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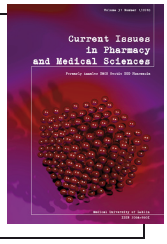


# The relationship between marginal bone loss around dental implants and the specific characteristics of implant-prosthetic treatment

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**ABSTRACT**

The marginal bone loss around dental implants is an important indicator that helps to evaluate the course and the final outcome of implant-prosthetic treatment. It is, therefore, important to understand the factors that may affect this. The aim of the study was to assess the impact of the specific characteristics of implant-prosthetic treatment on the marginal bone loss around implants. The study included 28 patients, aged 37-66 years, treated with dental implants. Every patient received at least one of the two types of implants: with Morse taper connection and with internal hexagonal connection. The average marginal bone loss around the implants was evaluated on the basis of the panoramic radiographs. The maximum follow-up period after implantation was 46 months. The peri-implant marginal bone loss was evaluated taking into consideration the implant localisation, the procedure of sinus lift with bone augmentation, implant type, implant diameter, vertical implant position relative to the compact bone level and the type of prosthetic restoration, the time between implantation and loading with prosthetic restoration, as well as the time between loading and the measurement of marginal bone loss. The correlation between bone loss and the selected characteristics of the treatment was assessed using generalised estimating equations (GEE). An objective analysis was enabled via the applied research model: evaluation of an impact of the specific implant-prosthetic treatment characteristics on peri-implant marginal bone loss in patients treated with implants with different implant-abutment interface systems. The results of the study showed that peri-implant marginal bone loss **increased** significantly with implant localisation in canine sites (compared to the localization in premolar sites), as well as with prosthetic restorations in the form of dentures (compared to bridges), and **decreased** when implants were placed below the compact bone level (compared to those placed at the bone level). At the same time, marginal bone loss was not significantly related to implant diameter or to the sinus lift procedure. The results obtained seem extremely useful in everyday clinical practice.

## INTRODUCTION

The criteria of therapeutic success in dental implant treatment of missing teeth include implant immobility, absence of pain and peri-implant bone loss below 1.5 mm (observed on radiographs), as well as healthy (showing no symptoms of inflammation and bleeding) soft tissues around implants. Important confirmation of implant-prosthetic treatment success is provided by functional, durable implant-supported prosthetic restorations. Implant-supported prostheses should survive as long as possible, in particular, no problems should occur within the first five years of usage [1]. Earlier studies show that peri-implant marginal bone loss increases with patients’ age, but is unrelated to gender and cigarette smoking habit [2].

## AIM

The aim of the study was to assess the impact of the specific characteristics of implant-prosthetic treatment on marginal bone loss around implants.

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## MATERIAL AND METHODS

The study involved 28 patients (11 men and 17 women) treated with dental implants, aged 37-66 years (mean age: 55.8). The maximum follow-up time after implantation was 46 months. The patients were treated at the Non-Public Health Centre Dent-Plast in Białystok.

A detailed description of the studied implant systems, implant treatment, surgical techniques, prosthetic restorations, techniques of peri-implant bone loss measurement and limitations of the research model has been included in the authors' earlier publication [3].

## RESULTS

### The characteristic of implant-prosthetic treatment

A total of 240 implants of Type I (with Morse taper) and Type II (with internal hexagonal connection) were surgically placed in 28 patients; every patient received at least one implant of each type. The maximum follow-up time was 46 months. The moment of loading with prosthetic restoration was between 5.0 and 26.5 months of the follow-up observation (mean – 10.6 months, median – 9.3 months). Type I implants were loaded, on average, 10.2 months after implantation (between 5.0 and 26.5 months), and Type II implants – after 10.8 months (between 5.0 and 22.1 months). In the case of two implants osseointegration did not occur and they were removed during uncovering. Those implants were not included in statistical analyses. The removed implants were: DENTSPLY Friadent ANKYLOS® with conical interface (Type I) and Alpha-Bio DFI® with hexagonal connection (Type II) [4]. Ultimately, implants of both types were placed in 26 patients. Before prosthetic loading, 14 patients had their marginal bone around implants evaluated; after loading, the evaluation was performed in 23 patients.

The changes in marginal bone related to time and implant type were described in an earlier paper [3].

### The relationship between peri-implant marginal bone loss and the specific characteristics of implant-prosthetic treatment

During a 46-month follow-up, multivariate generalised linear models were used to evaluate the relationship between the changes in peri-implant marginal bone and the factors related to the implant-prosthetic treatment specific characteristics (independent variables). The applied model allows taking into consideration repeated measurements of the same implant and the fact that a given patient had several implants inserted. The parameters of the models were estimated with generalised estimating equations (GEE) [5,6]. The correlation of the marginal bone loss with several independent variables is presented in Table 1. The independent variables included: implant localisation (incisors, canines and molars were compared to premolars as the reference category); sinus lift (implants placed without sinus lift were the reference category); prosthetic restoration loaded on implants (dentures and single crowns were compared to bridges as the reference category); implant type (Type I – DENTSPLY Friadent ANKYLOS® implants with conical connection – were the reference category); implant diameter (increase by 1 mm); implant vertical position (the reference was an implant placed at the marginal bone level; implants placed below and above that level were compared to it); time between implant placement and loading (time increase by 1 month); time between implant loading and the measurement of marginal bone loss (time increase by 1 month). The statistical hypotheses were verified for significance level $\alpha = 0.05$. The calculations were performed using the SPSS® Statistics 20.0 software by IBM®.

In the procedure of stepwise elimination of statistically insignificant independent variables in the initial model (Table 1), Wald statistics was used as the criterion. Accordingly, the variables: sinus lift and implant diameter, were eliminated. The final model, containing only the

***Table 1.*** The correlation of peri-implant marginal bone loss with the characteristics of implant-prosthetic treatment within a 46-month follow-up in the initial model

| Independent variable | | B | 95% confidence interval | | p value |
|---|---|---|---|---|---|
| | | | lower limit | upper limit | |
| Implant localisation | Tooth – incisors/**premolars** | 0.291 | -0.001 | 0.582 | 0.051 |
| | Tooth – canines/**premolars** | 0.333 | -0.003 | 0.668 | 0.052 |
| | Tooth – molars/**premolars** | 0.244 | -0.128 | 0.615 | 0.198 |
| Sinus lift with bone augmentation – yes/**no** | | 0.155 | -0.130 | 0.441 | 0.286 |
| Implant type – type II/**type I** | | 0.453 | 0.209 | 0.698 | 0.0001 |
| Implant diameter – increase by 1 mm | | -0.152 | -0.438 | 0.135 | 0.299 |
| Implant vertical position | implant placed above the compact bone/**implant placed at the compact bone level** | -0.108 | -0.342 | 0.125 | 0.363 |
| | implant placed below the compact bone/**implant placed at the compact bone level** | -0.465 | -0.827 | -0.103 | 0.012 |
| Prosthetic restoration | denture/**bridge** | 1.525 | 0.662 | 2.389 | 0.001 |
| | crown/**bridge** | 0.077 | -0.325 | 0.480 | 0.707 |
| Time from implant placement to loading with prosthetic restoration – increased by 1 month | | 0.063 | 0.029 | 0.097 | 0.0001 |
| Time from implant loading with prosthetic restoration to marginal bone loss measurement – increased by 1 month | | 0.026 | 0.018 | 0.034 | 0.0001 |

B – regression model coefficient (marginal bone loss in mm)
p – significance level < 0.05
(The reference categories for independent variables are printed in **bold**)

***Table 2.*** The correlation of peri-implant marginal bone loss with the characteristics of implant-prosthetic treatment within a 46-month follow-up in the final model

| Independent variable | | B | 95% confidence interval | | p value |
|---|---|---|---|---|---|
| | | | lower limit | upper limit | |
| Implant localisation | Tooth – incisors/**premolars** | 0.296 | 0.016 | 0.577 | 0.038 |
| | Tooth – canines/**premolars** | 0.364 | 0.050 | 0.677 | 0.023 |
| | Tooth – molars/**premolars** | 0.243 | -0.118 | 0.605 | 0.187 |
| Implant type – type II/**type I** | | 0.492 | 0.243 | 0.742 | 0.0001 |
| Implant vertical position | implant placed above the compact bone/**implant placed at the compact bone level** | -0.118 | -0.359 | 0.123 | 0.339 |
| | implant placed below the compact bone/**implant placed at the compact bone level** | -0.536 | -0.902 | -0.169 | 0.004 |
| Prosthetic restoration | denture/**bridge** | 1.404 | 0.561 | 2.247 | 0.001 |
| | crown/**bridge** | 0.061 | -0.329 | 0.451 | 0.759 |
| Time from implant placement to loading with prosthetic restoration – increased by 1 month | | 0.078 | 0.040 | 0.117 | 0.0001 |
| Time from implant loading with prosthetic restoration to marginal bone loss measurement – increased by 1 month | | 0.026 | 0.018 | 0.034 | 0.0001 |

B – regression model coefficient (marginal bone loss in mm)
p – significance level < 0.05
(The reference categories for independent variables are printed in **bold**)

variables related to peri-implant bones loss in a statistically significant way, is presented in Table 2.

In comparison to premolars (the reference category for implant localisation), marginal bone loss around implants placed in the site of the incisors was statistically significantly greater by 0.296 mm ($p = 0.038$), and around those placed in the site of canines – by 0.364 mm ($p = 0.023$). There were no statistically significant differences in marginal bone loss between implants placed in the sites of molars and premolars ($p = 0.187$).

Peri-implant marginal bone loss was significantly related to the implant type according to the connection structure. The mean bone loss around Type II implants was significantly greater by 0.492 mm, compared to Type I implants ($p < 0.0001$).

In comparison to implants placed at the level of compact bone, marginal bone loss around implants placed below that level was smaller by 0.536 mm ($p = 0.004$). In the regression model, no statistically significant differences occurred in the degree of marginal bone loss around implants placed above the compact bone level, in comparison to the implants placed at that level ($p = 0.339$).

Marginal bone loss was significantly greater by 1.404 mm in the case of implants loaded with a denture compared to the implants loaded with a bridge ($p = 0.001$). No statistically significant differences in marginal bone loss between the implants loaded with a crown and those loaded with a bridge were found ($p = 0.759$).

Marginal bone loss showed a statistically significant correlation with the time between implantation and implant loading with the prosthetic restoration. The marginal bone loss in this period increased, on average, by 0.078 mm every month ($p = 0.0001$). Also, in the period after implant loading with the prosthetic restoration, marginal bone loss showed a statistically significant increase of, on average, 0.026 mm a month.

## DISCUSSION

The full success of implant-prosthetic treatment is guaranteed by the application of the principles of long-term stability of the bone and healthy soft tissues. The choice of the implant system should be based on the consideration of the following factors: absence of micro-movements, tight implant-abutment connection – bacteria do not migrate into implants), platform-switching (the diameter of an implant is smaller than that of an abutment at the implant-abutment interface), optional placement of an implant below the bone level, micropore surface of an implant and implant neck [7].

There is no agreement as to the effect of implant localisation on peri-implant bone loss. Rasouli Ghahroudi *et al*. did not find any difference between implants placed in the anterior and posterior regions of the maxilla and mandible, nor between implants placed in the maxilla and mandible [8]. However, Chou *et al*. detected a greater marginal bone loss around implants placed in the anterior regions of the maxilla and mandible, compared to the posterior regions [9]. It is suggested that the least favourable localisation for implant treatment is the molar region [10], while implants placed in the site of premolars are the least exposed to failure, both as regards peri-implant marginal bone loss and implant survival [11].

Other studies of the entire osseointegration process found that implants with hexagonal connections (Type II in our research) are less favourable than implants with conical connection (Type I in our research) [12]. It was also discovered that the differences in marginal bone loss were additionally caused by different implant surface structure at the neck. Such differences were statistically significant [13]. Marginal bone loss may be smaller where there are no conditions conducive to bacterial colonisation of implant-abutment connection, as it is the case of implants with taper connection, there being no microgap that creates conditions favourable to bacteria multiplication [14]. A more detailed analysis of the changes in marginal bone loss around implants used in our study is contained in the topical literature review published earlier [15].

Yi *et al*. [16] found that dental implant placement below the level of compact bone, regardless of the implant type, was the least favourable because such a localisation was correlated with the greatest peri-implant bone loss. Our study results concerning the correlation between the position of an implant relative to the compact bone level and peri-implant bone loss, regardless of other circumstances, are different than the outcomes cited above.

A significant influence on the osseointergation process is exerted by the implant healing method – open or closed, regardless of the position of an implant relative to the compact bone level. Weng *et al*. [14], in their experimental research on dogs, did not discover differences in marginal bone loss around two types of implants regardless of whether they were placed at the compact bone level or below it. Despite the fact that one of the studied implant types (Nobel Biocare Brånemark System TiUnite®) had a microgap, in the conditions of closed healing, the circumstances conducive to microgap bacterial colonisation and adverse to osseointegration did not occur. In a different study, Weng *et al*. [17], using an open method of healing in dogs with two types of implants, showed that marginal bone loss was significantly greater around Nobel Biocare Brånemark System TiUnite® implants than in the case of DENTSPLY Friadent ANKYLOS® implants; the loss was the greatest for the first type of implants placed below the compact bone level. This was related to the conditions adverse to osseointegration created by the open healing method, as well as by bacterial colonisation of the implant-abutment connection microgap in Nobel Biocare Brånemark System TiUnite implants. It must be noted that in our study, closed healing of implants was applied, and stitches were removed about 2 weeks after implantation.

The results of our assessment of the effect of implant-supported restorations on peri-implant marginal bone loss indicate that dentures are less favourable to succeed than bridges; at the same time, no differences in bone loss were found around implants loaded with crowns and bridges. Similarly, Tandlich *et al*. [18,19] showed that bone loss around implants loaded with removable restorations was greater ($p < 0.05$) than that around implants supporting fixed restorations [18], and the risk of marginal bone loss around implants with removable restorations increase 2.5

times (OR = 2.57) in comparison to implants with fixed prostheses [19].

Chou *et al*. [9], however, found that the amount and speed of marginal bone loss around implants did not depend on the applied prosthetic restoration. They also did not detect significant differences between removable and fixed prostheses. What is more, Bryant and Zarb [20] did not discover statistically significant differences in bone loss around implants loaded with different types of prosthetic restorations in two age groups. Similarly, Rasouli Ghahroudi *et al*. [8], when evaluating Nobel Biocare Replace Select Tapered® implants (with a traditional hexagonal implant-abutment interface) after a year of functional loading, did not find a correlation between bone loss and the number of bridge splints (the mean number of splints was 3.79, in 1-11 interval).

## CONCLUSIONS

1. During 46-month follow-up observation of the patients with at least one implant of the two types differing in implant-abutment interface, it was found that peri-implant bone loss **increased** significantly for implants inserted in the site of canines (compared to implants in the premolar region), and in prosthetic restorations in the form of dentures (compared to bridges), while it **decreased** if implants were placed below the compact bone level (compared to implants at the bone level). At the same time, marginal bone loss was not significantly related to implant diameter and sinus lift.
2. An objective analysis was enabled via the applied research model: evaluation of an impact of the specific implant- prosthetic treatment characteristics on peri-implant marginal bone loss in patients treated with implants with different implant-abutment interface systems. The results obtained seem extremely useful in everyday clinical practice.

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