ORIGINAL PAPERS

Dent. Med. Probl. 2014, **51**, 4, 439–447
ISSN 1644-387X

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Evaluation of Selected Prognostic Factors in Dental Implant Treatment – Two-Year Follow-Up

Ocena wybranych czynników rokowniczych w leczeniu implantologicznym jamy ustnej w obserwacji dwuletniej

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A – research concept and design; **B** – collection and/or assembly of data; **C** – data analysis and interpretation; **D** – writing the article; **E** – critical revision of the article; **F** – final approval of article

Abstract

Background. Missing teeth is a social problem that affects the vast majority of the human population. The lack of dentition can be rehabilitated in a few ways: by removable prostheses, fixed prostheses (crowns, bridges) or appliances based on dental implants (crowns, bridges, overdentures). The use of implants as a foundation for prosthetic replacement of missing teeth is predictable and has a high success rate. It has become widespread nowadays. Therefore, it is essential to determine the risk factors in dental implantology.
Objectives. The aim of this study was to evaluate the effect of selected prognostic factors for bone loss around the dental implants in a two-year follow-up.
Material and Methods. The survey included 93 implants placed in 31 patients. Marginal bone loss (MBL) was assessed radiographically around implants using intraoral parallel technique with film holder and bite recording material at the moment of loading, after 12 and 24 months of follow-up. In this analysis a computer program Dental Studio® 2.0 was used. Such prediction factors as patient's age, gender, smoking habit, implant length and diameter, latency period, insertion torque, augmentation procedures, type of prosthetic appliance, site of implantation, type of implant system were analyzed.
Results. There was no statistical significance regarding gender, smoking habit, implant diameter and length, latency period, insertion torque, augmentation procedures, implantation site, type of implant system. A correlation was found between MBL and patient's age and type of prosthesis.
Conclusions. The type of prosthodontic restoration is essential for a reduction of marginal bone loss in alveolar crest in the population of patients treated by dental implants. In the first 12 months after loading, the loss of bone around implants is higher in younger patients (**Dent. Med. Probl. 2014, 51, 4, 439–447**).

Key words: dental implants, prediction factors, marginal bone loss, intra-oral radiographs.

Streszczenie

Wprowadzenie. Braki zębowe stanowią obecnie problem społeczny, który dotyka większość populacji ludzkiej. Braki te mogą być uzupełniane z użyciem ruchomych protez zębowych, stałych uzupełnień protetycznych (mosty, korony) lub uzupełnień opartych na wszczepach zębowych (korony, mosty, protezy nakładowe). Zastosowanie implantów zębowych jest bardzo skuteczną i przewidywalną metodą leczenia, stąd też często są one wykorzystywane w praktyce. Z tego powodu kluczowe staje się określenie czynników ryzyka w leczeniu implantologicznym jamy ustnej.
Cel pracy. Ocena wpływu wybranych czynników rokowniczych na zanik kości przy wszczepie zębowym.
Materiał i metody. W pracy analizie poddano 93 implanty wszczepione u 31 pacjentów. Określono zanik poziomu kości przy powierzchni implantu (wskaźnik *marginal bone loss* – MBL) na wewnątrzustnych cyfrowych zdjęciach radiologicznych wykonanych techniką kąta prostego z wykorzystaniem pozycjonerów i indeksów silikonowych. Oceny tej dokonano w momencie obciążenia odbudową protetyczną, 12 i 24 miesiące po obciążeniu. Do analizy zaniku kostnego użyto programu komputerowego Dental Studio® 2.0. W pracy przeanalizowano wpływ na poziom kości przy implancie takich czynników, jak: wiek i płeć pacjenta, palenie tytoniu, długość i średnica implantu, dłu-

gość okresu między wszczepieniem implantu a jego obciążeniem, siła wprowadzenia implantu, procedura augmentacyjna, okolica implantacji, rodzaj odbudowy protetycznej, rodzaj systemu implantologicznego.
Wyniki. Nie wykazano wpływu długości i średnicy implantu, długości okresu między wszczepieniem implantu a jego obciążeniem, siły wprowadzenia implantu, procedury augmentacyjnej, okolicy implantacji, rodzaju systemu implantologicznego na wartość wskaźnika MBL. Wykazano natomiast zależność wartości wskaźnika MBL od takich czynników, jak: wiek pacjenta i rodzaj odbudowy protetycznej.
Wnioski. Dla zmniejszenia zaniku kości przy implancie jest ważny wybór odpowiedniego rodzaju uzupełnienia protetycznego opartego na implantach. W ciągu pierwszych 12 miesięcy po obciążeniu wszczepu zębowego zanik kości przy implancie jest statystycznie większy u pacjentów młodszych (**Dent. Med. Probl. 2014, 51, 4, 439–447**).

Słowa kluczowe: implant, czynniki rokownicze, brzeżny zanik kości, zdjęcie radiologiczne.

Missing teeth is a significant issue of the human population. The most common causes of such deficiency include: destruction of teeth by caries, advanced periodontal disease and injuries. Young people lose their teeth mainly due to caries and injuries, in elderly patients both caries and periodontitis are generally responsible for the loss of teeth. This pathological oral status can be managed by removable dentures, fixed prostheses (crowns, bridges) or prostheses based on dental implants (crowns, bridges, overdentures).

Nowadays, dental implants are used more commonly. Due to the complicated procedure and a number of factors which affect the treatment, it is very important to determine factors that improve or worsen the prognosis. Literature in this field brings ambiguous and often contrary reports. This survey evaluates selected prognostic factors in dental implant treatment in Polish population. Conclusions are useful for general dental practitioners, periodontists and dental surgeons performing implantation procedures.

In the past, many attempts have been made to replace missing teeth with a variety of materials such as gold, wood, animal teeth, porcelain, platinum, ivory. They proved to be ineffective. It was not until the twentieth century, and particularly the research of Branemark in the 1970's and 1980's that gave rise to modern dental implantology. Branemark [1] discovered the phenomenon of osseointegration of titanium implants. This term refers to the structural and functional connection between the living bone tissue and the surface of the implant.

Of the several types of dental implants today endosseous ones are primarily used. They exhibit an acceptable, high success rate reaching 97% [2]. Mostly, implants are made from pure titanium or titanium alloys [grade 4: Ti, grade 5: Ti6Al4V] and, therefore, they exhibit the phenomenon of osseointegration [3, 4].

Implant treatment is highly predictable. However, failures do occur. Frequently the risk of implant loss can be revealed on the basis of a clinical examination (the depth of periodontal pockets, bleeding during probing, purulent exudate), as well as assessing the level of radiological bone contact with the implant and determining the dynamics of its disappearance. Isidor [5] demonstrated the superiority of radiological over clinical assessment. This is an important observation because the loss of bone can be reversed using augmentation methods.

These findings stress the importance of systematic radiological assessment of dental implants. There are different recommendations for the frequency of such assessment. Grøndahl et al. [6] recommend a radiological examination 6–12 months after loading of the implant, and then regularly every 2–3 years, if there are no symptoms of infection [6]. Other authors advocate the need for radiological assessment 12 months after implantation, and then once a year [7]. The best way to evaluate the bone level around the implant is to take an intraoral parallel technique radiograph [8, 9].

The purpose of this study was to evaluate the effect of selected prognostic factors for bone loss around dental implants.

Material and Methods

The study concerned 93 dental implants placed in 31 patients (Males – 12, Females – 19) by a single operator. Included patients were in good overall health with good oral hygiene. The presence of any general disease (i.e. diabetes, osteoporosis), acute inflammation in the implantation site or periodontal disease was an excluding criterion. Prior to implantation, the patients underwent the following tests: densitometry, complete blood test, TSH, parathyroid hormone and calcium serum level, urinary calcium excretion. Only those patients, whose tests were in the reference ranges, were included in the study.

Following dental implant systems were analyzed:

– AlphaBio DFI® implants [code DFI]; the number of implants: 17,

– AlphaBio SPI® implants [code SPI]; the number of implants: 48,

– AlphaBio SFB® implants [code SFB]; the number of implants: 10,

– MIS 7® implants [code MIS7]; the number of implants: 18.

Implants' diameter varied from 3.3 to 4.2 mm, whereas the length was from 8 to 16 mm, the most commonly used implant was 3.75 × 16 mm. Thirty eight implants were placed in the mandible, fifty five in the maxilla. All the analyzed implants were 2-stage. Implants were put into their drilled bony sites with hand torque-measuring ratchet. The maximum torque was recorded. After that, the closing screws were put and the surgical wound sutured with 5-0 non-absorbable monofilament. Apart from one case, where there was an immediate loading, all other cases underwent a close healing. The latency period varied from 0 (immediate loading) to 17 months. After that period implants were loaded with prosthetic appliances (single crowns, bridges or overdentures). In the case of overdentures, the ball anchor screws were screwed to implants. Bridges and crowns were cemented to the abutments. No excessive cementum in the vicinity of implant was seen either clinically or radiographically.

Augmentation procedures were performed in 34 implants. Those procedures were divided into three categories:

1) Sinus lift (20 implants) – carried out either:

a) 10 to 12 months before implantation (7 implants – if there was not enough bone for primal stability of implant) or

b) at the same time as implantation (13 implants – if there was enough bone to achieve primal stability of implant).

The mixture of tricalcium phosphate and hydroxylapatite were used in sinus lifts.

2) autogenous bone blocks grafts harvested from mandibular ramus 5 months before implantation (6 implants),

3) socket augmentation (8 implants) – by the same bone substitute materials as in sinus lift procedure. Full thickness flap was utilized for water-tight closure.

The analysis concerned digital intraoral radiographs (Optima Digora System®) of endosseous implants in three moments: at the time of loading, 12 months and 24 months after functional loading. Radiographs were performed in standardized way – using a parallel technique with positioners. To ensure identical conditions in all 3 periods, the same silicone bite index was used each time. This provided the same orientation of the digital sensor in relation to the implant and the X-ray camera tube, and thus identical projection [10]. All the radiographs were taken using the same equipment set on identical exposure parameters: 7 mA, 0.1 s, 70 mV.

Marginal bone loss (MBL) at the proximal and distal implant surfaces was analyzed. The value of this index was determined in the image points [later converted to millimeters, 19 pixels = 2 mm] as the difference between the level of the bone at the time of implant loading and after a certain period of time. In this study the periods of 12 and 24 months were taken into account (Fig. 1).

This analysis was made by one person on the same monitor. For this purpose, the Dental Studio® 2.0 program was used [11]. Firstly, the radiographs taken at the time of the loading was rotated, so that the implants adopted the vertical position. Then the radiographs taken in periods of 12 and 24 months after loading was geometrically aligned with the X-ray taken at the moment of loading (with vertical position of implant). After the alignment the exact match of implants was obtained [dental implants treated as geometric indicators – areas of reference]. Subsequently, most occlusal bone levels in contact with the surface of the implant on the mesial and distal surface were marked. Then, the difference between the level of bone on the X-rays taken at the time of loading and after 12 months and the difference between the level of bone on the X-rays taken at the time of loading and after 24 months were determined separately for each surface. The difference was calculated in pixels, and then the value counted to millimeters [12].

The following prognostic factors were taken into account: the patient's age, gender, smoking habit, implant length and diameter, latency period, insertion torque, augmentation procedures, type of prosthetic appliance, site of implantation, type of implant system.

The following statistical methods were used: descriptive statistics, parametric and non-parametric tests that compare the average value (Student's *t*-test, Mann-Witney-Wilcoxon W test), analysis of variance (ANOVA) for check the influence of clinical factors to MBL, and analysis of linear regression to found relation between param-

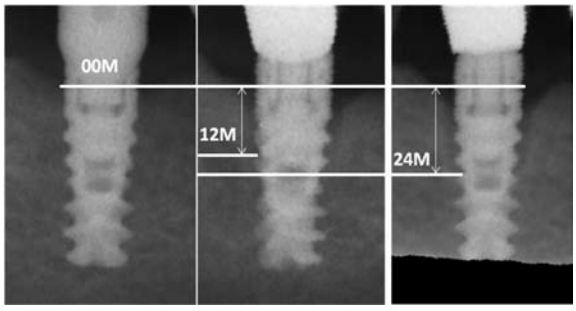

Fig. 1. The bone level registration on the mesial implant surface at the time of 12 and 24 months after functional loading

Ryc. 1. Ocena poziomu kości na powierzchni bliższej implantu w momencie jego obciążenia oraz 12 i 24 miesiące później

eters. Statistical analysis was performed in Statgraphics Centurion XVI, and significance level was established for $p < 0.05$.

Results

Summary statistics concerning marginal bone loss, the patient's age, implant diameter and length, insertion torque and latency period are shown in Table 1.

The mean MBL after 12 months on mesial implant surface was 1.6 ± 1.6 mm, whereas on distal surface 1.4 ± 1.3 mm. After 24 months, MBL on the mesial side was 2.1 ± 1.9 mm and on distal was 2.0 ± 1.8 mm. There was no statistical difference between these two surfaces ($p > 0.05$) (Fig. 2).

Marginal bone loss was higher in younger patients compared to the older ones on the distal implant surface within the first 12 months after loading with prosthesis ($p < 0.05$) (Fig. 3). In other periods and on other surfaces the tendency is same, but there is no significance.

The study showed with statistical significance that the lowest MBL was achieved in case of single crowns compared to bridges ($p < 0.05$) (Fig. 4). This relation concerns mesial implant surface in the first 12 months after loading. However, on distal surface and after 24 months the average MBL values were similarly lower for single crowns, but there was no statistical significance. There was no difference in MBL between the crown and overdenture, as well as the bridge and overdenture in both periods.

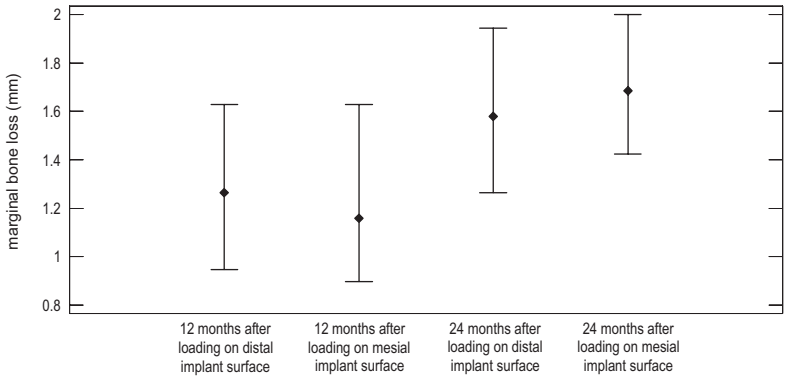

Fig. 2. Marginal bone loss on mesial and distal implant surface 12 and 24 months after loading

Ryc. 2. Utrata kości na powierzchni bliższej i dalszej implantu 12 i 24 miesiące po obciążeniu

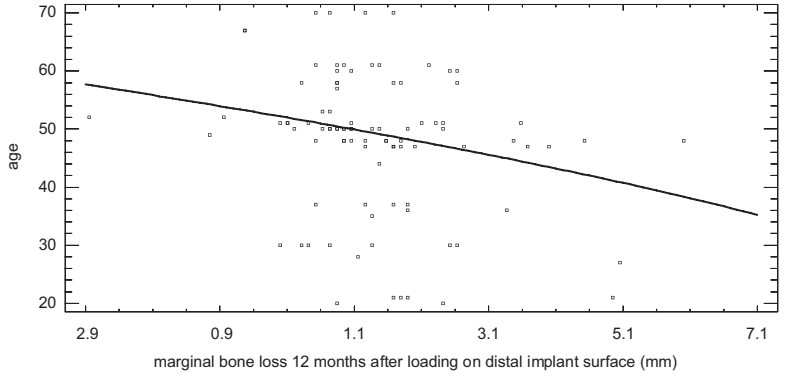

Fig. 3. Linear regression between the patient's age and marginal bone loss on distal implant surface 12, ($p = 0.0158$)

Ryc. 3. Utrata kości na powierzchni dalszej implantu 12 miesięcy po obciążeniu w odniesieniu do wieku pacjentów

Table 1. Summary statistics concerning marginal bone loss, patient's age, implant diameter and length, insertion torque and latency period

Tabela 1. Zbiorcze dane dotyczące utraty kości, wieku pacjentów, średnicy i długości implantu, siły wprowadzania implantu, okresu utajenia

	Age (year)	Diameter (mm)	Length (mm)	Torque (Ncm)	Latency (month)	MBL12M_ mesial (mm)	MBL12M_ distal (mm)	MBL24M_ mesial (mm)	MBL24M_ distal (mm)
Average	47.69	3.81	13.78	48.59	7.22	1.59	1.44	2.12	2.00
Standard deviation	12.20	0.18	2.35	12.05	3.67	1.64	1.31	1.90	1.78

MBL12M_mesial (mm) – marginal bone loss on mesial implant surface 12 months after loading.
MBL12M_distial (mm) – marginal bone loss on distal implant surface 12 months after loading.
MBL24M_mesial (mm) – marginal bone loss on mesial implant surface 24 months after loading.
MBL24M_distal (mm) – marginal bone loss on distal implant surface 24 months after loading.

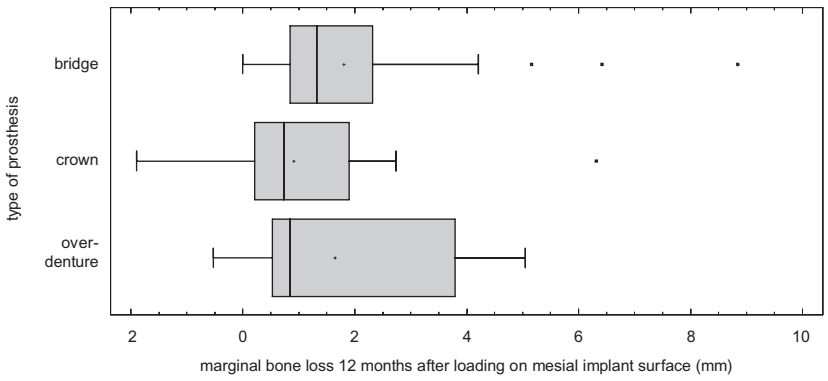

Fig. 4. Marginal bone loss on mesial implant surface 12 months after loading in relation to prosthetic restoration, (p = 0.093)

Ryc. 4. Utrata kości na powierzchni bliższej implantu 12 miesięcy po obciążeniu w odniesieniu do rodzaju uzupełnienia protetycznego

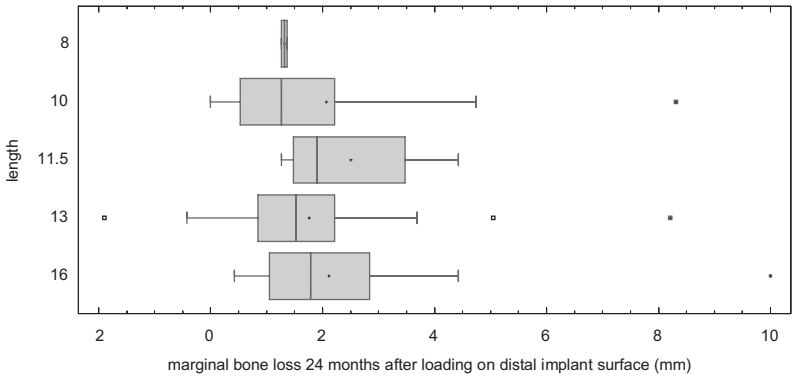

Fig. 5. Marginal bone loss on distal implant surface 24 months after loading in relation to implant length, (p = 0.8409)

Ryc. 5. Utrata kości na powierzchni dalszej implantu 24 miesiące po obciążeniu w odniesieniu do długości implantu

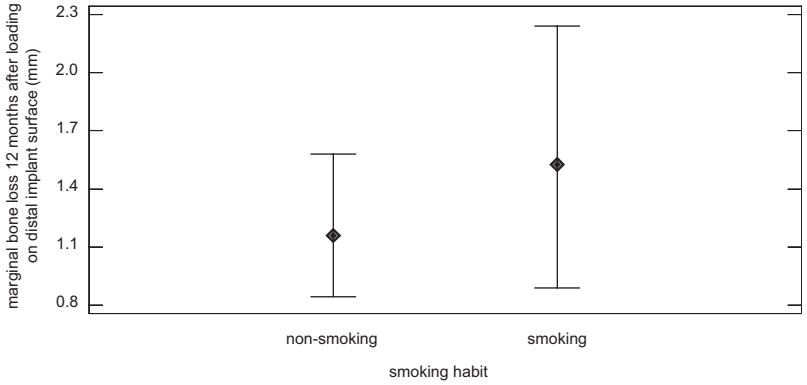

Fig. 6. Marginal bone loss on distal implant surface 12 months after loading in relation to smoking habit, (p = 0.0731)

Ryc. 6. Utrata kości na powierzchni dalszej implantu 12 miesięcy po obciążeniu w odniesieniu do nikotynizmu

The study showed that the length of the implant and its diameter do not have any significant effect on bone loss around implant both 12 and 24 months after loading with prosthetic appliance($p > 0.05$) (Fig. 5).

Despite the fact that the MBL values were higher in smoking patients, there was no statistical significance ($p > 0.05$) (Fig. 6).

There was no relation between MBL and the following factors: latency period, insertion torque and augmentation procedures. In case of augmentation procedures, we did not find any statistical difference between the implants put in intact bone and reconstructed bone. The difference was also absent between groups of implants placed: in intact bone, after sinus lift, with socket augmentation and after onlay bone grafts, despite the fact that the average MBL value was lowest in socket augmentation ($p > 0.05$) (Fig. 7).

No difference was found regarding the type of augmentation material (autogenous bone, bone substitute, intact bone).

The study showed no statistically significant difference regarding MBL and the implantation site (mandible or maxilla and anterior or lateral part of the jaw) both 12 and 24 months after loading.

The analysis of MBL and type of implant system revealed no significant difference between these systems in all periods, despite the fact that the average MBL values were the lowest in MIS7 implants ($p > 0.05$) (Fig. 8).

Discussion

We found that MBL was statistically higher in younger patients compared to the older ones in the first 12 months after loading with a prosthetic ap-

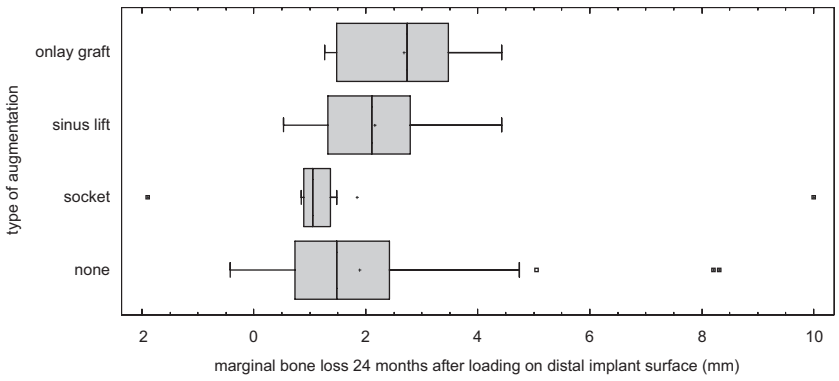

Fig. 7. Marginal bone loss on distal implant surface 24 months after loading in relation to augmentation procedure, (p = 0.5572)

Ryc. 7. Utrata kości na powierzchni dalszej implantu 24 miesiące po obciążeniu w odniesieniu do techniki zabiegu augmentacyjnego

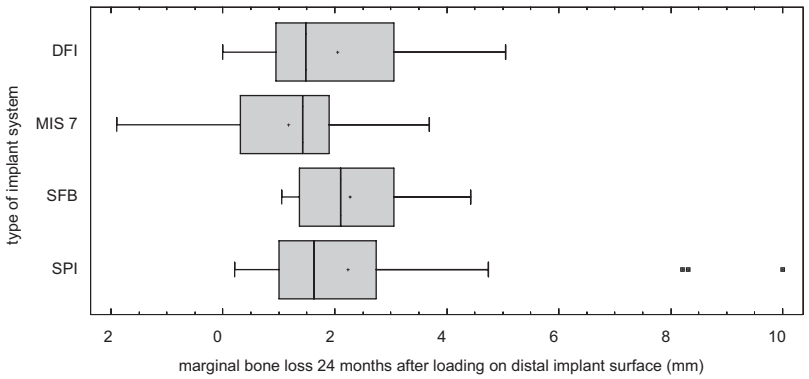

Fig. 8. Marginal bone loss on distal implant surface 24 months after loading in relation to implant design, (p = 0.1725)

Ryc. 8. Utrata kości na powierzchni dalszej implantu 24 miesiące po obciążeniu w odniesieniu do rodzaju systemu implantologicznego

pliance. This indicates more dynamic changes in the bone of younger patients in the first period. Several authors found that there was no correlation between patient's age and MBL [13–17]. Others showed that in elderly patients, bone resorption was more severe; therefore, the was MBL higher [18, 19].

The highest MB values were found within the first 12 months after loading, which is consistent to the other author's observation [20–22].

We did not find any relation between gender and MBL. The same observation was made by Bilhan et al. [23], who analyzed MBL around implants loaded with overdentures. However, Mumcu et al. [18] showed that MBL is higher in women than in men – the study was conducted on a group of 36 patients who received 126 dental implants. All those implants were loaded with permanent dentures. The follow-up was in 36 months [18].

Most authors indicate that smoking worsens the prognosis for implant treatment. Bain and Moy [24] proved a higher incidence of complications in smokers compared to that of non-smokers. Baelum and Ellegard [25] showed that implants were 2.6 times more often explanted due to complications in smokers than in non-smokers. This study was carried out in a group of patients with periodontal disease. Nitzan et al. [26] stated compromising influence of nicotine on bone level around implant, which was more pronounced in the maxilla than in the mandible. Similar conclusions were reached by other authors [27, 28]. There are only a few studies that show the lack of influence of smoking on implant treatment [29, 30]. In our study MBL was higher in smokers compared to non-smokers, but we did not find statistical significance.

Our study showed that the length of the implant does not have any significant effect on bone loss around the implant, both 12 and 24 months after loading with prosthetic appliance. The observed phenomenon is consistent with the findings of other authors [14, 18, 31]. It can be concluded that in the case of the vertical lack of bone in implantation site either augmentation procedure or short implant placement can be performed with the same good outcome.

We did not observe any difference in MBL regarding implant diameter. Mumcu et al. [18] showed similar values of bone loss for narrow and wide implants. The lack of correlation between implant diameter and MBL was also observed by other authors [14, 31]. These findings proved that narrow implants are reliable and should be used in narrow crests and space limitations.

In our study, there was no correlation between MBL and the following factors: latency period, insertion torque and augmentation procedures.

Suarez et al. [32] carried out a meta-analysis searching for the correlation between protocol of loading and MBL. Their review of studies until November 2011 showed that there was no difference in MBL regarding latency period. Therefore, if the primary stability is achieved, immediate loading can be performed.

Several authors proved that there was no dependency between MBL and insertion torque [14, 33], others did not find any correlation between MBL and augmentation procedures, as well as in this study [31, 34]. Moreover, we did not find any difference regarding the type of augmentation procedure (sinus lift, onlay bone graft, autogenous bone or bone substitute alveolar augmentation).

It can be concluded that bone obtained through augmentation procedure has the same slow pattern of resorption as native bone around the implant. Therefore, the outcome of treatment with bone regeneration is predictable and suitable in alveolar process atrophy.

The paper indicated no statistically significant difference regarding MBL and the implantation site (mandible or maxilla and anterior or lateral part of the jaw) both 12 and 24 months after loading. The observed phenomenon is consistent with the findings of other authors [14, 31]. On the contrary, Penarrocha et al. [9] claimed more bone loss around implants placed in maxilla compared to mandibular ones. Pikner and Gröndahl [35] in the survey of 3.462 Brånemark implants found that implants fixed in maxilla and close to midline of mandible were associated with statistically higher MBL.

The analysis of MBL and the type of implant system did not reveal any statistical difference (Fig. 8). It seems that regardless of the type of implant system, a good outcome can be achieved. There are a few studies which compare several systems. Ozkan et al. [36] showed that there was no statistical difference between Straumann implants, Swiss Plus implants, Camlog implants and Frialit implants 5 years after loading. Implants were placed in the posterior maxilla and mandible in partially edentulous patients. In another study by Ozkan et al. [37] no difference in MBL after 3 years was proven between ITI, Frialit and Camlog implants, implants were placed in the posterior maxilla and mandible in partially edentulous patients as well. Astrand et al. [20] compared AstraTech and Brånemark implants. Sixty-six patients with edentulous jaws were included in the study. All patients were provided with full-arch fixed bridges. After a 5-year follow-up, there was no statistical difference between those two implant systems [20].

The study showed with statistical significance that the lowest MBL was achieved in the case of single crowns compared to bridges ($p < 0.05$) in the first 12 months after loading, there was no difference in the following 12 months. There was no difference in MBL between the crown and overdenture as well as the bridge and overdenture in both periods. The survey of Pikner et al. [35] was concordant to our study – authors claimed that the placement of the implant within the prosthetic construction is associated with greater MBL up to 15 years. The lowest MBL around implants loaded with single crowns is probably due to good access for hygienic procedures and the absence of microtensions caused by compound prosthetic metal suprastructures. Good hygiene results in eliminating plaque, which helps to avoid peri-implantitis.

Currently, literature brings contrary reports about factors that improve or worsen the prognosis of implant treatment. The results of this study indicate a complexity of bone level changes around dental implants. The relation between MBL and the patient's age, as well as prosthetic appliance was statistically proved in this study. No statistical significance regarding gender, smoking habit, implant diameter and length, latency period, insertion torque, augmentation procedures, implantation site, type of implant system was found.

Concluding, the type of prosthodontic restoration is essential for the reduction of marginal bone loss in the alveolar crest in a population of patients treated with dental implants. In the first 12 months after loading, the loss of bone around implants is higher in younger patients.

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Conflict of interest: None declared

Received: 3.06.2014
Revised: 23.07.2014
Accepted: 7.08.2014

Praca wpłynęła do Redakcji: 3.06.2014 r.
Po recenzji: 20.07.2014 r.
Zaakceptowano do druku: 7.08.2014 r.