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SYSTEMATIC REVIEW

Marginal bone loss around dental implants with and without microthreads in the neck: A systematic review and meta-analysis

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ABSTRACT

Statement of problem. Whether microthreads in the crestal portion can reduce the amount of marginal bone loss (MBL) around implants has not yet been determined.

Purpose. The purpose of this systematic review was to investigate the marginal bone loss around dental implants with and without microthreads in the neck.

Material and methods. This review was based on the PRISMA guidelines. An electronic search with no restrictions on language was performed from inception to August 19, 2015, in PubMed, Cochrane Central Register of Controlled Trials, EMBASE, Web of Sciences, and AMED (Ovid) databases. A manual search was also performed. Randomized clinical trials (RCTs) that compared the MBL between implants with and without microthreads in the neck were included. Qualitative synthesis and meta-analysis were performed. MBL was measured by using the mean difference (MD). Review Manager v5.3 software was used for meta-analysis (α=.05).

Results. Five articles were included in the qualitative synthesis, and 3 articles were included in the meta-analysis. Four studies found that a microthread design can significantly reduce MBL under functional loading, whereas 1 study found no significant difference. The homogeneity test of meta-analysis confirmed acceptable heterogeneity among the 3 studies (I^2=0.49). A random-effects model was used. The result shows that MBL around implants with microthread design can be reduced significantly (P=.030; MD: −0.09; CI: −0.18 to −0.01).

Conclusions. Meta-analysis showed that microthread design in the implant neck can reduce the amount of MBL; however, RCTs included in the review were few and the difference was small. In clinical practice, an implant with a roughened surface and microthreaded neck could be selected to maintain bone level. (J Prosthet Dent 2016;■:■-■)

According to clinical studies,[1,2] the long-term survival of dental implants has exceeded 96%. Patients are concerned about the long-term function and esthetics of implants, so failures must be limited. Different factors relate to implant failures. Iatrogenic conditions (surgical technique, contamination, and occlusal trauma), poor bone quality and quantity, suboptimal implant choice, periimplantitis, and poor oral hygiene maintenance (heavy smoking) can cause early or late failures.[3,4] The implant design, including macrodesign and microdesign, is a fundamental factor in implant primary stability and stress distribution.[5]

More than 100 implant systems in different designs have been marketed.[6-8] Manufacturers have claimed that microthreads in the crestal portion can reduce marginal bone loss (MBL) around implants. Clinical studies have shown that rough surfaced implants with microthreads at the neck can maintain the marginal bone level during the healing period and cause significantly less MBL under long-term functional loading.[9-15] Microthreads location is important in reducing MBL, and implants with microthreads placed at the implant top have less bone loss than those in

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Clinical Implications

Randomized clinical trials that compared the marginal bone loss (MBL) around implants of different neck design show that MBL around implants is significantly less with microthreads in the neck than without microthreads. However, randomized clinical trials (RCTs) included in the review were few and the difference was small. The currently included evidence was insufficient, thus further RCTs with longer follow-up periods are needed.

which microthreads are placed below the top.[16] Studies with finite element analysis (FEA) indicate that the microthreaded implant model has higher compression and less shear stress at the crestal cortical bone adjacent to the implant and so can reduce marginal bone resorption.[17-19] These FEA studies show the possible mechanism of microthread, although further research should focus on analyzing stress distributions under dynamic loading conditions of mastication, which would better mimic the actual clinical situation. Animal studies find microthreaded implants show a higher degree of bone implant contact with the marginal portion of the implants and offer improved conditions for osseointegration.[20,21]

However, some scholars have different opinions that microthreads cannot improve marginal bone preservation, and there is no significant difference between implants with macrothreads and microthreads in terms of MBL after loading (1 year or 12 years) with good oral hygiene and a stable periodontal condition.[22-24] A study of 24 miniature pigs showed that no significant difference in removal torque value or bone to implant contact was found between implants with and without microthreads, and the existence of microthreads was not a significant factor in mechanical and histologic stability.[25]

This meta-analysis was done to answer questions regarding the efficacy of the microthread design of the implant neck in the preservation of marginal bone. The purpose of the review was to test the null hypothesis that no difference would be found in MBL around the implants with and without microthreads at the neck.

MATERIAL AND METHODS

This review was based on the PRISMA guidelines.[26,27] The protocol was registered in PROSPERO International Prospective Register of Systematic Reviews (CRD 42015023971). The patient, intervention, comparator, outcome (PICO) question formulated for this study was as follows: For patients who need implant treatment (P), will the implant neck design with microthreads (I) compared with that without microthreads (C) change the MBL around implants (O)?

Table 1. PubMed search strategy

Search ((((((((((((dental implant[MeSH Terms]) OR dental implantation[MeSH Terms]) OR dental prosthesis, implant supported[MeSH Terms]) OR dental implant*[Text Word]) OR oral implant*[Text Word]) OR ((tooth implant*[Text Word]) OR teeth implant*[Text Word])) OR (((osseointegrated AND implant*) AND (dental OR oral)))) OR ((dent*[Text Word]) AND implant*[Text Word])) OR endosseous implant*[Text Word]) OR ((overdenture*[Text Word]) AND implant*[Text Word])) OR ((((((crown*[Text Word]) OR bridge*[Text Word]) OR prosthesis[Text Word]) OR prostheses[Text Word]) OR restoration[Text Word]) AND implant*[Text Word]))) AND microthread*[Text Word]

Search strategy

An electronic search from inception to August 19, 2015, without any restrictions on language was performed in the following databases by 2 independent investigators (WN and PW): PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, Web of Sciences, AMED (Ovid). A detailed search strategy was prepared for each database using the following Medical Subject Headings (MeSH) terms exploded: 'Dental implant', 'Dental implantation', in combination with the following text words: 'dental implant*', 'oral implant*', 'tooth implant*', 'teeth implant*', 'osseointegrated AND implant*' and 'microthread*'. The exact search strategy for PubMed is presented in Table 1. The search idiom was adapted for the different databases. In addition, a hand search was performed in the following journals: *Clinical Implant Dentistry and Related Research, Clinical Oral Implants Research, European Journal of Oral Implantology, Implant Dentistry, International Journal of Oral and Maxillofacial Surgery, Journal of Cranio Maxillofacial Surgery, Journal of Dental Research, Journal of Oral Implantology*, and *Journal of Periodontology*.

Inclusion criteria and exclusion criteria

Randomized clinical trials (RCTs) that compared the MBL between implants with and without microthreads in the neck were included. The exclusion criteria were the following: case report, review, animal studies, FEA, and in vitro studies; studies comparing not only the microthread design but others with mixed design; and studies with a follow-up period of less than 1 year.

Two reviewers (W.N. and S.Z.) read the titles and abstracts of the studies independently to decide whether the studies met the inclusion criteria. Full articles were examined if necessary. Any disagreement between the reviewers was resolved by an interviewer consensus with a third reviewer (P.J.).

Quality assessment

Quality assessment was performed independently by 2 investigators (W.N. and P.W.) by using the Cochrane

Collaboration tool for assessing risk of bias.[28] The tool contains 2 parts, addressing the 7 specific domains (namely sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, and other issues). An estimated risk of bias (low, medium, or high) was assigned to each of the included studies by the investigators. The disagreements were resolved by discussion.

Data extraction and statistical analysis

Data were extracted by 2 reviewers (W.N. and P.W.) independently using a designed form that included the following information: year of publication, characteristics of participants, duration of follow-up, implant brand, implant surface (with microthreads at the neck or not, rough or machined), data on dental implant failure, and data on MBL. Contact was made with authors whenever the data were missing or ambiguous. The studies in which the data were not clearly stated were excluded from analysis.

Mean differences (MD), a continuous outcome, were used to measure MBL. The level of significance was α=.05. Heterogeneity was assessed for the outcomes in each study and investigated using forest plots and the I^2 statistic. A random-effects model was preferred for meta-analysis if statistically significant heterogeneity was identified among a group of studies. Publication bias was measured using visualization of funnel plots if there had been sufficient numbers of trials (more than 10).[28] Asymmetry of the funnel plot may indicate publication bias and other biases related to sample size. Software (Review Manager v5.3; Nordic Cochrane Centre, Cochrane Collaboration, 2014) was used for the meta-analysis.

RESULTS

One hundred and thirty-eight records were obtained from the electronic search and 36 records by hand-searching. After duplicates were removed, 94 records remained. After reading the title and abstract, 57 records were excluded. Altogether, 37 articles were eligible for full-text screening. Of these, 33 records were excluded because they did not compare the implant with and without microthreads (did not have a control group),[29-46] or compared not only the implant neck design but also other mixed designs,[14,23,47] or studied the efficacy of a combination of microthreaded implants and leukocyte and platelet rich fibrin,[48] or had insufficient data.[13] Therefore, 5 articles were included in the qualitative synthesis and 3 articles in the meta-analysis (Fig. 1).

Detailed data of the 5 included studies are listed in Table 2. All the participants included were adults (aged 23 to 78 years). Each study studied 2 groups of implants of the same brand, dimensions, surface, and implant−abutment connection type, differing only in the design of the neck. A total of 339 implants were studied with a follow-up time that ranged from 1 to 5 years. All the implants survived. These studies can be divided into 2 subgroups (S1, S2): 2 studies[12,15] compared the effects of implants with a roughened microthreaded neck or a polished neck (S1), 3 other studies[10,16,24] compared the effects of implants with a roughened neck with or without microthreads (S2). Two studies in the S1 group had different MBL baselines and were thus excluded from the meta-analysis. Four studies found that a microthread design in the implant neck can significantly reduce the amount of MBL under functional loading, whereas 1 study[24] found no significant difference between implants with macroneck and microneck threads in terms of MBL after 1 year of loading. Studies in the S1 group could not discern the exact impact of microthreads and the roughened surface on MBL. However, Kang et al[24] believed the thread size at the implant neck area did not affect the amount of MBL during the erst year loading when both groups of implants had the identical rough surface.

The risk of bias in each study was assessed and summarized in Figure 2. Two studies[12,15] (40%) were assessed as being at high risk of bias for random sequence generation, 4 studies[10,15,16,24] (80%) of unclear risk of bias for allocation concealment, 1 study[12] (20%) of high risk of bias for incomplete outcome data, and 1 study[15] (20%) of unclear risk of bias for blinding of outcome assessment (Fig. 3).

Meta-analysis

The meta-analysis was performed by combining the results of 3 studies (Fig. 4).[10,16,24] Fifty-seven implants were included. The homogeneity test confirmed acceptable heterogeneity among the 3 studies (I^2=0.49). A random-effects model was used. The results show that the mean difference was −0.09 (95% Cl = −0.18 to −0.01). This means that MBL was significantly less in roughened implants with microthreads than without microthreads.

A visual inspection of the funnel plots showed no clear asymmetry (Fig. 5), indicating the possible absence of publication bias. However, considering the small number of studies included in the meta-analyses, publication bias was given the low power of the statistical tests.

DISCUSSION

This review was designed to compare the MBL around implants of different neck design (with or without microthreads at the coronal portion). The finding was that the MBL around implants is significantly less with microthreads in the neck than without microthreads. All the studies included were RCTs. The heterogeneity was

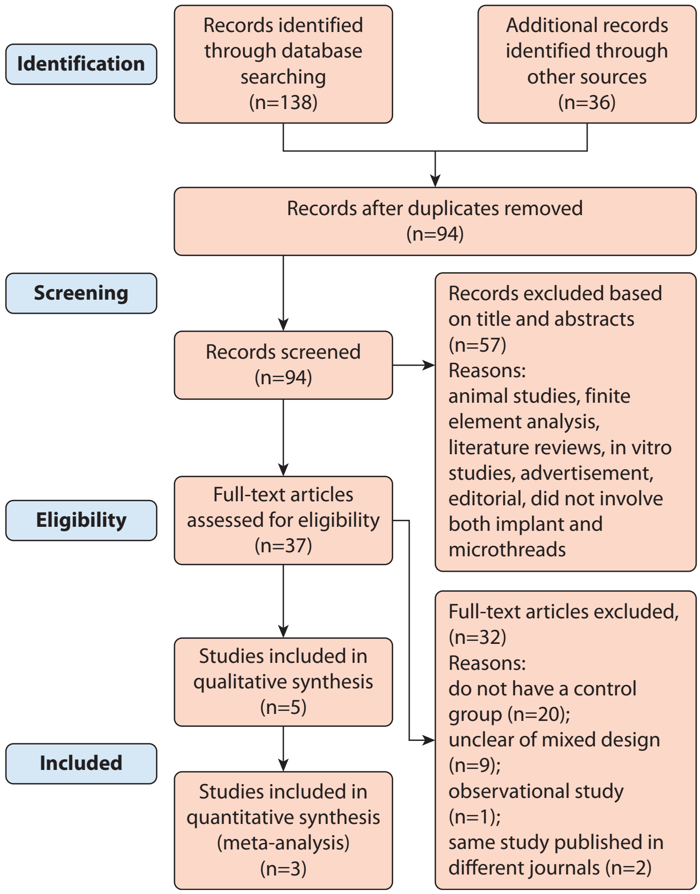

Figure 1. Literature search flow.

Table 2. Detailed data of included studies

Study	Year	Patients, n (sex distribution)	Age (y) Range, (average)	Implants, n (groups)	Failed/ Placed Implants n	Follow-up, y	Mean ±SD Marginal Bone Loss 1 Year After Functional Loading, mm (group)	Implant Brand	Implant Surface
Bratu et al[12]	2009	46 (NR)[a]	23-65 (NR)	92 (C46, E46)	0/92	1	1.47 ±0.4 (C) 0.69 ±0.25 (E)	MIS-Implants Inc	C Polished neck E Rough microthreaded
Kang et al[24]	2012	20 (12M,8F)	23-65 (52.6)	40 (C20, E20)	0/40	1	0.15 ±0.14 (C) 0.13 ±0.14 (E)	Megagen	C Rough macrothreaded E Rough microthreaded
Lee et al[10]	2007	17 (9M, 8F)	31-76 (53.3)	34 (C17, E17)	0/34	3	0.28 ±0.19 (C) 0.14 ±0.11 (E)	Astra Tech TiOblast Implant	C Rough E Rough microthreaded
Song et al[16]	2009	20 (11M, 9F)	37-78 (57.3)	40 (C20, E20)	0/40	1	0.30 ±0.22 (C) 0.16 ±0.19 (E)	Dentium	C Rough without microthread at the top 0.5 mm of the neck E Rough with microthread at the top
Nickenig et al[15]	2013	34 (NM)	25.2-55.5 (45.2)	133 (C63, E70)	0/133	5	0.8 (0∼2.4) (C)[b] 0.4 (0∼2.1) (E)	Replace, Nobel	C Polished neck E Rough microthreaded

NR, not reported; C, control group; E, experiment group; SD, standard deviation. [a]There were 48 participants; however, 2 participants failed to complete all follow-up meetings and were thus excluded. [b]Data show amount of marginal bone loss (MBL) after 6 months of functional loading. Study did not report MBL after 1 year of functional loading.

acceptable, and a random-effects model was used for meta-analysis.

Marginal bone level is important to final esthetics and implant survival. One criterion of a successful implant was that MBL should be less than 1 to 1.5 mm during the first year after implant loading and less than 0.2 mm annually.[49] Many studies of implant design were undertaken to balance stress at the crest and decrease marginal bone resorption. Hansson,[50] after a 3-dimensional and axisymmetric finite element analysis, determined that a rough surface of suitable microthread could decrease the peak interfacial shear

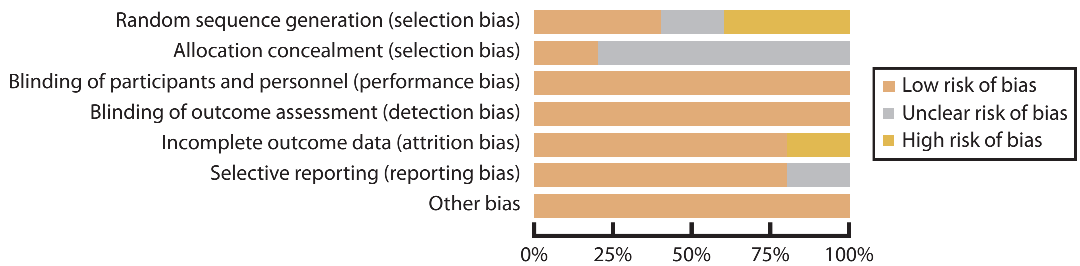

Figure 2. Risk of bias. Review authors' judgments about each risk of bias item presented as percentages across included studies.

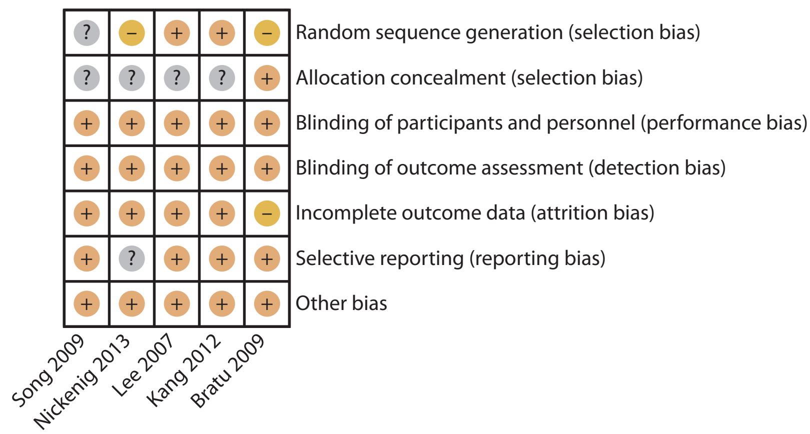

Figure 3. Risk of bias summary. Review authors' judgments about each risk of bias item for each included study.

stress and reduce marginal bone resorption. Subsequently, many studies were published on the effect of microthreads. Many publications indicated microthreads could reduce MBL; however, many of these studies were confounded by other factors. For example, the implants studied by Shin et al[9] and Piao et al[14] were of different brands and macrodesign. These studies with confounding factors were excluded according to our inclusion and exclusion criteria. Studies included in this review studied implants that differed only in their neck design so the exact effect of the microthreads on the MBL could be discerned. The result of the meta-analysis showed that MBL around implants with a roughened neck with microthreads was significantly less than without microthreads (P=.030). However, the difference was small (MD: − 0.09; CI: − 0.18 to − 0.01) and did not show any significant clinical difference of implant failure during the follow-up period for all surviving implants. Studies in the S1 group showed that the difference between a roughened neck with microthreads and a polished neck without microthreads was even larger. This may indicate that both the microthreads and the roughened neck have an effect on MBL. Nickenig et al[15] compared the marginal bone levels adjacent to machined-neck and rough-surfaced microthreaded implants and found, as in this review, that implants with the microthreaded design caused less bone loss. This study was not included in the meta-analysis because the exact data were not obtainable.

This review has 3 limitations. First, the follow-up period was short. Three of the studies observed MBL only 1 year after functional loading.[12,16,24] Lee et al[10] observed MBL at 1, 2, and 3 years of follow-up, and Nickenig et al[15] at 0.5, 2, 3, and 5 years of follow-up. Lee et al[10] found that the amount of MBL during the first year of loading was significantly greater than during the second and third year, which is consistent with findings of Nickenig et al.[15] However, the meta-analysis containing Lee et al[10] and Nickenig et al's studies[15] could not be performed because the baseline was different in the 2 studies. Second, the selection bias risk was high. Two studies[12,15] (40%) were assessed as being at high risk of bias for random sequence generation. In 1 study,[12] all implants with a polished neck were installed in the mesial site and implants with a roughened microthreaded neck were installed in the distal site. However, bone levels in the mesial site were presumed to be stable because the mesial site was next to a natural tooth.[51] MBL around implants with a polished neck inserted into the mesial site were more than around implants with

Study or Subgroup	Experimental Mean	Experimental ±SD	Experimental Total	Control Mean	Control ±SD	Control Total	Weight, %	Mean Difference IV, Random, 95% CI
Kang 2012	0.13	0.14	20	0.15	0.14	20	39.7	−0.02 (−0.11, 0.07)
Lee 2007	0.14	0.11	17	0.28	0.19	17	33.5	−0.14 (−0.24, −0.04)
Song 2009	0.16	0.19	20	0.3	0.22	20	26.8	−0.14 (−0.27, −0.01)
Total (95% CI)			**57**			**57**	**100.0**	**−0.09 (−0.18, −0.01)**

Heterogeneity: τ^2=0.00; χ^2=3.94, *df*=2 (*P*=.14); I^2=49%
Test for overall effect: Z = 2.13 (*P*=.03)

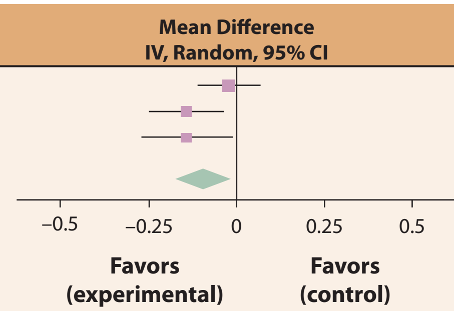

Figure 4. Forest plot of comparison. Marginal bone loss 1 year after functional loading.

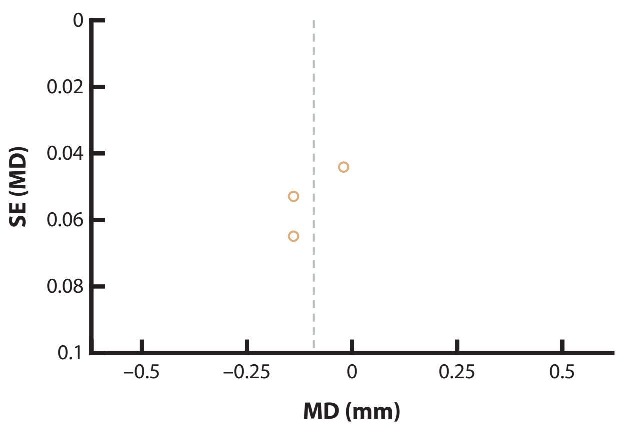

Figure 5. Funnel plot of comparison. Marginal bone loss 1 year after functional loading (mm).

a roughened microthreaded neck. This makes the result even stronger. In another study, all patients received an integer ID number based on the date of their appearance in the clinic.[15] The sequence of patient allocation was generated based on the odd or even ID number. However, a paired design was applied in the research, and implants in the control group and experimental group of 1 pair were inserted in the left and right side of the same mandible, producing comparable groups. Finally, studies included in the meta-analysis were limited. Only 3 studies were included in the meta-analysis, and the power of the statistical test for publication bias was low. This may be because MBL is dependent upon a series of factors and microthread design is just 1 of them. Many studies have compared not only the microthread design but also other designs. These studies with confounding factors were excluded, and only RCTs focusing on microthreads in the neck were included in our inclusion and exclusion criteria. The limited number of studies indicates that the result should be interpreted carefully and verified by further studies.

On the limitations of the review, more RCTs with longer follow-up periods and without mixed design are required to determine the real effect of the microthread design on marginal bone preservation.

CONCLUSIONS

Within the limitations of this systematic review and meta-analysis, the following conclusions were drawn:

1. A microthread design in the implant neck can significantly reduce the amount of MBL under functional loading.
2. The amount of MBL around implants with a roughened neck is less than with a polished neck.
3. Because of the limited number of RCTs included in the review, the evidence was insufficient to draw a definite conclusion on the effect of the microthread design.
4. Further RCTs are needed, with longer follow-up periods, larger patient samples, and adequate control for confounding factors.

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