Review

Role of implant loading time in the prevention of marginal bone loss after implant-supported restorations: A targeted review

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Abstract

The implant-supported restoration of missing teeth is a recognized method of treatment that ensures a functional, esthetic and durable effect, along with patient satisfaction. However, the preferable time of dental implant loading is under debate. Currently, 3 protocols are used: immediate loading; early loading; and conventional (late) loading. Immediate loading provides benefits such as short treatment time, the elimination of the second surgery required for later loading protocols, the protection of the gingival papilla, an immediate esthetic effect, and high patient satisfaction. This review aimed to summarize the evidence on the impact of loading time on marginal bone loss (MBL) around dental implants, which is considered a useful measure of implantological treatment effects. A literature search was conducted based on the PubMed/MEDLINE database. The search focused on studies providing the MBL values by protocol. Out of the 1,366 hits received in the initial search, 10 studies were included in the qualitative analysis. At 12 months, the MBL range was 0.17–1.86 mm in patients undergoing the immediate protocol, 0.14–1.22 mm in patients undergoing the early protocol, and 0.44–0.91 mm in patients undergoing the late protocol. The studies were heterogeneous, but no significant differences in the occurrence of MBL were reported between the immediately and early loaded implants as compared with the conventionally loaded ones. Further studies are needed to determine other factors that might be related to the type of protocol, important for optimal patient treatment.

Keywords: dental implants, marginal bone loss, loading protocol, loading time

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Introduction

Dental treatment involving implants is an effective and widely used method of restoring missing teeth, which may result from untreated caries, injuries, tumors, or congenital defects (hypodontia). The reconstruction of missing teeth with the application of implants is a recognized method of treatment. It ensures functional, esthetic and durable restoration, along with patient satisfaction. Over the years, efforts have been made to shorten the duration of implant treatment.

Currently, success in implant therapy is not only based on the implant survival rate and the condition of the tissue in direct implant vicinity, as previously suggested by Albrektsson et al.[1] and Buser et al.,[2] but also on the full esthetic effect and patient satisfaction. The peri-implant soft tissue, i.e., the pink esthetic score (PES), is assessed using 5 parameters: the mesial papilla; the distal papilla; the curvatures of the facial mucosa; the level of the facial mucosa; and root convexity/soft tissue color and texture. To evaluate the white esthetic score (WES) of the visible portion of the implant restoration, 5 parameters are taken into consideration: the tooth form; the outline/volume of the clinical crown; color; surface texture; and translucency. Each of the 5 parameters of PES and WES was graded with a 0-1-2 score, and consequently, the assessment resulted in the lowest score of 0 and the highest score of 10 for each of the 2 indices.[3] High PES and WES scores indicate good condition of soft tissues and esthetic prosthetic reconstruction. In implant-supported prosthetic reconstruction, we can distinguish 3 protocols: immediate loading; early loading; and conventional (late) loading.[4] All 3 protocols are used for different types of restorations – single, multiple and full-arch.

The extent of marginal bone loss (MBL) is the basic indicator of peri-implantitis. Marginal bone loss is measured from the neck of the implant to the first bone-to-implant contact and is determined during a radiological examination. Marginal bone loss has been considered a useful measure to evaluate the effects of treatment with implants. This review aimed to summarize the current evidence on the impact of loading time on MBL around dental implants.

Methods

A literature search was conducted in the PubMed/MEDLINE database with the use of advanced search options. Only publications in English, studies on humans with an observation period of at least 12 months as determined by authors, and studies published between January 2002 and June 2021 were considered. No restrictions in terms of geographical scope were imposed. Only full-text articles were included; abstracts and posters were excluded. The following search terms and their combinations were used: 'implant loading'; 'protocol'; and 'marginal bone loss'. The inclusion criteria are reported according to the PICOS criteria and are presented in Table 1. The search was run on February 17, 2022. The list of titles, abstracts and full texts was reviewed by one reviewer according to the defined inclusion and exclusion criteria to identify and select articles related to the topic of interest. The non-systematic approach was used with regard to the qualitative analysis of the identified publications. The extracted data included the loading protocol, the MBL values and the factors affecting the degree of MBL.

Table 1. Inclusion and exclusion criteria

PICOS model	Inclusion criteria	Exclusion criteria
Population	adult human population	animal models
Intervention	implantological treatment	–
Comparison	controlled or single-arm studies	–
Outcome	MBL evaluated during at least 1 year of follow-up	follow-up below 1 year
Study design	RCT, cohort study, case–control study, prospective and retrospective studies	review, meta-analysis, letter to the editor, editorial, opinion

MBL – marginal bone loss; RCT – randomized clinical trial.

Results

After searching PubMed with the use of the keywords related to implantological treatment and its association with MBL, we received 1,366 hits, of which 10 were included in the qualitative analysis. The flowchart of the study is depicted in Fig. 1.

Overall, 10 studies met the inclusion criteria and reported values for MBL, along with definitions of loading protocols; however, they presented data for different follow-up periods and different patient populations. Overall, at 12 months, the MBL values ranged from 0.17 mm

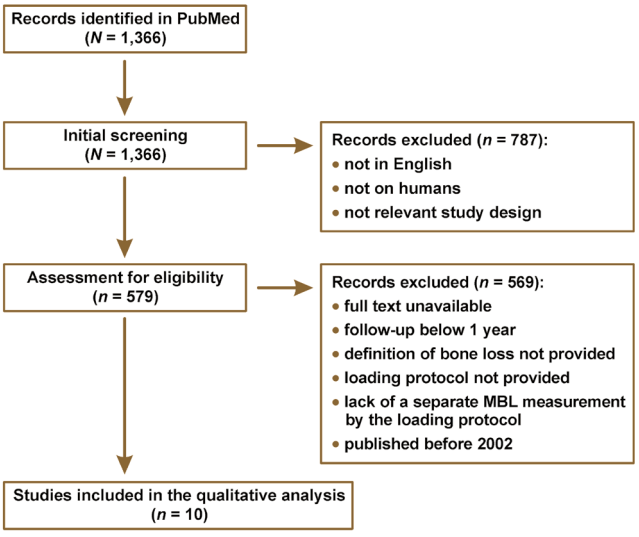

Fig. 1. Flow chart of the study selection process for the systematic review

to 1.86 mm in patients undergoing the immediate protocol, from 0.14 mm to 1.22 mm in patients undergoing the early protocol, and from 0.44 mm to 0.91 mm in patients undergoing the late protocol. The summary of the studies is presented in Table 2.

Discussion

Our review showed that there is still insufficient evidence on the impact of the implant loading protocols on maintaining healthy bone tissue as measured with MBL. Most identified studies concluded that differences in MBL between patients receiving implants according to different loading protocols were not significant. However, a great heterogeneity was observed among studies. They differed in terms of follow-up periods, characteristics of the populations studied, sample sizes, and other factors related to treatment.

Immediate loading

In the literature there is no agreement on the time at which a prosthetic construction is attached to the implant. Ostman defines immediate loading, also called direct loading, as attaching a prosthetic construction to the implant up to 24 h after implantation.[15] Galli et al. considered 48 h as the maximum time of the restoration placement on the implant.[8] According to Esposito et al., immediate loading can be defined as taking place up to 7 days after implantation.[16] There is also disagreement with regard to the occlusal contact of crowns or other prosthetic restoration. Some authors claim that prosthetic restorations loaded immediately can be used without occlusal contacts, while others claim that the term "immediate loading" applies only to prosthetic restorations that are in full occlusion, both in centric and eccentric movements.[17–19] However, there is agreement that the most important criterion for applying the immediate loading protocol is that the implant achieves adequate primary stabilization. This is possible due to a high value of insertion torque, which seems to be crucial in the immediate loading procedure. On the basis of many studies identified in Esposito et al.'s review, this value was determined to be above 35 N·cm.[16]

Primary stabilization is the mechanical anchoring of the implant to bone. It enables the correct process of osseointegration, i.e., the direct functional and

Table 2. Characteristics of the selected studies

Author	Study design	Follow-up period	Type of loading	MBL [mm]
Al Amri et al. 2016[5]	30 healthy people	2 years	immediate	0.46 ±0.16
	30 T2D patients (HbA1c: 6.1–8.0%)			0.58 ±0.15
	31 T2D patients (HbA1c: 8.1–10.0%)			0.59 ±0.20
Bilhan et al. 2010[6]	252 implants in 87 patients	3 years	early (60–90 days)	1.01 ±0.15
			late (91–140 days)	0.90 ±0.18
			late (>140 days)	1.07 ±0.13
Crespi et al. 2007[7]	160 implants in 27 patients	18 months	immediate, distal side, maxilla	0.84 ±0.69
			immediate, distal side, mandible	1.24 ±0.60
Galli et al. 2008[8]	104 implants in 52 patients	14 months	immediate	1.10 ±0.58
			early	1.11 ±0.54
Gjelvold et al. 2021[9]	2 implants	12 months	immediate (smokers)	1.86 ±1.33
	5 implants		late (smokers)	0.91 ±0.66
	22 implants		immediate (non-smokers)	0.37 ±0.55
	18 implants		late (non-smokers)	0.44 ±0.62
Krawiec et al. 2021[10]	40 implants	12 months	early (within 4 weeks)	0.14 ±0.24
Krawiec et al. 2021[11]	40 implants	12 months	early (within 4 weeks)	0.20 ±0.88
Meijer and Raghoebar 2020[12]	15 implants in 15 patients	12 months	immediate	0.17 ±0.73
Pellicer-Chover et al. 2016[13]	10 crestal implants	12 months	early	0.06 ±1.11
	13 subcrestal implants			1.22 ±1.06
Zöllner et al. 2008[14]	383 implants	3 years	total	0.70 ±0.83
			immediate	0.56 ±0.73
			early	0.82 ±0.89

T2D – type 2 diabetes; HbA1c – glycated hemoglobin.

structural connection of bone tissue with the implant surface.[20,21] Proper primary stabilization is a condition of the implant when movements are sufficiently reduced. Micromovements cannot be completely eliminated, but can be reduced by binding implants together (for example in a bridge), and also by removing lateral contacts, thus diminishing lateral forces.[22] Unless primary stabilization is achieved, healing is disturbed by inhibiting osteoblasts. Consequently, connective tissue is formed between the implant and bone (fibrointegration), which results in the loss of the implant. This phenomenon has been studied in animal models.[23]

Over the years, many studies have been carried out on factors that may affect primary stabilization, including the following:

– the appropriate preparation of the implant bed[18];
– the use of appropriate techniques, such as osseodensification drilling[24];
– the appropriate shape and length of the implant[16];
– the appropriate modification of the implant surface[10,25];
– the type of implant and the distribution of load[26,27];
– the condition of bone tissue and its changes during treatment[28];
– demographic factors[9]; and
– the type of crown.[9]

The structure of the implant surface is relatively well examined. As previously shown, the appropriate modification of the implant surface, e.g., chemical modification through the immersion of the implant in a special solution[11] or acid etching[14], may increase the probability of achieving primary stabilization by the implant at a level that allows its immediate loading.

The use of immediate implant loading provides many benefits. First of all, it reduces treatment time, which positively affects patient satisfaction. The quick restoration of missing teeth increases patient comfort and reduces the negative psychological effects caused by tooth loss.[29] Furthermore, the second surgery is avoided to uncover the implant and insert an abutment. With the immediate insertion of a crown, it is more likely to maintain the appropriate tissue contour (especially of the gingival papilla) with a better esthetic result.[30] The risk factors for complications that may occur during immediate loading are significant malocclusion, bruxism, a previous implant loss, and any other general contraindications for conventional implantation.

Early loading

Early loading is defined as the implant-prosthetic restoration carried out up to 2–3 months after implantation; however, the average time is 3–6 weeks. This period is critical due to a decline in primary stabilization and still incomplete secondary stabilization.[15,16,31] Nevertheless, during this time, the primary bone tissue is formed, the mechanical properties of which enable prosthetic reconstruction. Therefore, it seems reasonable to load the implant 3–4 weeks after implantation. Furthermore, implants with a modified surface achieve secondary stabilization faster than conventional implants.[32]

The immediate and early loading of implants have many positive aspects, e.g., fewer surgical interventions, the reduction of soft and hard tissue loss, or the shortening of total treatment time. Those benefits enable basic functions, such as eating, chewing and articulating, to be resumed faster.[33] The use of early or immediate loading is of importance, especially for the esthetic result. This applies to the area between the second right premolar and the second left premolar, which greatly affects the patient's appearance and well-being.

Late loading

The term "late loading" is used when the prosthetic structure is attached late, after the conventional healing period, which lasts at least 3–6 months.[6,31] This is a 3-step procedure. In the 1st stage, the implant site is allowed to fully heal before loading. During this phase, the osseointegration process occurs. After 3–6 months, the 2nd stage takes place, i.e., the exposure of the implant and the insertion of the healing screw (abutment). The 3rd stage involves placing a prosthetic crown.

Late loading is the most common protocol. One of its advantages is a reduced risk of implant loss after loading.[16] It is recommended in situations where primary stabilization was not achieved using a minimal insertion torque above 20 N·cm, in cases with simultaneous extensive augmentation, or when the patient is not convinced of immediate loading and does not accept the associated risks.

Marginal bone loss

Marginal bone loss is a key parameter that is used to assess the proper healing and functioning of implants.[34] This parameter is important, as the gradual loss of bone around the implant may lead to its loss. Researchers report different values of MBL. Despite somewhat varying results, MBL of 2 mm is generally regarded as the maximum acceptable value. During the 1st year after implantation, an acceptable MBL value should be no more than 1.5 mm, with an increase of 0.2 mm per year in subsequent years.[1,35] Currently, however, it is claimed that no marginal bone atrophy is the only evidence of the adequate healing of the implant (the so-called "zero bone loss concept").[36] It is worth considering, especially in young patients, in whom even the 'acceptable' bone loss would amount to 6 mm 20 years after implantation.

Marginal bone loss depends on many factors. One of the most important ones is the thickness of the gingiva around the implants. The critical value is defined as 2 mm; below this value, the risk of atrophy is much higher.[37]

Other factors include:
– poor oral hygiene[5];
– the position of the implant in relation to the anatomy of the bone[13,38];
– the presence of keratinized gingiva[39,40];
– an improperly made prosthetic restoration[41];
– the type of implant[42,43];
– the type of prosthetic restoration[44];
– the type of abutment, and the type of connection between the implant and the abutment[45,46];
– bruxism[47];
– tobacco smoking[9,48];
– a history of periodontal disease[49,50];
– general diseases, e.g., diabetes[5,51]; and
– the experience of the operator and the dental technician.[52,53]

It should be noted that marginal bone atrophy is independent of gender, the degree of primary and secondary stabilization, and the crown-to-implant ratio, while the effect of age is inconclusive.[54–56]

To assess the MBL value, cone-beam computed tomography (CBCT) or radiovisiography (RVG) can be used. In order to correctly determine it, 2 measurements – made on the day of implantation and during the follow-up visit – should be compared. Using the 'As Low As Reasonably Achievable' (ALARA) principle, to minimize the radiation dose, 2 RVG (2–5 microSv) images taken using the right angle technique are sufficient to measure MBL. This ensures the repeatability of the images, and thus the correctness of the measurements.[57]

General considerations

Receiving an answer to the question of whether immediate or early implant loading have important clinical implications as compared to the conventional treatment is important for the physician and the patient, since it enables faster restoration of the functions of the stomatognathic system. Therefore, in recent years, scientists have searched for ways of shortening the time of treatment without affecting its quality. Much research has been conducted to assess the effect of loading time on MBL. A meta-analysis by Esposito et al. showed that there were no significant differences between immediate and conventional loading.[16] In contrast, comparisons between early (6 weeks) and conventional loading as well as between early and immediate loading provide insufficient and inconclusive evidence to determine whether there are any clinically significant differences between the protocols. A meta-analysis by Suarez et al., which included 11 articles, showed that the time of implant loading did not affect MBL.[31] It was also revealed that after achieving osseointegration, there were no differences between the protocols.[31] Similar conclusions can be drawn based on other meta-analyses.[58–61]

The conclusions of the meta-analyses are in line with those of clinical trials, but the latter provide a deeper understanding of other factors that can play a role in the maintenance of proper bone tissue. A prospective controlled clinical trial conducted by De Smet et al. reported that distal implants were more likely to fail in the immediate loading protocol.[62] According to Kawai and Taylor, the immediately loaded implants showed a loss of about 0.6 mm in the first 12 months, and the same or greater value in the 2nd year.[63] Conversely, the implants receiving conventional loading showed almost the same loss as the immediately loaded implants in the 1st year, but resulted in less MBL in the following year.[63] Aires and Berger[64] as well as Crespi et al.[7] claim that the loading of implants immediately after extraction can be carried out successfully. Bilhan et al.[6] and Sommer et al.[29] indicate that late loading increases the risk of MBL. This is due to the lack of occlusal forces in this protocol, which act on the implant and activate proper bone remodeling. However, in some reports, immediate or early implant loading may be associated with slightly greater MBL, and also with a higher overall risk of implant failure.[4,65] Discrepancies in the results may be due to many reasons.[19,65] Possible factors include research bias, a small number of studies available in the literature, small samples sizes, short observation periods, ambiguous definitions of implant loading time, the types of implants and prosthetic reconstruction used, the characteristics of missing teeth (single, multiple, in the mandible, in the maxilla, anterior or lateral), the previously conducted augmentation procedures, whether the reconstruction is made in occlusion or not, etc. Thus, more well-designed and randomized controlled trials (RCTs) in line with the CONSORT (Consolidated Standards of Reporting Trials) guidelines are needed.[16] It is also important that the treating physician understands the healing processes of bone and soft tissue, and performs a thorough examination of the patient's characteristics, which allows selecting the appropriate therapy and avoiding possible complications.

Conclusions

The analysis of the available data leads to the conclusion that there are no statistically significant differences in the occurrence of marginal bone atrophy between the immediately and early loaded implants as compared to the conventionally loaded ones. Nevertheless, immediate and early implant loading are important alternatives for properly selected and compliant patients undergoing treatment according to the guidelines. Further studies are needed to determine other factors, in addition to the type of protocol, to ensure better patient satisfaction .

Ethics approval and consent to participate

Not applicable.

Data availability

All data analyzed during this study is included in this published article.

Consent for publication

Not applicable.

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