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Effect of thread size on the implant neck area: preliminary results at 1 year of function

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Abstract

Objectives: To evaluate and compare the effect of the coronal thread size on the marginal bone loss around the fixtures, when both implants were provided with threads to the top of fixture.

Materials and methods: Two groups of implants, one with a macro-thread to the top of the fixture (A) and the other with a micro-thread to the top of the fixture (B), were placed adjacent to each other in the partially edentulous areas of 20 patients. Bone loss around each implant was analyzed after 1 year of functional loading. The bone losses after loading were compared using Wilcoxon's signed-rank test.

Results: The mean marginal bone losses (A, 0.154 ± 0.144 mm; B, 0.125 ± 0.136 mm) were not statistically significant between the two groups ($P = 0.669$).

Conclusions: There was no significant difference between implant with macro- and micro-neck thread in terms of marginal bone loss after 1 year of loading.

Recent clinical studies by our group regarding the effect of micro-thread on the marginal bone level showed that (i) the use of micro-thread on the implant neck area can preserve the peri-implant marginal bone effectively, compared with the fixtures without micro-thread (Lee et al. 2007), (ii) the location of the micro-thread in the neck area plays an important role in peri-implant marginal bone stabilization (Song et al. 2009) and (iii) difference in gross fixture design on the neck area did not result in significant difference of marginal bone loss (Kim et al. 2010). Naturally, the sequel question arose regarding the effect of the thread size on the neck portion of the implant.

The use of certain pitch distances of the threads was known to be a favorable element in preserving the peri-implant bone (Motoyoshi et al. 2005). According to finite element analysis, very small threads with a favorable profile can affect the stress distribution in the bone as much as commonly sized threads (Hansson & Werke 2003).

Adequate mechanical stimulation is an important requirement for the successful integration of load-bearing surfaces (Wiskott & Belser 1999). From a biomechanical perspective, retention elements such as the threads on the implant neck area provide the mechanical stimulation required to maintain

the marginal bone level (Hansson 1999). Studies have verified the advantages of micro-thread on the coronal portion of fixture, compared with a smooth neck, in terms of the established bone-to-implant contact and marginal bone level maintenance (Berglundh et al. 2005; Abrahamsson & Berglundh 2006). The role of micro-threads in the neck portion has been researched in numerous studies (Hansson & Werke 2003; Berglundh et al. 2005; Abrahamsson & Berglundh 2006; Lee et al. 2007; Song et al. 2009; Kim et al. 2010).

In contrast, few clinical studies have addressed the role of thread size, or thread pitch distance, on the maintenance of the peri-implant marginal bone, when the threads were positioned to the top of fixtures. Thus, the aim of this clinical investigation was to evaluate and to compare the effect of the coronal thread design on the marginal bone loss around the fixtures, when both implants were provided with threads to the top of fixture, but the size of the threads differs between the implants.

Material and methods

This study was approved by the Institutional Review Board of Gangnam Severance Hospital, Yonsei University. Patients were

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informed of the study procedures and all provided with written informed consent.

Patients

Using the data from the previous publication (Lee et al. 2007), which had similar protocol with the present study, sample calculation was performed with computer software (MedCalc for Windows, version 11.5.0, MedCalc Software, Mariakerke, Belgium). It revealed that 20 cases were necessary to obtain statistically significant results (the difference between the mean of groups is 0.14; SD 1 = 0.11; SD 2 = 0.19; $\alpha = 0.05$; $\beta = 0.20$).

At the time of inclusion to the present study, all the patients showed good general health, had been treated for existing moderate to severe chronic periodontal disease. The diagnostic criteria followed the 1999 classification for periodontal disease (Armitage 1999). All the patients received initial therapy including oral hygiene instruction, scaling and root planning, and subsequent corrective therapy including extraction and periodontal flap surgery at the Department of Periodontology at Gangnam Severance Hospital (College of Dentistry, Yonsei University, Seoul, Korea). Patients received implant surgeries from July 2007 to June 2008. In total, 40 implants in 20 patients (12 men, 8 women, mean age: 52.6 years, age range: 23–65 years, Table 1) were included in the study.

Implants

The two groups of implants used in this study differ in the thread size of the implant neck area. Group A implants (EZ Plus Internal, Megagen, Seoul, Korea) have a uniform

thread pitch from the apex to the neck area. Compared to Group A, the threads of the Group B implants (Megafix Internal, Megagen, Seoul, Korea) are smaller in both pitch and depth in the 3.0-mm neck area (Fig. 1). The depth and pitch of the Group A implants were 0.35 and 0.6 mm, respectively, and those of the Group B implant were 0.15 and 0.3 mm, respectively. Both implant types are single-threaded screws with a V-shape thread (Abuhussein et al. 2010). The thread on the neck portion of Group A is designated as a “macro-thread” and that of Group B is designated as a “micro-thread.” Both implant types are made of commercially pure titanium, surface treated with resorbable blast media, and both have the same implant–abutment connection type (conical seal type with an internal slope of 11°).

Treatment procedure

The treatment procedure was performed as previously described (Lee et al. 2007; Song

et al. 2009; Kim et al. 2010). In brief, all surgeries were performed using a two-stage method. Implants from each group were placed adjacent to each other in the partially edentulous premolar and molar areas of each patient. The mesiodistal location of each implant was randomly determined. The diameter could not be matched on some patients (patient 1, 3, 6, 10, 11, and 19), since utmost care was taken to preserve 1 mm of bone remaining both buccally and lingually. The implants were placed at or slightly below the marginal bone level, following the manufacturer's guidelines.

The location of each implant type is illustrated in Table 1. A second surgery was performed 3 or 6 months later for maxillary or mandibular implants, respectively. The prostheses were delivered 3 weeks after the second surgery. Patients were recalled every 6 months for oral hygiene evaluation, professional plaque control, and review of self-performed oral hygiene instructions.

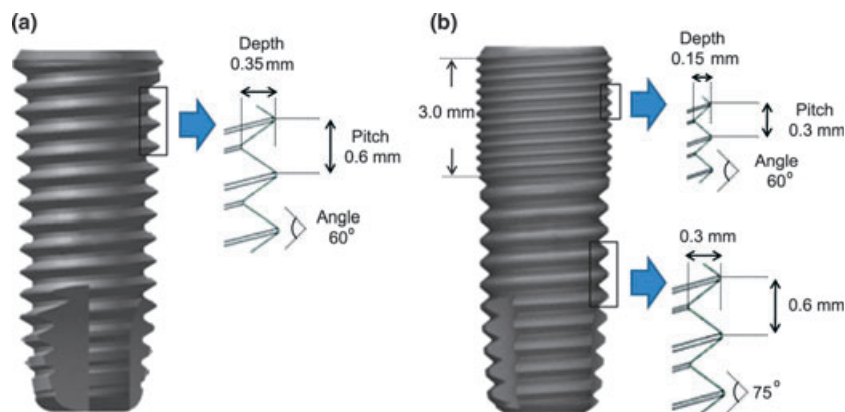


Fig. 1. Schematic presentation of the implants. (a) Macro-thread implant; (b) Micro-thread implant.

Table 1. Characteristics of the subject population, position, and type of the implants

Subject	Age	Gender	Tooth no.	Fixture type	Subject	Age	Gender	Tooth no.	Fixture type
1	52	M	35	A	11	55	M	15	A
			36	B				14	B
2	55	M	26	A	12	55	M	25	A
			27	B				24	B
3	23	F	15	A	13	60	F	36	A
			14	B				37	B
4	63	M	47	A	14	42	F	27	A
			46	B				26	B
5	56	F	36	A	15	62	M	35	A
			37	B				34	B
6	65	F	25	A	16	56	M	15	A
			26	B				14	B
7	48	F	24	A	17	56	M	26	A
			25	B				25	B
8	47	M	25	A	18	60	M	17	A
			26	B				16	B
9	56	M	25	A*	19	39	F	47	A
			27	B*				46	B
10	56	M	35	A	20	49	F	36	A
			36	B				37	B

*In one patient, the implants were not placed immediately adjacent to each other and were splinted to fabricate three-unit bridges.

Radiographic examination

Radiographs were taken and measured as previously described (Lee et al. 2005, 2007; Song et al. 2009; Kim et al. 2010). Briefly, periapical radiographs (Kodak Insight, film speed F, Rochester, NY, USA) were taken at several time points: 1 day after implant placement, immediately after the second surgery, immediately after prosthesis delivery, and 1 year after functional loading (Fig. 2). Radiographs were taken with an XCP device (Extension cone paralleling Kit, Rinn, Elgin, IL, USA) using the parallel cone technique (70 kV, 8 mA, 0.250 s). A 5.5-mm spherical metal bearing was placed for calibration. All films were developed using the same automatic processor (Periomat, Durr Dental, Bietigheim-Bissingen, Germany) following the manufacturer's instructions. Films were digitized using a digital scanner (EpsonGT-12000, Epson, Nagano, Japan) at an input resolution of 2400 dpi with 256 gray scale values.

Measurement of marginal bone level change

All images were transferred to a personal computer (Processor, Intel Core2 Duo E8200, Santa Clara, CA, USA; operating system, Windows XP Professional 2002, Redmond, WA, USA). The same monitor (Flatron LX1717, LG, Seoul, Korea), set to a resolution of 1280 × 1024, was used to examine all the digitized radiographs. The room was kept dark throughout the computer-assisted radiographic measurement process.

The marginal bone height was measured at three time points: at implant placement, at prosthesis delivery, and after 1 year of functional loading. The marginal bone height was measured as the distance between the reference point and the most apical point of the marginal bone level. The reference point was the border between the polished surface and the rough surface of the fixture. Calibration was performed using the known distance of the spherical metal bearing (5.5 mm). Measurements were taken to the nearest 0.01 mm using the UTHSCSA Image Tool computer software program (version 3.00, University of Texas Health Science Center in

San Antonio). Bone height was measured at the mesial and distal peri-implant sites, and their average values were used. Bone loss was measured by comparing the radiographs taken immediately after prosthesis delivery to those taken 1 year after functional loading. As the interval between implant placement and baseline differed between the subjects, the marginal bone height measured at implant placement was not used for statistical analysis. All measurements were made by the same operator (Y-I K.). To test intra-observer variability, the marginal bone loss values of 20 arbitrarily selected periapical films were measured twice within a 1-week time interval.

Follow-up parameters

At the 1-year follow-up visit, implants were evaluated for pain, discomfort, and implant-related infection. An implant was deemed as "surviving" when it was stable, functional, and asymptomatic. To rule out the possible influence of inflammatory changes of the peri-implant tissues on the surrounding marginal bone, the modified plaque index (mPI), and modified sulcus bleeding index (mBI) were measured at four aspects around each implant (Mombelli et al. 1987). The averages of the four mPI and mBI values were calculated to represent the respective values for each implant.

Statistical analysis

Intra-class correlation was used to test intra-rater reliability. As the differences of the paired data on marginal bone loss did not show symmetric distribution (coefficient of skewness = 1.18, $P = 0.025$), Sign test was used to analyze the differences in peri-implant marginal bone loss between the two groups. Wilcoxon's signed-rank test was used to analyze the differences in mPI and mBI. Computer software programs (MedCalc for Windows, version 11.5.0, MedCalc Software; SPSS, version 17, SPSS Inc, Chicago, IL, USA) were used to process the data. The values were deemed statistically significant if the P -value was <0.05 .

Results

Clinical examination

The implants of all of the patients were well maintained at the periodic follow-ups. All of the implants functioned normally during the observation period, with no sign of pain, swelling, pus discharge, or mobility. No prosthetic complications were observed.

Marginal bone level changes

The intra-rater reliability was high ($R = 0.89$) for measurements of Group A and Group B implants. A sign test indicated that marginal bone loss of Group A and Group B did not differ statistically ($P = 0.803$, Fig. 3, Table 2). Fig. 4 illustrates the median value of marginal bone level at different examinations.

Evaluation of peri-implant soft tissue

For Groups A and B, the average plaque indices were 0.35 and 0.4, respectively, and the

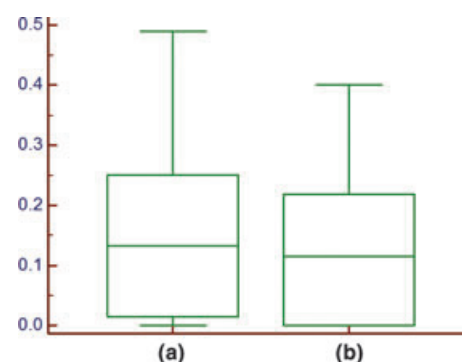


Fig. 3. Box plot of the bone loss around the macro-thread (A) and micro-threads (B) implants.

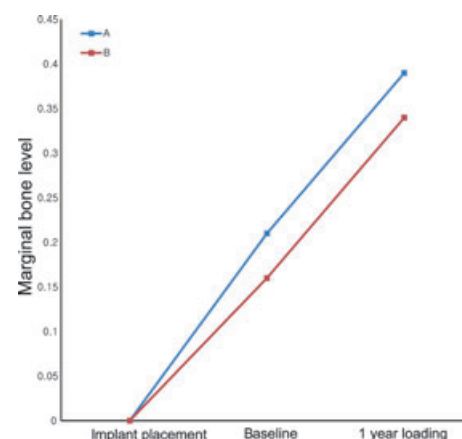


Fig. 4. Median value of marginal bone level at implant placement, baseline (prosthesis delivery) and 1 year after functional loading on macro-threads (A) and micro-threads (B) implants.

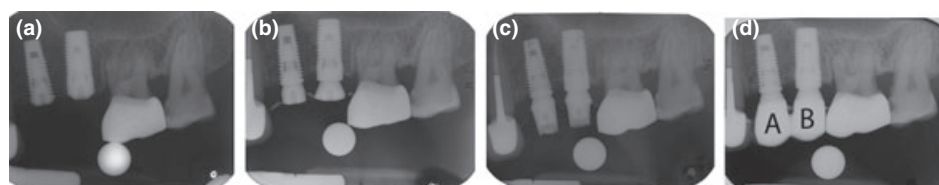


Fig. 2. Intra-oral radiographs of the implants with macro-threads (A) and micro-threads (B). (a) First surgery; (b) Second surgery; (c) Prosthesis delivery; (d) 1-year follow-up.

Table 2. Marginal bone loss (mm) around implants in Groups A and B

Subject	Type of implant	
	A	B
1	0.14	0.315
2	0.175	0.165
3	0.215	0.01
4	0	0
5	0.175	0.4
6	0.275	0.38
7	0.1	0
8	0.28	0.15
9	0.295	0.255
10	0.49	0
11	0.125	0
12	0	0
13	0.225	0.23
14	0.415	0.205
15	0.005	0
16	0.07	0.125
17	0	0
18	0.025	0.165
19	0.06	0.105
20	0	0
Median	0.133	0.115
95% confidence interval for the median	0.031–0.223	0–0.198
95% confidence interval for the median of the difference	–0.04 to 0.09	
P-value	0.804	

average mucosal indices were 0.28 and 0.21, respectively. The mPI and mBI for each implant type are illustrated in Table 3. No

significant differences in plaque accumulation ($P = 0.297$) or sulcus bleeding ($P = 0.636$) were found between Groups A and B.

Discussion

Placing micro-threads on the implant neck greatly increases the ability of an implant to resist axial loads, and the mechanical stimulus provided by the micro-threads helps to preserve peri-implant marginal bone (Hansson 1999). In a 3-year prospective study, we previously reported that use of micro-threads in the implant neck area can reduce peri-implant marginal bone loss, although the study was performed on implants with different neck designs (Lee et al. 2007). Kim et al. (2010) found no difference in bone loss between conical- and straight-shaped implants, both of which had micro-threads. Another study found that implants with threads that began at the top showed less bone loss than otherwise-identical implants where the threads began 0.5-mm from the top (Song et al. 2009). These results indicate that the presence or absence of threads and the thread location can affect the marginal bone preservation.

The thread size can be described by the thread depth (i.e. distance from the tip of the thread to the body) and thread pitch (i.e. distance from the center of the thread to the center of the next thread). A finite element

study comparing the effect of thread depth on marginal bone found no significant difference in the stress distribution when a thread depth of 0.1 or 0.4 mm was used, so long as the thread profile was favorable (Hansson & Werke 2003). However, the results of studies for thread pitch are controversial. In a finite element study, implants with a 0.5-mm pitch had a more favorable stress distribution than those with a pitch of 1.0 or 1.5, and the maximum effective stress gradually decreased with decreasing thread pitch (Motoyoshi et al. 2005). In another study also using finite element study, a thread pitch of 0.18–0.30 mm was considered as optimal from a biomechanical point of view (Kong et al. 2008).

The present study was planned to examine the effect of thread size on the marginal bone. In particular, we compared the effect of macro- and micro-threads in the implant neck area in cases where the thread location was identical. To minimize the influence of the peri-implant mucosa and plaque accumulation on bone loss, oral hygiene instructions were provided to the patients and periodic clinical examinations of the peri-implant mucosa and professional plaque control were performed. The average bone losses in Groups A and B were 0.154 and 0.125 mm, respectively, after 1 year of functional loading ($P > 0.05$). The results of this study suggest that the thread size at the implant neck area does not affect the amount of marginal bone loss during the initial first year physiologic bone remodeling period, since both groups of implants had the identical rough surface. The amount of bone loss was minor, likely because both groups of implants had internal conical seal type fixture-abutment connections, which are advantageous in marginal bone preservation (Norton 1998; Hansson 2000; van Steenberghe et al. 2000; Engquist et al. 2002). It is possible that the beneficial effects of the rough surface and conical fixture-abutment interface on the marginal bone-level maintenance overwhelmed the additional effects of the micro-thread. Alternatively, macro-threads that begin at the top of the implant neck can be assumed to distribute stress under load and to maintain the marginal bone as much as micro-threads.

There are several drawbacks of the present study. One is the short-term follow up period (1 year after functional loading). As graphically demonstrated on Fig. 4, the marginal bone loss of both implant systems is not yet stabilized. However, when we analyze a previous study using similar protocol of the

Table 3. Modified plaque index (mPI) and modified sulcus bleeding index (mBI) of implants in Groups A and B

Subject	mPI		mBI	
	Type of implant		Type of implant	
	A	B	A	B
1	0	0.25	0	0.25
2	0.25	0.25	0	0.5
3	0.25	0.25	0.75	0.5
4	1	1	0	0
5	1	1	0.25	0.25
6	0.00	0.25	0.5	0
7	0.25	0.25	1.25	0.25
8	1	1	0.75	0.75
9	0	0	0.25	0
10	0	0	0.25	0
11	0.75	0.5	0.25	0
12	0.5	0.25	0	0.25
13	1	1.25	0.25	0.5
14	0	0	0	0
15	0.25	0.75	0	0
16	0.00	0.25	0.25	0.25
17	0.25	0.25	0	0
18	0.5	0.5	0	0.25
19	0	0	0.75	0
20	0	0	0	0.5
Median	0.25	0.25	0.25	0.25
95% confidence interval for the median	0–0.5	0.25–0.5	0–0.25	0–0.25
P-value	0.297		0.636	

present study (Lee et al. 2007), the most critical period of the bone level changes occurred 1 year after loading. Stabilization around peri-implant marginal bone was observed after 1-year, which did not show statistically significant additional marginal bone resorption. It was interesting to compare the bone loss during this period, since it shows us the effect of implant design on the initial physiologic bone remodeling phase. After this phase, bone loss is mainly due to the bacterial infection (Lang & Berglundh 2011). However, whether this stabilization period would

occur in this implant system is currently not known. This study is an interim report of the 5-year prospective study, and further evaluation and patient recruitment is still ongoing.

The other drawback is the differences in fixture diameter, gender, age, and implant sites. These factors are possible confounding factors for the marginal bone loss and need to be stratified, if we could recruit larger numbers of patients.

Within the limitations of the study, it may be concluded that macro-threads in the neck portion of an implant appear to have a simi-

lar ability to preserve the marginal bone as micro-threads.

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