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A rough surface implant neck with microthreads reduces the amount of marginal bone loss: a prospective clinical study

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Abstract

Objectives: An intra-individual controlled clinical trial was conducted to evaluate and compare the amount of marginal bone loss (MBL) found around implants of a comparable design, with or without retention grooves (microthreads) or polished necks, during the early stages of healing.

Materials and methods: Forty-eight (48) patients with missing mandibular posterior teeth were treated with two commercially available implants of the same brand (MIS): one with microthreads (S-model) and the other with a polished neck (L-model). MBL around each implant was measured on follow-up radiograms taken 4 months after placement (exposure and crown cementation), and 6 and 12 months after loading.

Results: Forty-six (46) patients completed the study, making 46 implant pairs available for statistical analysis. None of the implants failed to integrate. All the implants displayed some extent of bone loss throughout the follow-up period. At each time point (exposure, 6 and 12 months after loading), the S-model implants displayed statistically significant lower amounts of bone loss (0.22 vs. 0.76, 0.57 vs. 1.22 and 0.9 vs. 1.5 mm, respectively). Other than the type of the implant, no correlation was found between MBL and the implant stability values (PerioTest), dimensions, site of insertion or any of the other collected variables.

Conclusions: Implants with a roughened neck surface and microthreads are more resistant to MBL during the first phases of healing, as compared with implants with a polished neck.

It is accepted that all implants will display some extent of bone loss after integration and through time of function (Albrektsson et al. 1986). This bone loss can be divided into two different phases (Manz 2000; Spray et al. 2000). One, which is related to the time of implant exposure or prosthetic appliance connection (Oh et al. 2002), can be regarded as 'early bone loss'. The second is bone loss that emerges through the time of implant function (Esposito et al. 1998a, 1998b; Kronstrom et al. 2001), and can be termed 'late bone loss'. The latter is believed to be related to an infectious process (Roos-Jansaker et al. 2006), i.e., periimplantitis.

Different processes are believed to influence the extent of the early marginal bone loss (MBL) and they have been reviewed elsewhere (Oh et al. 2002). The mainstay of this process seems to be the establishment of the so-called 'biological seal', which is influenced by the configuration of the prosthetic platform of the implant. It was suggested that one-piece implants, placed in a non-submerged manner, tend to present a shorter 'biological seal' space, and thus present lower rates of MBL (Hermann et al. 2001).

In an effort to reduce the amount of early MBL around two-piece implants, different

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prosthetic platform configurations were proposed, suggesting a more stable bone–implant interface. Early data from a canine model showed that the placement of a polished area subcrestally facilitates higher rates of early MBL (Alomrani et al. 2005), whereas a rough implant surface placed at the bone level reduces the amount of this bone loss (Hartman & Cochran 2004; Hanggi et al. 2005). Accordingly, some implant manufacturers have recently produced implants roughened along their entire length, without a polished neck.

Recently, it was also claimed by several manufacturers that the introduction of retention grooves (microthreads) at the neck of the implant may further reduce the amount of bone loss following the implant installation (Hansson 1999).

In a prospective cohort study, Shin et al. (2006) compared the amount of MBL around three different implants of different brands. Their study implied that implants with coronal retention grooves exhibit the lowest levels of MBL and present a more stable outcome. Although the results of this study were found to be statistically significant, it can be argued that the results may be explained by the different implant geometry and surface characteristics found in the different implants examined in this study. Lee et al. (2007), in a different split-mouth clinical trial, repeated these results. Their study compared implants of the same brand, with similar surface characteristics; however the implants in their study differed in their macro-configuration: one had a tapered neck (test implants with microthreads) and another had a cylindrical shape (control implants with a polished neck). The authors concluded that this may explain the results of their study.

The aim of the present study was to prospectively compare the amount of MBL found around two different implant designs of the same brand, surface characteristics, and with comparable macro-design (tapered implants): one with a 1-mm polished neck, and another with no polished neck but with retention grooves instead. The secondary goals of our study were to examine the influence of the thread geometry of the two different implants on the initial stability of the implants, and to evaluate its impact on the amount of MBL during the early phases of implant function.

Material and methods

Subjects

Patients referred to the Department of Implant Restorations at the University of Medicine and Pharmacy of Timisoara, Romania, who were scheduled for a two neighboring implant placement in the posterior mandible were recruited for the study. Inclusion criteria were patients indicated for a standard implant placement procedure in the posterior mandible. Patients with a need for any bone augmentation procedure or with any systemic condition contraindicated for implant placement were excluded from the study. The protocol of the study was approved by the Institution Ethics Committee, and each patient signed an informed consent.

The implants

Each surgical site was treated by two different commercially available implants of the same brand (MIS-Implants Inc., Shlomi, Israel) (Fig. 1). Both implant models have the same dimensions, taper, titanium alloy and surface (a moderately rough surface) characteristics. Although they have comparable features, the implants differ in two main attributes: the L (*Lance*) model has a 1-mm polished neck, whereas the S (Seven) model does not, but rather includes a roughened surface with microthreads up to its prosthetic platform; secondly, the implants differ in their thread configurations, found apical to the implant neck.

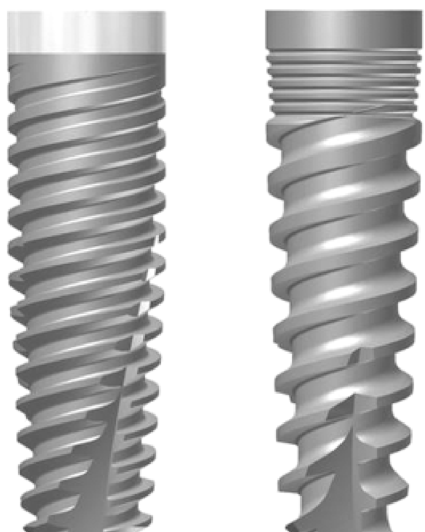

Fig. 1. The two evaluated implants. L-model (left) with a 1-mm polished neck and with no retention grooves, and S-model (right) implant with retention grooves (microthreads) and rough surface body and neck.

Surgical procedure

At each surgical site, each patient received two implants with the same dimensions: on the mesial site an L-model implant was installed, and an S-model was installed on the distal site. All implants were installed using a standard protocol recommended by the manufacturer, in a two-stage approach (implants were covered with mucosal flaps and were exposed 3 months later). The S-model is supplied with a disposable tapered 'final drill', which is indicated to be used right before the implants' installation. All implants were installed with their prosthetic platform level with the bone crest. This was regarded as the baseline (zero) bone level.

Measurements and data collection

We evaluated the process implant integration by evaluating the implants' stability and marginal bone level through the time of implant integration and 1 year of functional loading.

Implant stability was evaluated upon installation and at the end of the healing period, at the time of prosthesis cementation, four months later, using a PerioTest (Medizintechnik Gulden, Modautal, Germany) measuring tool.

MBL was assessed by repeated measurements performed on panoramic orthograms taken for follow-up evaluation at the day of prosthesis cementation (4 months after implant installation), 6 months afterwards, and 6 months later (1 year after loading). Measurements were performed using a magnifying glass and a digital Vernier Caliper (SV-08 Stainless Steel Digimatic Vernier Caliper, E-Base Measuring Tools Co. no. 132, Yun-Lin, Taiwan) on the distal aspect of each implant. Each implant's prosthetic platform, as identified in the radiogram, was used as a reference point due to the fact that all implants were installed level with the bone crest.

Any event of premature implant exposure or soft tissue dehiscence, before the implant exposure procedure, was observed and recorded. No additional treatment was performed in these cases. A case in which the final disposable drill was not used

Table 1. **Patient and implant demographics**

	Number of implants pairs
Started the study	56
Dropout	2
Treated at the left side	26
Treated at the right side	20
Implant diameter (dropout)	
3.75 × 10	11(– 1)
3.75 × 11.5	16
4.2 × 10	11
4.2 × 11.5	10(– 1)

while installing the S-model implant, due to the operator's decision, was also recorded.

All implant pairs were loaded in the same manner at the 4-month time-point, using a two-piece connected crowns cemented to a standard milled abutment, commercially available from the manufacturer.

The amount of MBL around the implants was regarded as the study's primary outcome variable. The implants' stability, premature exposure and relevant bone loss were regarded as secondary.

Statistical analysis

Implant and patient demographic data were assessed using descriptive statistics. A *paired t-test* was used to compare the amount of MBL around the two different implant models at each time point (4 months after installation, 6 months of functional loading and 12 months). Analysis of variance (ANOVA) for repeated measurements was utilized to evaluate the average amount of bone loss around each implant model at every time point.

The stability PerioTest values (PTV) of the two different models were compared at each time point using a Wilcoxon's matched pairs test. The same test was utilized to compare each implant stability value change over time (baseline and at the 4-month time point). Repeated tests were statistically corrected using Bonferroni's correction for repeated measurements.

Results

Forty-eight volunteers ranging in age from 23 to 65 years were recruited for the study, most of whom (40) were treated on only one side of their mandibles. Two patients failed to complete all the follow-up meetings, and were thus excluded from the study. In patients treated on both sides of the mandibles, only one randomly selected pair of implants was evaluated. This made 46 pairs of implants available for statistical testing.

The dimensions of the implant pairs ranged between 10 and 11.5 mm in length, and 3.75 and 4.2 mm in diameter (Table 1). No short implants or wide platform implants were installed. There was no intention to balance the groups: the largest available implants, as permitted by the pre-operatory radiogram to be installed as an identical pair, were used.

Besides premature exposures (soft tissue dehiscence over the implant head: eight in the L-model group and four in the S-model group), the healing period was uneventful. None of the implants failed to integrate, yielding an overall survival rate of 100% at 1 year of function.

MBL

Both implant models exhibited bone loss that occurred over time (Table 2). This bone loss was found to be statistically significant for both implant models (repeated measures ANOVA, $P<0.05$). At each time point, the L-model implants showed higher amounts of bone loss, as compared with the S-model implants ($P<0.05$, paired *t*-test) (Fig. 2). In both models, the profile of the MBL was similar: more bone receded during the first 6 months of function as compared with the succeeding time period (12 months).

A low number of premature exposures was found in both implant groups (eight in the L–model group and four in the S-model group). Implants of the L-model, which exhibited premature exposure at the 4-month follow-up appointment, showed higher amounts of MBL ($P<0.05$, Student's *t*-test) (Fig. 3). This phenomenon had no impact on the amount of MBL in the S-model implants, and was not found

Table 2. **Mean marginal bone loss values**

Follow-up time (months)	L-model (SD)	S-model (SD)	
4	0.77 (0.46)	0.21 (0.19)	$5 \times 10^{-10*}$
6	1.2 (0.44)	0.56 (0.23)	$2 \times 10^{-12*}$
12	1.47 (0.4)	0.69 (0.25)	$1 \times 10^{-11*}$
	$P<0.05$†	$P<0.05$†	

Mean marginal bone loss found around each implant model at the different time points.
*Paired *t*-test.
†ANOVA on repeated measures.
ANOVA, analysis of variance; SD, standard deviation.

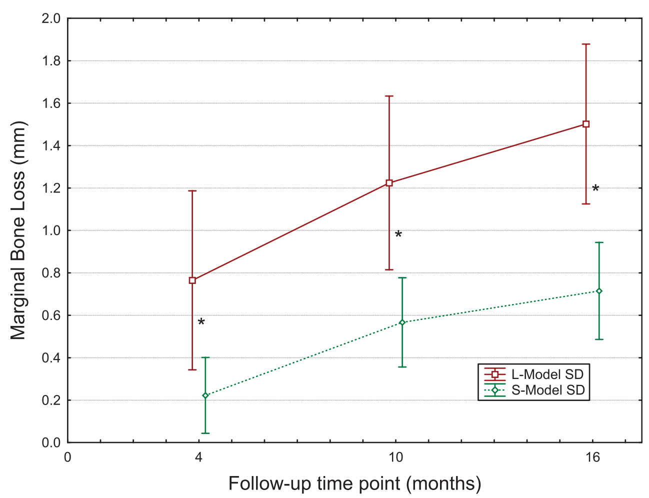

Fig. 2. Mean marginal bone loss found at each flow-up period: 4 months after installation, 6 and 12 months after loading. Whiskers denote statistical deviation values.
*$P<0.05$, Paired T-test.

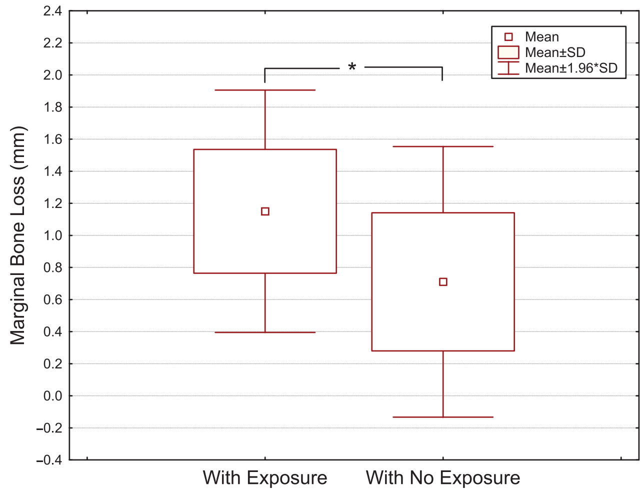

Fig. 3. Mean marginal bone loss found around L-model implants at prosthetic appliance connection (4 months after implant installation), with or without premature soft tissue dehiscence.
*$P<0.05$, Paired T-test.

Table 3. **PerioTest median values (PTVs)**

Follow-up	L-model PTV (quartiles)	S-model PTV (quartiles)	
Installation	−3.5 (−4, −2)	−4 (−5, −2)	$P=0.04$
4 months	−5 (−7, −5)	−6.5 (−7, −5)	$P=0.04$
	1×10^{-8}	3×10^{-8}	

PerioTest values (PTVs) recorded for each implant at the two follow-up appointments. PTVs recorded at implant installation (baseline) and 4 months later at prosthetic appliance cementation.
*$P<0.05$, Wilcoxon's matched pair test.

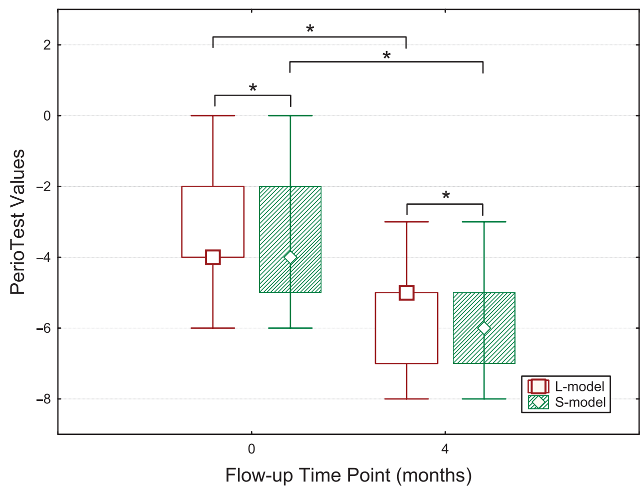

Fig. 4. PerioTest median values (PTVs) recorded at implant installation and on the prosthetic appliance cementation (4 months after implant installation). Boxes denote upper and lower quartiles, and whiskers minimum and maximum values.
*$P<0.05$, Wilcoxon matched pair test.

to be statistically significant at any of the follow-up appointments (data not shown).

Stability values

Both implant models showed an improvement in their stability tests over time (Table 3): both displayed a highly statistically significant improvement in their PTV between the time of installation and the 4-month follow-up period ($P<0.001$ for both models, Wilcoxon's matched pairs test) (Fig. 4). At each time point, the S-model showed statistically significant lower (better) PTV than the L-model.

No correlation was found between the PTV and the dimensions of any of the evaluated implants, either at the installation, or at the end of the integration period, i.e. at the 4-month follow-up examination.

The use of the 'final drill' at the installation of the S-model implant was not correlated with its PTV, either at the installation of the implant or at the follow-up examination (data not shown).

Discussion

Different theories have emerged to explain the phenomenon of MBL that occurs in association with the connection of the prosthetic appliance to dental implants (Albrektsson et al. 1986; Oh et al. 2002). This bone loss, designated as early MBL, should be distinguished from late MBL, which is associated with a state of periimplantitis, and, arguably, with high occlusal strain (Isidor 1996; Esposito et al. 1998a, 1998b; Kronstrom et al. 2001). The rate and profile of the amount of this bone loss was evaluated and criticized in a literature review (Schwartz-Arad et al. 2005), and the differences were explained by the type of implants examined. It has also been postulated that the amount of early MBL is related to the implant's design and involves the procedure of the biologic seal establishment and stabilization (Oh et al. 2002), whereas the late MBL is modified by the susceptibility of the implant to display periimplantitis.

In our study, we are able to show that implants that differ only in their neck configuration do display different amounts of early MBL. The implants of the S-model, which are designed with microthreads and are roughened up to their prosthetic platform, displayed almost half the amount of MBL in the first 6 months after the installation, and almost 60% less bone loss 6 months later, as compared with the L-model implants. However, the rate of bone loss was different between the two implant designs only during the first 6 months after installation. Because of the fact that the two tested implants were identical in their metal composition and implant surface treatment, the differences in MBL cannot be explained by these two variables.

We cannot discern, using the present study design, the exact impact of either the microthreads or the presence of the roughened surface at the neck of the implants on the amount of bone loss: the S-model implant implements these two features, which are absent in the L-model implants, which have a 1-mm polished neck without microthreads. The fact that the rate of bone loss was different between the S- and the L-types only in the first 6 months may suggest that the surface roughness is determining the amount of early bone loss, and not the macro-design.

It has been observed previously in a canine model (Alomrani et al. 2005; Schwarz et al. 2008) and later in a human retrospective analyses (Hartman & Cochran 2004; Hanggi et al. 2005) that the presence and location of the polished neck in relation to the bone crest influences the amount of bone loss during the early phases of the implant's function. Our prospective results support this concept.

Our observations are in agreement with other studies. Shin et al. (2006), compared three different implant designs from three different brands, in a parallel-arm clinical trial. They demonstrated that implants with a neck configuration similar to the S-model implants tended to display a statistically significant lower amount of MBL as compared with implants resembling the L-model implants. Lee et al. (2007), in another well-controlled split-mouth study, also found that implants utilizing microthreads showed significantly less bone loss as compared to implants without microthreads. However, although the studied implants were of the same brand and surface characteristics, they differed in their macro-design: one had a tapered neck and the other had a cylindrical design. In our study, both implant models, although distinct in thread configuration, have a tapered design.

Another phenomenon found in our study that may support the claim that a roughened surface facilitates bone tissue stability around the implant neck is the fact that the L-model implants (no microthreads or roughened surface neck) that showed premature soft tissue dehiscence over their covering screw had statistically significant higher amounts of bone loss compared with those that showed intact soft tissue coverage throughout the healing time (4 months). In the S-model implants, this event was not found to be statistically significant. These data should be considered cautiously because of the low total number of soft tissue dehiscences found in the present study.

We utilized extra-oral panoramic radiograms to evaluate the difference between the amounts of MBL around the two implant models. Although it seems rational to argue that intra-oral peri-apical radiograms would have been probably more accurate (Penarrocha et al. 2004), the use of panoramic radiograms for evaluating bone loss is quite common (Naert et al. 2004; Zechner et al. 2004). There are some data that support the notion that panoramic radiograms correlate well with intra-oral radiograms, especially when utilized for linear measurements (i.e. for the evaluation of marginal bone loss) (Persson et al. 2003; Zechner et al. 2003; Kullman et al. 2007). In our study, we compared the amount of MBL around neighboring implants, placed at the same area (posterior mandible). This makes the impact of the error inherent in radiogram magnification more consistent and smaller (Persson et al. 2003).

Our study may be flawed in the fact that no randomization was performed in relation to the selection of implant model placement (all L-model implants were installed in the mesial site and the S-model in the distal). However, all implant pairs were installed in different sites at the premolar–molar area, allowing a diversity in the sites accounted for each implant model. Furthermore, the mesial site was always a site that is in proximity to a natural tooth, in which bone levels are presumed to be stable (Botticelli et al. 2004). In the present case, the L-model implants, which were inserted into the mesial site, showed more bone loss compared with the S-model. This argument makes our results even stronger. In addition, we could not show any correlation between the amount of MBL and any of the other investigated variables. We found no correlation between the implants' dimensions, installation site (either the premolar or the molar site) implant stability values (PTV) and the amount of MBL. The absence of this latter correlation may be explained in part by the high stability values (PTVs) of the implants acheived at their installation (Truhlar et al. 2000; Aparicio et al. 2006). We believe that this is by virtue of the fact that both implants have a tapered design (O'Sullivan et al. 2004). In addition, this is also in accordance with the claim that the PTV have a low prognostic value for the survival and success of an implant (Faulkner et al. 2001; Salvi & Lang 2004; Aparicio et al. 2006).

In conclusion, the S-model implants (MIS Seven) display statistically significant less early MBL and more bone-level stability as compared with the L-model implants. Two features implemented in the S-model implants may contribute to this: either the absence of the polished neck or the presence of microthreads at the implant neck. Further clinical trials are needed to clarify the impact of each on the resistance for MBL during the first months of implant function.

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