.

Table 1 continue-14: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Nickenig et al. 2013	A 5-year prospective radio-graphic evaluation of mar-ginal bone levels adjacent to parallel-screw cylinder machined-neck implants and rough-surfaced microthread-ed implants using digitized panoramic radiographs. J Craniomaxillofac Surg. 2013 Oct;41(7):564-8.	Prospective	34 patients 133 implants	MBL in mm mea-sured with Friacom Dental Office Soft-ware 2.4, Friatec AG, Mannheim, Germany	OPG	Implant surface (rugged microtreated, machined neck) Implant location (PM, M) Implant length	The machined-neck group had a mean crestal bone loss of 0.5 mm (0.0–2.3) after the healing period, 1.1 mm (0.0–3.0) at the 2-year follow-up and 1.4 mm (0.0–2.9) at the 5-year follow-up. The rough-surfaced microthreaded implant group had a mean bone loss of 0.1 mm (−0.4 to 2.0) after the healing period, 0.5 mm (0.0 to 2.1) at the 2-year follow-up, and 0.7 mm (0.0 to 2.3) at the 5-year follow-up. The two implant types showed significant differences in marginal bone levels.
Cehreli et al. 2010	Marginal bone level changes and prosthetic maintenance of mandibler overdentures supported by 2 implants: a 5-year randomized clinical trial. Clin Implant Dent Relat Res. 2010 Jun 1;12(2):114-21.	Clinical trial	28 patients 56 implants	MBL in mm mea-sured with ImageJ 1.32j, NIH, USA	Intraoral Rx with parallelizer (parallel technique)	Type of implant (Branemark vs. Straumann)	The MBL around Brånemark implants (1.21 ± 0.1) was higher than around Straumann implants (0.73 ± 0.06) after 5 years of functioning (p = .002).
Crespi et al. 2014	Immediate occlusal load-ing of full-arch rehabilita-tions: screw-retained versus cement-retained prosthesis. An 8-year clinical evalua-tion Int J Oral Maxillofac Implants. 2014 Nov-Dec;29(6):1406-11.	Prospective	28 patients 272 implants	MBL in mm mea-sured with oftware (Schick Technolo-gies)	Intraoral Rx with parallelizer (parallel technique)	Prosthetic rehabilita-tion (cemented or screwed) Implant length Implant diameter Postextraction im-plant or not	Within 1 year after implant placement, bone loss was recorded as follows: the cement-retained group (CRG) showed mean bone levels of −1.23 ± 0.45 mm, and the screw-retained group (SRG) showed mean bone levels of −1.01 ± 0.33 mm. A slight increase appeared after a 3-year follow-up (0.30 ± 0.25 mm in CRG and 0.45 ± 0.29 mm in SRG). After that, marginal bone levels remained over time up to the 8-year follow-up. No statistically significant differences were found between groups (P > .05). Defini-tive cement- and screw-retained ceramic restorations are highly predictable, bio-compatible and esthetically pleasing, and the two groups presented no statistically significant differences in bone loss.
Simunek et al. 2010	Changes in stability after healing of immediately loaded dental implants. Int J Oral Maxillofac Implants. 2010 Nov-Dec;25(6):1085-92.	Prospective	188 patients 940 implants	MBL in mm (does not specify program used)	OPG	Moment of implant loading (immediate or deferred) Implant stability (insertion torque)	Correlations between the MBL and the final insertion torque and between the MBL and the DISQ values were observed.

Table 1 continue-15: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

den Hartog et al. 2017	Anterior single implants with different neck designs: 5 Year results of a random-ized clinical trial. Clin Im-plant Dent Relat Res. 2017 Aug;19(4):717-724.	Clinical trial	93 patients 93 implants	MBL in mm mea-sured with Adobe Photoshop (Adobe Photoshop CS3 Ex-tended, Adobe Sys-tems Inc., San Jose, California).	Intraoral Rx with parallelizer (parallel technique)	Implant location (I, C, PM, M) Implant diameter Prosthetic rehabilita-tion (cemented or screwed) Implant design	No statistically significant differences were found between implants with a 1.5 mm smooth neck ("smooth group"), a rough neck with grooves ("rough group") or a scalloped rough neck with grooves ("scalloped group").
Sayardoust et al. 2017	Clinical, radiological, and gene expression analyses in smokers and non-smokers, Part 2: RCT on the late healing phase of osseo-integration. Clin Implant Dent Relat Res. 2017 Oct;19(5):901-915	Clinical trial	32 patients 92 implants	MBL in mm (does not specify program used) with a magnifica-tion x7	Intraoral Rx with parallelizer (parallel technique)	Smoking habit Bone quality and quantity Type of implant Implant location (maxilar, mandible)	Smoking has an early effect on osseo-integration, which is dependent on the implant surface properties and the local host response.
Pessoa et al. 2017	Bone Remodeling Around Implants with External Hexagon and Morse-Taper Connections: A Random-ized, Controlled, Split-Mouth, Clinical Trial. Clin Implant Dent Relat Res. 2017 Feb;19(1):97-110.	Clinical trial	12 patients 24 implants	MBL in mm mea-sured with Image J, National Institutes of Health, Bethesda, MD, USA	Intraoral Rx with parallelizer (parallel technique)	Implant connection (external hexagonal or internal Morse) Gingival biotype Probing depth	Radiographic peri-implant bone loss depends on the implant connection type. Morse-taper connections showed less peri-implant bone loss compared to external hexagon connections, but no statistically significant differences were found.
Lee et al. 2010	A 3-year prospective ra-diographic evaluation of marginal bone level around different implant systems J Oral Rehabil. 2010 Jul;37(7):538-44.	Prospective	54 patients 135 implants	MBL in mm mea-sured with UTHSCSA Image Too	Intraoral Rx with parallelizer (parallel technique)	Implant location (maxilar or man-dible) Implant system	Significant differences were noted in the MBL recorded for the three groups: rough-surface implants, a hybrid of smooth and rough-surface implants and rough surface with microthread implants ($P < 0.0001$). At 3 years, the rough sur-face with microthread implants had a mean crestal bone loss of 0.59 ± 0.30 mm; the rough-surface implants, 0.95 ± 0.27 mm and the hybrid surface implants, 1.05 ± 0.34 mm.
Koutouzis et al. 2011	Retrospective evaluation of crestal bone changes around implants with reduced abut-ment diameter placed non-submerged and at subcrestal positions: the effect of bone grafting at implant place-ment. J Periodontol. 2011 Feb;82(2):234-42.	Retrospective	100 patients 287 implants	MBL in mm mea-sured with DEXIS, Des Plaines, IL.	Intraoral Rx with parallelizer (parallel technique)	Bone regeneration or not Implant location (maxilar or man-dible)	There were no statistically sig-nificant differences between the subcrestally placed dental im-plants grafted with a xenograft and the subcrestally placed dental im-plants without any grafting material. They were reviewed regarding marginal peri-implant hard-tissue loss.

Table 1 continue-16: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Nickenig et al. 2009	Radiographic evaluation of marginal bone levels adjacent to parallel-screw cylinder machined-neck implants and rough-surfaced microthreaded implants using digitized panoramic radiographs. Clin Oral Implants Res. 2009 Jun;20(6):550-4	Prospective	34 patients 133 implants	MBL in mm mea-sured with Friacom Dental Office Soft-ware 2.4, Fria- tec AG, Mannheim, Germany	OPG	Implant design	The machined-neck group had a mean crestal bone loss of 0.5 mm (range: 0 to 2.3) after the healing period, 0.8 mm af-ter 6 months (range: 0 to 2.4) and 1.1 mm (range: 0 to 3) at the end of the follow-up. The rough-surfaced microthreaded implant group had a mean bone loss of 0.1 mm (range: −0.4 to 2) after the heal-ing period, 0.4 mm (range: 0 to 2.1) after 6 months and 0.5 mm (range: 0 to 2.1) at the end of the follow-up. The two implant types showed significant differences in marginal bone levels (healing period: $P = 0.01$; end of follow-up: $P < 0.01$).
Vigolo et al. 2010	Clinical evaluation of mar-ginal bone level change of multiple adjacent implants restored with splinted and nonsplinted restorations: a 5-year prospective study. Int J Oral Maxillofac Implants. 2010 Nov-Dec;25(6):1189-94.	Prospective	44 patients 132 implants	MBL in mm (does not specify program used) with a magnifica-tion x6	Intraoral Rx with parallelizer (parallel technique)	Implant length Bone quality Prosthetic rehabilita-tion (splinted or not)	The mean marginal bone level changes at the 5-year recall were −0.7 ± 0.2 mm for splinted restorations and −0.8 ± 0.2 mm) for nonsplinted restorations. The peri-implant MBL around nonsplinted implants in the present study was sta-tistically equivalent to that observed in splinted implants.
Barone et al. 2012	A randomized clinical trial to evaluate and compare implants placed in augment-ed versus non-augmented extraction sockets: 3-year results. J Periodontol. 2012 Jul;83(7):836-46.	Clinical trial	40 patients 40 implants	MBL in mm mea-sured with UTHSCSA Image Tool, v.3.0, University of Texas Health Science Cen-ter, San Antonio, TX	Intraoral Rx with parallelizer (parallel technique)	Implant length Implant diameter Postextraction im-plants with regenera-tion or not	No statistical differences were found between the grafted extraction sock-ets compared to implants placed into non-grafted sites in terms of implant survival and MBL.
Sakka et al. 2013	Investigation of the effect of ibuprofen on the heal-ing of osseointegrated oral implants. J Investig Clin Dent. 2013 May;4(2):113-9	Clinical trial	28 patients 57 implants	MBL in mm manually measured with magni-fication x8	Intraoral Rx with parallelizer (parallel technique)	Ibuprofen intake or not after surgery	There were no significant differences between the ibuprofen and no-ibuprofen groups when comparing bone changes.
Zuffetti et al. 2015	The topical administration of bisphosphonates in im-plant surgery: a randomized split-mouth prospective study with a follow-up up to 5 years. Clin Implant Dent Relat Res. 2015 Jan;17 Suppl 1:e168-76.	Prospective	39 patients 155 implants	MBL in mm mea-sured with ImageJ version 1.46, National Institutes of Health, Bethesda, MD, USA;	Intraoral Rx with parallelizer (parallel technique)	Topical biphospho-nate during surgery or not Implant length Type of edentulism (total or partial)	The mean MBL was 0.85 ± 0.71 mm in the TG (a 3% clodronate solution mixed with the surfactant Tween-20 at a 1:3 ratio topically administered at the im-plant surface and at the implant site) and 1.12 ± 0.85 mm in the CG (a conventional insertion) after 1 year of loading and was stable thereafter. The difference was not significant.

Table 1 continue-17: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Alissa et al. 2009	Influence of ibuprofen on bone healing around dental implants: a randomised double-blind placebo-controlled clinical study. Eur J Oral Implantol. 2009 Autumn;2(3):185-99.	Clinical trial	61 patients 132 implants	MBL in mm manual measured magnificacionx8, MAG 6, Pyser-SGI, Kent, UK	Intraoral Rx with parallelizer (parallel technique)	Ibuprofen intake or not after surgery Implant location (maxilar vs. mandible)	For the mean marginal bone level changes at 3 months (P = 0.27) and at 6 months (P = 0.97), there were no statistically significant differences between a short course of systemic ibuprofen for postoperative pain management subsequent to implant placement and a placebo.
Lago et al. 2018	Crestal Bone Level Around Tissue-Level Implants Restored with Platform Matching and Bone-Level Implants Restored with Platform-switching: A 5-Year Randomized Controlled Trial. Int J Oral Maxillofac Implants. 2018 Mar/Apr;33(2):448-456.	Clinical trial	100 patients 202 implants	MBL in mm measured with ImageJ (Wayne Rasband, National Institutes of Health)	Intraoral Rx with parallelizer (parallel technique)	Type of implants (tissue level vs. bone level) Implant length Implant diameter	The mean difference between the tissue-level implants restored with platform matching and the bone-level implants restored with platform-switching was 0.31 mm at the baseline to 1 year, 0.53 mm at 1 to 5 years and 0.85 mm at the baseline to 5 years. There was a statistically significant difference in the MBL (P < .001).
Derks et al. 2016	Peri-implantitis - onset and pattern of progression. J Clin Periodontol. 2016 Apr;43(4):383-8	Retrospective	427 patients 596 implants	MBL in mm (does not specify program used)	Does not specify the radiographic method used	Progression pattern of peri-implantitis in implants with moderate to severe peri-impantitis from 1 to 9 years	A total of 70% and 81% of subjects presented with ≥ 1 implant with a bone loss of > 0.5 mm at 2 and 3 years, respectively. Peri-implantitis progresses in a non-linear, accelerating pattern and, for the majority of cases, the onset occurs within 3 years of functioning (p < 0.0001).
Esposito et al. 2016	Dental implants with internal versus external connections: 5-year post-loading results from a pragmatic multicenter randomised controlled trial. Eur J Oral Implantol. 2016;9 Suppl 1(2):129-41.	Clinical trial	120 patients 203 implants	MBL in mm (does not specify program used)	Intraoral Rx (parallel technique)	Implant connection MBL	Five years after loading, there were no statistically significant differences in marginal bone level estimates between the internal and external connections (difference = 0.14 mm, 95% CI: −0.28 to 0.56, P (ancova) = 0.505), and both groups had statistically significant bone loss from implant placement: 1.13 mm for the external connection implants and 1.21 mm for the internal connection implants.
Gamper et al. 2017	Randomized controlled clinical trial comparing one-piece and two-piece dental implants supporting fixed and removable dental prostheses: 4- to 6-year observations. Clin Oral Implants Res. 2017 Dec;28(12):1553-1559. doi: 10.1111/clr.13025. Epub 2017 May 29.	Clinical trial	60 patients 151 implants	MBL in mm measured with ImageJ, National Institutes of Health, Bethesda, Maryland USA	Intraoral Rx (parallel technique)	Implant design (implant and abutment one piece or not) Bone regeneration or not Prosthetic rehabilitation	The median marginal bone level for the one-piece implant system group changed from 0.51 mm at the baseline to 0.49 mm. The two-piece implant system changed from 1.02 mm to 1.35 mm (P < 0.001) from the 4- to 6-year follow-up.

Table 1 continue-18: Studies included after the research "marginal bone loss and peri-implantitis" and mar-ginal bone loss and dental implant.

Sahrmann et al. 2016	Success of 6-mm Implants with Single-Tooth Restora-tions: A 3-year Random-ized Controlled Clinical Trial. J Dent Res. 2016 Jun;95(6):623-8	Clinical trial	172 implants	MBL in mm mea-sured with ImageJ, (Image J64; National Institutes of Health, Bethesda, MD, USA)	Intraoral Rx (parallel technique)	Implant length	We found no significant change in the crestal bone level from the baseline to 3 years for 6-mm or 10-mm implants. The changes were −0.19 ± 0.62 mm and −0.33 ± 0.71 mm, respectively. The inter-group difference was not significant.
Kütan et al. 2015	Clinical and Radiographic Evaluation of Marginal Bone Changes around Platform-Switching Im-plants Placed in Crestal or Subcrestal Positions: A Randomized Controlled Clinical Trial. Clin Implant Dent Relat Res. 2015 Oct;17 Suppl 2:e364-75	Clinical trial	28 patients 56 implants	MBL in mm (does not specify program used)	Intraoral Rx (parallel technique)	Implant location (crestal or subcrestal)	After 3 years, the mean radiograph-ic vertical bone loss for the control bone-level group was significantly lower than in the below bone-level group (0.56±0.35 mm and 1.21±1.05 mm, respectively) ($p < .01$).
Guljé et al. 2014	Single crowns in the re-sorbed posterior maxilla supported by either 6-mm implants or by 11-mm im-plants combined with sinus floor elevation surgery: a 1-year randomised con-trolled trial. Eur J Oral Implantol. 2014 Autumn;7(3):247-55.	Clinical trial	41 patients 41 implants	MBL in mm mea-sured with Dicom-Works, Biomedical Engineering, Univer-sity Medical Center Groningen, the Neth-erlands	Intraoral Rx (parallel technique)	Implant length Bone regeneration (maxillary sinus lift or not)	No statistical differences were found between 6-mm implants and 11-mm im-plants combined with sinus floor eleva-tion surgery to support a single crown in the resorbed posterior maxilla after a 1-year follow-up.
Ravald et al. 2013	Long-term evaluation of Astra Tech and Brånemark implants in patients treated with full-arch bridges. Re-sults after 12-15 years. Clin Oral Implants Res. 2013 Oct;24(10):1144-51	Clinical trial	66 patients 184 implants	MBL in mm (does not specify program used)	Intraoral Rx (parallel technique)	Implant location (maxilar o mandible) Implant design Moment of implant loading (immediate or deferred)	No statistically significant difference in implant loss or bone level change was found between Astra Tech TiOblast sur-faces and Brånemark-turned implants.
Gotfredsen et al. 2012	A 10-year prospective study of single tooth implants placed in the anterior max-illa. Clin Implant Dent Relat Res. 2012 Mar;14(1):80-7	Clinical trial	20 patients 20 implants	MBL in mm was changed to Digora digital film (The Den-tal Imaging Company Ltd, Portslade, East Sussex, UK)	Intraoral Rx (parallel technique)	MBL Esthetic outcome	The average marginal bone-level change was less than 1 mm, and there was no difference between early and delayed implant placement.

Temmerman *et al.* 2017 (27) focused their study on postmenopausal women with osteoporosis/osteopenia, showing an MBL around implants of 0.01 ± 0.51 mm (Control Group [CG]: 0.05 ± 0.52 mm); the mean MBL from a subject was of 0.04 ± 0.27 mm (Osteoporosis/Osteopenia Group: -0.17 ± 0.30 mm, CG: 0.04 ± 0.23 mm). They concluded that rehabilitation using implants in patients with osteoporosis can be carried out with the same success rate as in healthy patients.

The stability analysis off dental implants can also be conditioned due to certain drugs that treat the patient's underlying pathology and that alter bone remodeling immunity (28). Bisphosphonates are one such drug family that has been studied due to their ability to inhibit normal bone resorption, which entails a reduction in remodeling, for a higher bone density, better mineralization and a lower risk of bone fracture (29). Tallarico *et al.* 2016 (26) found that patients who were previously under bisphosphonate treatment had a 98.98% overall implant survival success rate and 100% prosthesis success rate. The mean MBL was 1.35 ± 0.21 mm (95% CI 1.24-1.38) at 3 years. Zuffetti *et al.* 2015 (30) obtained 100% survival rates in the implants for the experimental group; the implants for this group were topically rinsed with bisphosphonate before surgery implantation. The CG, on the other hand, had a 91.3% success rate; in this group, the implants were placed without applying the topical bisphosphonate rinse, and a significant difference was observed at 5 years ($p < 0.01$). The average MBL observed was 0.85 ± 0.71 mm in the experimental group and 1.12 ± 0.85 mm in the CG after one year of prosthetic loading; it then remained stable with no statistically significant differences. Thus, some authors suggested that implants coated with bisphosphonates allow the prolonged conservation of marginal bone. These authors observed that the implants coated with bisphosphonates show even less marginal bone resorption than the CG not coated with bisphosphonates, and a mean difference after 5 years of loading 0.34 mm (95% confidence interval 0.00-0.75 mm, $p = 0.04$) was observed (23).

The medication prescribed after surgery must also be taken into account due to its possible effect on MBL, since several studies observed a greater MBL in patients who were administered ibuprofen after surgery, although their results were not statistically significant (20).

-MBL Factors Related to Implant Design

Dental implant surface is one of the factors more frequently analyzed, a greater crestal bone loss was observed in those implants with a mechanized surface ($p = 0.01$, end of follow-up: $p < 0.01$) (31). Among implants with a rough surface, those with coronal microtreatments have the lowest MBL compared with rough surface and hybrid implants ($p < 0.05$) (32, 33). Other authors agreed with these results, although they did not observe any statistically significant differences between the rough surface implants and the implants with mechanized coronal parts (34). However, the type of surface treatment used by different brands of implants with rough surfaces has been found to have lower MBL ($p = 0.002$) (35). However, they suggested that implants with a microtreatment in the crestal area of the implant may not have a positive effect on implants located in the anterior maxilla and with relatively recent extractions (36).

In addition to considering the surface of an implant, implant design has been studied, comparing cylindrical implants and conical implants; these studies have concluded that the implants with less highly polished surfaces and cylindrical shapes suffered less MBL per year in a statistically significant way ($p < 0.05$) (37). The extension of the spirals along the implant is another feature that has been studied and that shows a statistically significant difference in crestal bone loss, specifically between implants designed with spirals that run until the coronal part of the implant, which suffered a loss of 0.16 mm (SD 0.19 mm) after one year of functional loading compared to 0.30 mm (SD 0.22 mm) in the implants without spirals reaching the coronal part (38).

Implant platform and connection type to the prosthetic abutment have also been shown to influence MBL. The implant abutment connection being located in the crestal area in straight implants and implants with platform-switching reflects greater marginal bone resorption, and the implants with platform change in infracrestal locations showed a significantly lower bone loss (8). This suggests that platform-switching can facilitate bone conservation at the crestal level (4). The implants with platform-switching and conical connection presented MBL that was significantly lower than implants with a standard platform (5). Some authors highlighted a slightly lower MBL in crestal implants compared with infracrestal implants ($p < 0.01$) (6). However, other authors did not obtain differences in the MBL of infracrestal implants with platform-switching in the maxilla and mandible (7). When analyzing the implant's location with an internal conical connection screwed into an infracrestal and a crestal position and with respect to implants with a conical connection and a Morse-type internal seal in similar positions, no significant differences were observed, although the group with the crestal location and Morse-type connection presented the lowest MBL (8).

The type of connection between dental implant and prosthetic rehabilitation has also been studied; some studies show that after one year of follow-up, there is significant MBL in implants with internal connection and in implants with external connection without a statistically significant difference existing between the type of connections (39). However, the results obtained in other studies highlight a greater MBL in external connection implants (40).

Conclusions

The analyzed articles maintain a common criterion regarding the concept and measurement of the MBL, emphasizing the importance of the radiodiagnosis for its quantification. Few articles focus on the relationship between systemic pathology and MBL. In relation to the characteristics of the implants, the conclusions are more unequal and less homogeneous, highlighting an MBL in all the implants, regardless of the type of prosthetic rehabilitation and moment of loading. MBL is lower when an implant's surface is rough and in implants with platform-switching and infracrestal position. However, greater loss is described in those with external connections. No statistically significant alterations were observed in surgical techniques with a flapneither in one-piece implants nor in the type of crown fixation (screwed versus cemented). Therefore, several factors of different natures can influence MBL, requiring more studies be done to increase our knowledge about how to prevent MBL.

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Conflict of interest

The authors have declared that no conflict of interest exist.