Cranio-maxillofacial

Implant Directions®

Vol. 6 N° 4 December 2011

Full Length Article»

Peri - implantitis and implant characteristics in Dental Implantology: A Systematic Review

Kopp S., Maier T., Ihde S.

ISSN 1864-1199 / e-ISSN 1864-1237

OFFPRINT

Published by IF Publishing, Germany

Editorial board

Single Issue Price
Euro 30
Annual Subscription
Euro 120

Contact
publishing@implantfoundation.org

CMF.Impl.dir.
ISSN 1864-1199
e-ISSN 1864-1237

Disclaimer

Peri-implantitis and implant characteristics in Dental Implantology: A Systematic Review

Authors:
Dr. med. dent. Sigmar Kopp
Niklotstrasse 39
D-18273 Guestrow / Germany
Phone business: +49 3843 214553
Phone home: +49 3843 843967
Mobil phone: +49 172 301 31 58
Fax.: +49 3843 22272
e-mail: dres.kopp@t-online.de

Dr. Thomas Maier
Bahnhofstrasse 7
D-73447 Oberkochen / Germany
info@zahnundgesund.de

Prof. Dr. Stefan K.A. Ihde
International Implant Foundation Munich
Head of Dental Implant Faculty
Leopoldstr. 116
DE- 80802 Munich/Germany
email: dr.s.ihde@gmail.com

Abstract

Objective: To report outcomes of treatment for periimplantis and to determine the influence of implant characteristics.

Methods

A systematic review of literature was performed. The strength of literature was classified using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE).

Results

103 articles were screened and 24 met the inclusion criteria. Treatment modalities were categorized into chemical, mechanical, and surgical interventions. Conflicting results were found regarding outcomes of various chemical treatments using antibacterials compared to mechanical debridement. Chemical treatments may have a beneficial effect upon gingival parameters. Only implant surface modification resulted in significantly improved gingival parameters. The influence of implant diameter was not significant. Different studies reported results without leading to a generable suggestion. In regards to surface structure, implants with roughened surfaces lead to a greater incidence of periimplantitis than did turned or machined implants. These findings correspondences with the only significant periimplantitis treatment by surface modification.

Conclusions

The quality of evidence of treatment outcomes for peri-implant disease is "Low"; for the relationship between implant diameter and peri-implant disease is "Very Low", and between implant surface structure and peri-implant disease is "Moderate" to "Low". The small number of available studies limits conclusions for periimplant disease as well as prognostic factors such as implant diameter and surface structure.

Keywords

Peri-implantitis, treatment, implant diameter, implant surface structure

Introduction

Inflammatory lesions that develop in the tissues around implants are collectively recognized as peri-implant diseases. Peri-implant disease includes peri-implant mucositis and periimplantitis. Peri-implant mucositis is a reversible inflammatory reaction in soft tissues surrounding a functioning implant with no signs of loss of supporting bone. Peri-implantitis is described as inflammatory reactions associated with loss of supporting bone around an implant in function. [1] The clinical presence of peri-implant disease requires periodontal probing to identify bleeding and/or suppuration, while radiographs are required to detect the presence (periimplantitis) or absence external f of marginal or crater-like bone loss. The pathogenesis of peri-implantitis seems to be related to the peri-implant environment and the soft tissue/implant interface, patient-related factors, and microbial factors. Potential causes include bacterial biologic complications [2,3], mechanical overload [4], or a combination of these factors. It has been suggested that microbial colonization of the implant surface and infection of the peri-implant tissues may result in peri-implant bone destruction [1]. Some reports have indicated a healing potential of peri-implant tissues following suppression of the peri-implant microbiota.[5] Because mechanical cleansing around implants is hampered by threads and often a rough surface structure, the use of mechanical debridement alone might not be sufficient to suppress the microflora to a level associated with healing and healthy peri-implant tissues.[6] The use of chemical agents (irrigation with local disinfectants, local or systemic antibiotic therapy) has been recommended to enhance healing after treatment.[7] The elimination of biofilm is essential in the management and control of peri-implant infections.[8,6] The screwshaped designs of dental implants, combined with surface modifications that allow for an enhanced osseointegration, may also enhance biofilm formation, and thereby increase the risk for inflammation.[9] Since the surface structure of the implant hinders to remove hard and soft deposits from the implant surface without surgical intervention, another treatment option may be regenerating bone defects around the implants. [10] The use of laser systems has been proposed for the treatment of peri-implant infections since lasers can perform excellent tissue ablation with high bactericidal and detoxification effects.[11] Another phenomenon called "retrograde periimplantitis" has been recently described in literature.[12,13] It is defined as a periapical radiolucency that develops shortly after implant insertion while the coronal portion of the implant achieves a healthy bone to implant interface and integrates well. This condition may be accompanied by symptoms of pain, tenderness, swelling and/or the presence of a fistula. Such lesions start at the implant apex but may exhibit the capacity of spreading coronally, proximally, and facially. It has been questioned whether or not implant characteristics such as diameter and surface structure may contribute to the development of peri-implant disease. Wider-diameter implants have been suggested in jaw regions with low-dense bone. They are used to avoid damage to the inferior

alveolar canal or maxillary sinus where there is inadequate bone available for implant placement.[14] In areas of a reduced buccolingual dimension (less than 4 mm in width), where the placement of a standard-diameter implant is not possible, narrow-diameter implants may be an alternative treatment.[15-17] Surfaces modifications with coating, surface blasting or acid treatments increase the surface area and roughness of the implant, which is proposed to improve osseointegration.[18-20] However, surface roughness may also increase the risk of periimplantitis [21]due to an increased susceptibility to bacterial infection and rapid osseous breakdown around the implant site.[22,23] The purpose of this systematic review was to answer three clinical questions:

1. What are the outcomes of treatment for peri-implant disease?
2. What is the relationship between implant diameter and peri-implant disease?
3. What is the relationship between surface structure of dental implants and peri-implant disease?

Material and Methods

Electronic Literature Database

In the first step, a systematic search in MEDLINE and the Cochrane Collaboration Library for literature published through July 2009 was conducted to identify studies reporting peri-implant disease with respect to the clinical questions identified above. Searches were done using standard MeSH terms (controlled vocabulary) as well as specific free-text terms and combinations of terms related to the clinical conditions. A subsequent hand search in the bibliographies of key articles followed to ensure each topic was comprehensively examined. The retrieved and examined full text articles of those remaining applied the same inclusion criteria once more.

Inclusion Criteria

For questions of efficacy or effectiveness of an intervention (i.e. treatment for peri-implant disease) or technology (i.e. implant diameter, implant surface structure), randomized controlled trials or comparative cohort studies were searched and included. Comparative cohort studies were defined as clinical studies comparing the treatment or technology of interest to another concurrent treatment or technology. Studies of prognosis that identified risks or rates of complications from endosseous dental implants were included if both, the numerator (number of cases with the complication or the number of complications) and the denominator (number of patients at risk for the complication) were reported. Results were limited to human cohorts, articles published in English, and articles that reported on peri-implant disease associated with endosseous dental implants. Only studies which reported both, clinical and radiographic diagnostic criteria for peri-implant disease, were evaluated.

Exclusion Criteria

Editorials, review articles without quantitative data, opinion articles, articles without scientific data or a report of their methodology, cadavers, and case reports were excluded (Figure 1). Studies with subjects less than 18 years of age and with less than 10 subjects were also omitted. For the first study question, studies specifically designed to evaluate

the outcomes of treatment for peri-implant disease were desired. To determine the relationship between implant diameter and peri-implant disease (study question #2), studies that specifically evaluated peri-implant outcomes associated with implant diameter were identified. To determine the relationship between surface structure of dental implants and peri-implant disease (study question #3), studies that evaluated peri-implant outcomes associated with dental implant surface structure were searched for.

Data Extraction

Each retrieved citation was reviewed by two independently working reviewers (D.N., D.J.F.). Most articles (61 %) were excluded on the basis of information provided by the title or abstract. Citations that appeared to be appropriate or those that could not be excluded from title or abstract were identified, and the corresponding full text reports were investigated. Any disagreement between the reviewers was resolved by consensus. The following data were extracted from the included articles: study design, study population characteristics, implant characteristics, definition of peri-implant disease, treatment/intervention for therapeutic studies, diagnostic tests and reference standards for diagnosis, outcome measures, study complications, and follow-up time.

Study Quality

Articles, which were selected for inclusion were classified by level of evidence. The method for assessing the quality of evidence and the overall quality of the body of evidence incorporates aspects of the rating scheme developed by the Oxford Centre for Evidence-based Medicine.[24] It was used with modification by The Journal of Bone and Joint Surgery American Volume (J Bone Joint Surg Am),[25] precepts outlined by the Grades of Recommendation Assessment, Development and Evaluation (GRADE) Working Group[26] and recommendations made by the Agency for Healthcare Research and Quality (AHRQ).[27] Each individual study was rated by two different investigators based on pre-set criteria that resulted in an evidence rating (Level of Evidence I, II, III, or IV). Disagreements were resolved through discussion.

Analysis

Outcomes were reported as the proportion of patients experiencing an outcome or mean values for gingival and radiographic parameters. Analysis was performed for quality of studies (level of evidence), quantity of studies (the number of published studies similar in patient population, condition treated and outcome assessed) and consistency of results across studies (whether the results of the different studies lead to a similar conclusion).[28,27] Data were summarized in tables. It was judged whether the retrieved literature represented a minimum standard for each of the three domains using the following criteria: for study quality, at least 80 % of the studies reported needed to be rated as a level of evidence I or II; for study quantity, at least three published studies were needed which were adequately powered to answer the study question; for study consistency, at least 70 % of the studies had to have consistent results. The overall strength of the selected literature was expressed in terms of the impact that further research may have on the results. An overall strength of "HIGH" means that further research is very unlikely to change the results or the confidence in the results. The

overall strength of "MODERATE" is interpreted as further research is likely to have an important impact on the results and may change the results. A grade of "LOW" means that further research is very likely to have an important impact on confidence in the results and likely to change the results, while "VERY LOW" means that any result reported is uncertain. (Figure 2).

Results

103 articles were identified reporting on implant structure and peri-implant disease or outcomes associated with treatment for peri-implant disease. 40 were involved in full text review, whereof 16 were excluded for the following reasons: In thirteen articles, outcome did not include peri-implant disease, and three treatment efficacy studies were poorly designed, Figure 3. Of the remaining 24 articles, 16 provided information on outcomes of treatment for peri-implant disease (study question 1), 3 reported on the relationship between implant diameter and peri-implant disease (study question 2), and 5 provided information on the relationship between implant surface structure and peri-implant disease (study question 3).

Question 1. What are the outcomes of treatment for peri-implant disease?

Several comparative studies attempted to evaluate treatment outcomes for peri-implant disease are highlighted in Table 1. Fifteen of these studies were randomized controlled trials graded level of evidence II[29-34,9,35-42] and one was a prospective cohort study graded level of evidence III.[43] Treatment modalities were categorized into chemical, mechanical and surgical interventions. Five studies reported on the outcomes of chemical treatments using antibacterials for peri-implant disease. Two of these studies found a beneficial change in gingival parameters after using local antibiotics (Atridox)[44]or antiseptic (Chlorhexidine) [32] compared to mechanical debridement. Studies evaluating the effects of antibiotic (Tetracycline[37] or Metronidazole gel [42]) to mechanical debridement did not influence gingival parameters. In one study a significant decrease in bleeding on probing in individuals who were treated with Arestin was found.[45] Two studies evaluated the effects of mechanical debridement using a Vector System compared to standard mechanical debridement. The autors did not find significant differences in gingival parameters between these two mechanical treatment modalities.[30,9] Surgical treatments for peri-implant disease were assessed in four studies.[31,35,43,41] In one study, periimplant defects were treated with a bone graft with or without a resorbable membrane and a significant decrease in periodontal probing depth in the group that received the resorbable membrane was found.[31] In another study implant surface modification was compared to resective surgery to treat peri-implant disease. Gingival parameters significantly improved in the surface modification group, while mucosal recession was significantly greater compared to the resective surgery group.[35] No differences in treatment outcomes were found in studies that investigated peri-implant defects with: a) bone substitute placement with vs. without a resorbable mem-

brane, [43] or b) natural bone placement with a resorbable membrane compared to bone substitute placement with no membrane.[41]

Question 2. What is the relationship between implant diameter and peri-implant disease?

One prospective cohort graded level of evidence III [46] and 2 case series graded level of evidence IV that evaluated the relationship between implant diameter and peri-implant disease were identified. (Table 2) In the prospective cohort study 68 patients were treated with small (3.3 mm) diameter titanium plasma-sprayed (TPS) implants while 120 patients received standarddiameter (4.1 mm) TPS implants. Peri-implantitis was reported in 5.7 % (n=7/122) of narrow diameter implants and 3.4 % (n=7/208) of standard diameter implants.[46] Three narrow diameter and 2 standard diameter implants failed secondary to peri-implantitis. Additionally, 3 narrow diameter and 2 standard diameter implants experienced pathologic peri-implant bone resorption as a result of peri-implantitis. There were no significant differences in gingival parameters between the two groups.

Question 3. What is the relationship between surface structure of dental implants and periimplant disease?

Four comparative studies and one noncomparative study evaluated the relationship between surface structure of dental implants and peri-implant disease.(Table 3) The studies differentiated as follows: One was a meta-analysis of randomized controlled trials graded level of evidence I [47], one was a prospective cohort graded level of evidence II, [48] one was a prospective and retrospective cohort graded level of evidence II-III,[13] one was a retrospective cohort graded level of evidence III, [49] and one was a case series graded level of evidence IV.[50] Esposito and colleagues [47] performed a meta-analysis to evaluate the frequency of periimplantitis in implants with turned (machined) surfaces compared to those with roughened surfaces at 3 years following placement. Three randomized controlled trials were included [51,52,47,53] Peri-implantitis was significantly less in implants with turned compared o roughened surfaces (RR=0.80, 95 % CI: 0.67-0.98).

In a prospective cohort study[48], 89 patients were treated with 112 hollow screw, 49 hollow cylinder, or 18 angulated hollow cylinder implants and were followed for 8 to 12 years. The incidence of peri-implantitis was 15.4 % (n=27/179). The incidence was greatest for hollow cylinder implants (29 %), followed by angulated hollow cylinder implants (12 %), and then hollow screw implants (10 %). The incidence of peri-implantitis was significantly greater for hollow cylinder compared to hollow screw implants (p<.03). In a retrospective cohort study [54], standard (n=53), self-tapping (n=14), MKII (n=320), MKIII machined (n=72), and roughened TiUnite (n=80) implants were placed and evaluated for he presence of retrograde peri-implantitis. The frequency of retrograde peri-implantitis was 9 %. The prevalence of retrograde peri-implantitis was significantly greater in TiUnite (10.0 %) ompared to machined (0.4 %) implants (p<.0001).

Evidence Summary

The overall strength of evidence with respect to treatment outcomes for peri-implant disease is “Low”. The outcomes of treatment are unclear and further research could alter the results. Theoverall strength of evidence for the relationship between implant diameter and peri-implant disease is “Very Low”, indicating that, any result reported is uncertain. The overall strength of evidence for the relationship between implant surface structure and peri-implant disease is “Moderate” to “Low”, that means that, for surface microstructure, results are likely to have an important impact on the results and may change the results, and for surface macrostructure, further research is likely to change the results. The overall strength of evidence for each key question is highlighted in Table 4. The evidence levels stratified for the questions above, the summarized findings in the studies as well as a definition of the different levels of evidence for articles on therapy and prognosis of peri-implant diseases are in Table 5-11.

Discussion

This systematic review showed that there is a wide variety of treatment modalities for periimplant disease but just few significance.

1. Chemical treatments, in addition to mechanical debridement, may have a beneficial effect upon gingival parameters. There appears to be no difference between types of mechanical treatment for peri-implant disease. There is minimal evidence proving that modification of the implant surface may have a beneficial effect upon peri-implant gingival parameters.

2. The rate of peri-implantitis in small diameter implants is reported to be 2.3 to 5.7 %. One comparative study demonstrated that the rate of peri-implantitis was greater in small diameter implants, though the difference was not statistically significant. One case series of large diameter implants reported no cases of peri-implantitis. So no direct influence from diameter to peri-implantitis could be found.

3. The risk of peri-implantitis was greater in roughened surface microstructure compared to machined dental implants. The small number of studies limits conclusions with respect to treatment outcomes for periimplant disease as well as prognostic factors such as implant diameter and surface structure that may contribute to the risk for peri-implant disease. Additional studies may provide a more robust estimation if implant characteristics are associated with peri-implantitis.

References

1. Albrektsson TaIF (1994) Consensus report of session iv. Proceedings of the First European Workshop on Periodontology. London

2. Mombelli A, van Oosten MA, Schurch E, Jr., Land NP, Rutar A, Lang NP, Buser D, BurginW, Isidor F, Langer B, Langer L, Herrmann I, Jorneus L, Polizzi G, Fabbro S, Furri M,
Squarzoni S, Zinsli B, Sagesser T, Mericske E, Mericske-Stern R, Albrektsson T, Wennerberg A, Cochran DL, Shalabi MM, Gortemaker A, Van`t Hof MA, Jansen JA, Creugers NH, Wright JG, Swiontkowski MF, Heckman JD, West S, King V, Carey TS, Lohr KN, McKoy N, Sutton SF, Lux L, van Tulder M, Furlan A, Bombardier C, Bouter L, Schou S, Berglundh T, Deppe H, Horch HH, Henke J, Donath K (1987) The microbiota associated with successful or failing osseointegrated titanium implants retrospective assessment of clinical and microbiological factors affecting periimplant tissue conditions loss of osseointegration caused by occlusal load of oral implants. A clinical and radiographic study in monkeys microbiology and antimicrobial therapy of peri-implantitis the wide fixture: A solution for special bone situations and a rescue for the compromised
implant. Part 1
clinical application of narrow branemark system implants for single-tooth restorations
clinical evaluation of small-diameter iti implants: A prospective study oral implant surfaces: Part 1–review focusing on topographic and chemical properties of different surfaces and in vivo responses to them a comparison of endosseous dental implant surfaces implant surface roughness and bone healing: A systematic review oral implant surfaces: Part 2–review focusing on clinical knowledge of different surfaces introducing levels of evidence to the journal systems to rate the strength of scientific evidence updated method guidelines for systematic reviews in the cochrane collaboration back review group surgical treatment of peri-implantitis per-implant care of ailing implants with the carbon dioxide laser. Oral Microbiol Immunol 2 (4):145-151

3. Rutar A, Lang NP, Buser D, Burgin W, Mombelli A (2001) Retrospective assessment of
clinical and microbiological factors affecting periimplant tissue conditions. Clin Oral Implants Res 12 (3):189-195

4. Isidor F (1996) Loss of osseointegration caused by occlusal load of oral implants. A clinical and radiographic study in monkeys. Clin Oral Implants Res 7 (2):143-152

5. Klinge B, Gustafsson A, Berglundh T (2002) A systematic review of the effect of antiinfective therapy in the treatment of peri-implantitis. J Clin Periodontol 29 Suppl 3:213-225; discussion 232-213

6. Schwarz F, Papanicolau P, Rothamel D, Beck B, Herten M, Becker J (2006) Influence of
plaque biofilm removal on reestablishment of the biocompatibility of contaminated titanium
surfaces. J Biomed Mater Res A 77 (3):437-44

7. Mombelli A, Lang NP (1992) Antimicrobial treatment of peri-implant infections. Clin Oral
Implants Res 3 (4):162-168

8. Mombelli A, Lang NP (2000) Microbial aspects of implant dentistry. Periodontol 4:74-80

9. Renvert S, Samuelsson E, Lindahl C, Persson GR (2009) Mechanical non-surgical treatment of peri-implantitis: A double-blind randomized longitudinal clinical study. I: Clinical results. J Clin Periodontol 36 (7):604-609
10. Schou S, Berglundh T, Lang NP (2004) Surgical treatment of peri-implantitis. Int J Oral Maxillofac Implants 19 Suppl:140-149
11. Deppe H, Horch HH, Neff A (2007) Conventional versus co2 laser-assisted treatment of peri-implant defects with the concomitant use of pure-phase beta-tricalcium phosphate: A 5-year clinical report. Int J Oral Maxillofac Implants 22 (1):79-86
12. Ayangco L, Sheridan PJ (2001) Development and treatment of retrograde peri-implantitis involving a site with a history of failed endodontic and apicoectomy procedures: A series of reports. Int J Oral Maxillofac Implants 16 (3):412-417
13. Quirynen M, Vogels R, Alsaadi G, Naert I, Jacobs R, van Steenberghe D (2005) Predisposing conditions for retrograde peri-implantitis, and treatment suggestions. Clin Oral Implants Res 16 (5):599-608
14. Langer B, Langer L, Herrmann I, Jorneus L (1993) The wide fixture: A solution for special bone situations and a rescue for the compromised implant. Part 1. Int J Oral Maxillofac Implants 8 (4):400-408
15. Andersen E, Saxegaard E, Knutsen BM, Haanaes HR (2001) A prospective clinical study evaluating the safety and effectiveness of narrow-diameter threaded implants in the anterior region of the maxilla. Int J Oral Maxillofac Implants 16 (2):217-224
16. Polizzi G, Fabbro S, Furri M, Herrmann I, Squarzoni S (1999) Clinical application of narrow branemark system implants for single-tooth restorations. Int J Oral Maxillofac Implants 14 (4):496-503
17. Zinsli B, Sagesser T, Mericske E, Mericske-Stern R (2004) Clinical evaluation of smalldiameter iti implants: A prospective study. Int J Oral Maxillofac Implants 19 (1):92-99
18. Albrektsson T, Wennerberg A (2004) Oral implant surfaces: Part 1–review focusing on topographic and chemical properties of different surfaces and in vivo responses to them. Int J Prosthodont 17 (5):536-543
19. Cochran DL (1999) A comparison of endosseous dental implant surfaces. J Periodontol 70 (12):1523-1539
20. Shalabi MM, Gortemaker A, Van`t Hof MA, Jansen JA, Creugers NH (2006) Implant surface roughness and bone healing: A systematic review. J Dent Res 85 (6):496-500
21. Becker W, Becker BE, Ricci A, Bahat O, Rosenberg E, Rose LF, Handelsman M, Israelson H (2000) A prospective multicenter clinical trial comparing one- and two-stage titanium screwshaped fixtures with one-stage plasma-sprayed solid-screw fixtures. Clin Implant Dent Relat Res 2 (3):159-165

22. Albrektsson T, Wennerberg A (2004) Oral implant surfaces: Part 2--review focusing on clinical knowledge of different surfaces. Int J Prosthodont 17 (5):544-564
23. Morris HF, Ochi S, Spray JR, Olson JW (2000) Periodontal-type measurements associated with hydroxyapatite-coated and non-ha-coated implants: Uncovering to 36 months. Ann Periodontol 5 (1):56-67
24. Phillips B, Ball C, Sackett D, Badenoch D, Straus S, Haynes B, Dawes M (2001) Levels of evidence and grades of recommendation. Available at:
Http://www.Cebm.Net/levels_of_evidence.Asp. Accessed December 2, 2006 2006
25. Wright JG, Swiontkowski MF, Heckman JD (2003) Introducing levels of evidence to the journal. J Bone Joint Surg Am 85-A (1):1-3
26. Atkins D, Best D, Briss PA, Eccles M, Falck-Ytter Y, Flottorp S, Guyatt GH, Harbour RT, Haugh MC, Henry D, Hill S, Jaeschke R, Leng G, Liberati A, Magrini N, Mason J, Middleton P, Mrukowicz J, O`Connell D, Oxman AD, Phillips B, Schunemann HJ, Edejer TT, Varonen H, Vist GE, Williams JW, Jr., Zaza S (2004) Grading quality of evidence and strength of recommendations. Bmj 328 (7454):1490
27. West S, King V, Carey TS, et.al. (2002) Systems to rate the strength of scientific evidence. Evidence report/technology assessment no. 47 (prepared by the research triangle instituteuniversity of north carolina evidence-based practice center, contract no. 290-97-0011). Agency for Healthcare Research and Quality, Rockville, MD,
28. van Tulder M, Furlan A, Bombardier C, Bouter L (2003) Updated method guidelines for systematic reviews in the cochrane collaboration back review group. Spine 28 (12):1290-1299
29. Buchter A, Kleinheinz J, Meyer U, Joos U (2004) Treatment of severe peri-implant bone loss using autogenous bone and a bioabsorbable polymer that delivered doxycycline (atridox). Br J Oral Maxillofac Surg 42 (5):454-456
30. Karring ES, Stavropoulos A, Ellegaard B, Karring T (2005) Treatment of peri-implantitis by the vector system. Clin Oral Implants Res 16 (3):288-293
31. Khoury F, Buchmann R (2001) Surgical therapy of peri-implant disease: A 3-year follow-up study of cases treated with 3 different techniques of bone regeneration. J Periodontol 72 (11):1498-1508
32. Porras R, Anderson GB, Caffesse R, Narendran S, Trejo PM (2002) Clinical response to 2 different therapeutic regimens to treat peri-implant mucositis. J Periodontol 73 (10):1118-1125
33. Renvert S, Lessem J, Dahlen G, Lindahl C, Svensson M (2006) Topical minocycline microspheres versus topical chlorhexidine gel as an adjunct to mechanical debridement of incipient peri-implant infections: A randomized clinical trial. J Clin Periodontol 33 (5):362-369
34. Renvert S, Roos-Jansaker AM, Claffey N (2008) Non-surgical treatment of peri-implant mucositis and peri-implantitis: A literature review. J Clin Periodontol 35 (8 Suppl):305-315
35. Romeo E, Ghisolfi M, Murgolo N, Chiapasco M, Lops D, Vogel G (2005) Therapy of periimplantitis with resective surgery. A 3-year clinical trial on rough screw-shaped oral implants. Part i: Clinical outcome. Clin Oral Implants Res 16 (1):9-18

36. Romeo E, Lops D, Chiapasco M, Ghisolfi M, Vogel G (2007) Therapy of peri-implantitis with resective surgery. A 3-year clinical trial on rough screw-shaped oral implants. Part ii: Radiographic outcome. Clin Oral Implants Res 18 (2):179-187
37. Schenk G, Flemmig TF, Betz T, Reuther J, Klaiber B (1997) Controlled local delivery of tetracycline hcl in the treatment of periimplant mucosal hyperplasia and mucositis. A controlled case series. Clin Oral Implants Res 8 (5):427-433
38. Schwartz-Arad D, Mardinger O, Levin L, Kozlovsky A, Hirshberg A (2005) Marginal bone loss pattern around hydroxyapatite-coated versus commercially pure titanium implants after up to 12 years of follow-up. Int J Oral Maxillofac Implants 20 (2):238-244
39. Schwarz F, Bieling K, Bonsmann M, Latz T, Becker J (2006) Nonsurgical treatment of moderate and advanced periimplantitis lesions: A controlled clinical study. Clin Oral Investig 10 (4):279-288
40. Schwarz F, Bieling K, Latz T, Nuesry E, Becker J (2006) Healing of intrabony periimplantitis defects following application of a nanocrystalline hydroxyapatite (ostim) or a bovine xenograft (bio-oss) in combination with a collagen membrane (bio-gide). A case series. J Clin Periodontol 33 (7):491-499
41. Schwarz F, Sculean A, Bieling K, Ferrari D, Rothamel D, Becker J (2008) Two-year clinical results following treatment of peri-implantitis lesions using a nanocrystalline hydroxyapatite or a natural bone mineral in combination with a collagen membrane. J Clin Periodontol 35 (1):80-87
42. Tang Z, Cao C, Sha Y, Lin Y, Wang X (2002) Effects of non-surgical treatment modalities on peri-implantitis. Zhonghua Kou Qiang Yi Xue Za Zhi 37 (3):173-175
43. Roos-Jansaker AM, Renvert H, Lindahl C, Renvert S (2007) Surgical treatment of periimplantitis using a bone substitute with or without a resorbable membrane: A prospective cohort study. J Clin Periodontol 34 (7):625-632
44. Buchter A, Meyer U, Kruse-Losler B, Joos U, Kleinheinz J (2004) Sustained release of doxycycline for the treatment of peri-implantitis: Randomised controlled trial. Br J Oral Maxillofac Surg 42 (5):439-444
45. Renvert S, Lessem J, Dahlen G, Renvert H, Lindahl C (2008) Mechanical and repeated antimicrobial therapy using a local drug delivery system in the treatment of peri-implantitis: A randomized clinical trial. J Periodontol 79 (5):836-844
46. Romeo E, Lops D, Amorfini L, Chiapasco M, Ghisolfi M, Vogel G (2006) Clinical and radiographic evaluation of small-diameter (3.3-mm) implants followed for 1-7 years: A longitudinal study. Clin Oral Implants Res 17 (2):139-148
47. Esposito M, Coulthard P, Thomsen P, Worthington HV (2005) The role of implant surface modifications, shape and material on the success of osseointegrated dental implants. A cochrane systematic review. Eur J Prosthodont Restor Dent 13 (1):15-31

48. Karoussis IK, Bragger U, Salvi GE, Burgin W, Lang NP (2004) Effect of implant design on survival and success rates of titanium oral implants: A 10-year prospective cohort study of the iti dental implant system. Clin Oral Implants Res 15 (1):8-17
49. Teixeira ER, Sato Y, Akagawa Y, Kimoto T (1997) Correlation between mucosal inflammation and marginal bone loss around hydroxyapatite-coated implants: A 3-year crosssectional study. Int J Oral Maxillofac Implants 12 (1):74-81
50. Tang Z, Sha Y, Lin Y, Zhang G, Wang X, Cao C (2000) Peri-implant mucosal inflammation and bone loss: Clinical and radiographic evaluation of 108 dental implants after 1-year loading. Chin J Dent Res 3 (2):15-20
51. Astrand P, Engquist B, Anzen B, Bergendal T, Hallman M, Karlsson U, Kvint S, Lysell L, Rundcrantz T (2002) Nonsubmerged and submerged implants in the treatment of the partially edentulous maxilla. Clin Implant Dent Relat Res 4 (3):115-127
52. Astrand P, Engquist B, Dahlgren S, Engquist E, Feldmann H, Grondahl K (1999) Astra tech and branemark system implants: A prospective 5-year comparative study. Results after one year. Clin Implant Dent Relat Res 1 (1):17-26
53. Moberg LE, Kondell PA, Sagulin GB, Bolin A, Heimdahl A, Gynther GW (2001) Branemark system and iti dental implant system for treatment of mandibular edentulism. A comparative randomized study: 3-year follow-up. Clin Oral Implants Res 12 (5):450-461
54. Quirynen M, Abarca M, Van Assche N, Nevins M, van Steenberghe D (2007) Impact of supportive periodontal therapy and implant surface roughness on implant outcome in patients with a history of periodontitis. J Clin Periodontol 34 (9):805-815

Figure Legends

Figure 1. Inclusion and Exclusion criteria.
Figure 2. Definition of overall strength of evidence.
Figure 3. Flow chart showing results of literature search

Table Legends

Table 1. Summary studies comparing treatment outcomes for peri-implant disease
Table 2. Summary of studies evaluating outcomes associated with diameter of endosseous dental implants
Table 3. Summary of studies evaluating outcomes associated with surface structure of endosseous dental implants
Table 4. Rating of overall strength of evidence for each key question.
Table 5. Level of Evidence grade for studies comparing treatments for peri-implant disease associated with endosseous dental implants
Table 6. Level of Evidence grade for studies evaluating the association between implant diameter and peri-implant disease in endosseous dental implants
Table 7. Level of Evidence grade for studies evaluating the association between implant surface structure and peri-implant disease in

endosseous dental implants
Table 8. Detailed information on studies comparing treatments for peri-implant disease associated with endosseous dental implants
Table 9. Detailed information on studies evaluating peri-implantitis associated with endosseous dental implant diameter
Table 10. Detailed information on studies evaluating peri-implantitis associated with endosseous dental implant surface structure
Table 11. Definition of the different levels of evidence for articles on therapy and prognosis

Figure 1. Inclusion 1 and Exclusion criteria.

Study Component	Inclusion	Exclusion
Participants	• Adults • Patients with peri-impla titis (question #1) • Patients with and without peri-implantitis (question #2 and #3)	• Animal • ≤ 10 in each treatment group • <18 years of age
Intervention	• Patients treated for peri-implantitis as a result of dental implant surgery (question #1) • Patients treated with dental implants (questions #2 and #3)	• No surgery or treatment other than dental implants
Comparator	• No treatment given or other treatments than primary intervention for peri-implantitis • Patients treated with dental implants (questions #2 and #3)	• NA
Outcomes	• Outcomes of treatment for peri-implantitis • Correlation between implant diameter and peri-implantitis • Correlation between implant surface structure and peri-implantitis	• Outcomes not associated with treatment for peri-implantitis

Figure 2. Definition of overall 1 strength of evidence.

Overall Strength of Evidence	Further Research Impact	Domain Criterion Met		
		Quality	Quantity	Consistency
HIGH	Very unlikely to change the results or the confidence in the results	+	+	+
MODERATE	Likely to have an important impact on the results and may change the results	+	-	+
		+	+	-
LOW	Very likely to have an important impact on confidence in the results and likely to change the results	+	-	-
		-	+	+
VERY LOW	Any result reported is uncertain	-	+	-
		-	-	+
		-	-	-

Figure 3. Flow chart showing results 1 of literature search.

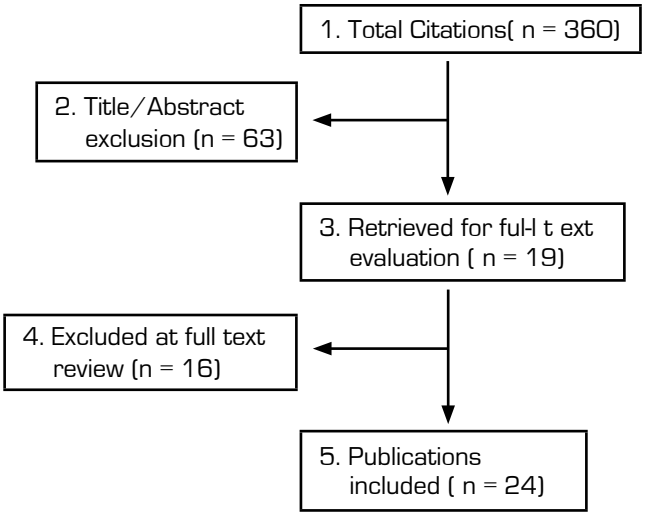

Table 1. Summary studies comparing treatment outcomes for peri-implant disease

		LoE	Outcomes	No. of Studies	Antibacterial Mean SD	Mechanical Debridement Mean SD	Effect Size	Favors*
Chemical	Atridox	II	BOP Change	1 (Bucher 2004)	0.27±0.06 mm	0.13±0.08 mm	p=.01	**Atridox**
			PPD Change		1.15±0.23 mm	0.56±0.30 mm	p<.05	**Atridox**
			PAL Change		1.17±0.27 mm	0.56±0.30 mm	p<.03	**Atridox**
	CHX	I1	PPD	1 [32]	0.56 mm	0.93 mm	p<.05	**CHX**
			PAL		0.33 mm	1.07 mm	p<.05	**CHX**
	Arestin vs. CHX	II	Plaque Score	1 (Renvert, 2008)	27±24 %	27±45 %	p>.05	Neither
			BOP		48.1±20.7 %	63.5±19.2 %	p<.001	**Arestin**
			PPD		3.55±0.98 mm	3.72±1.02 mm	p>.05	Neither
			MBL		0.70±0.85 mm	0.46±0.76 mm	p>.05	Neither
			# Bacteria		1.6±4.5	1.4±4.2	p>.05	Neither
	Tetracycline	II	mPI Change	1 (Schenk 1997)	0.11±0.15	0.01±0.53	p>.05	Neither
			BOP Change		-17±25 %	15±37 %	p>.05	Neither
	Metronidazole Gel	II	BOP Change	1 (Tang 2002)	0.7±1.0 mm	0.9±1.6 mm	p>.05	Neither
Mechanical		**LoE**	**Outcomes**	**No. of Studies**	**Vector System Mean ± SD**	**Mechanical Debridement Mean ± SD**	**Effect Size**	**Favors***
		II	BOP	1 (Karring 2005)	36.4 %	81.8 %	p>.05	Neither
			PPD		5.8±1.2 mm	6.3±2.2 mm	p>.05	Neither
			MBL Change		-0.3±1.0 mm	-0.3±0.8 mm	p>.05	Neither
		I1	Plaque Score	1 (Renvert 2009)	51.3±23.9 %	54.9±29.5 %	p>.05	Neither
			BOP		28.7±26.4 %	34.3±28.2 %	p>.05	Neither
			PPD		3.9±0.8 mm	4.0±0.8 mm	p>.05	Neither
		CoE	**Outcomes**	**Studies**	**Case Mean ± SD**	**Control Mean ± SD**	**Effect Size**	**Favors***
	Bone graft with vs. without resorb membrane	II	PPD Change	1 (Khoury 2001)	2.6±1.6 mm	5.1±2.7 mm	p<.05	Membrane
			Intrabony Defect Change		1.9±3.2 mm	2.4±2.7 mm	Incalculable	Neither
Surgical	Implant surf modification vs. resective surgery	II	Implant Survival	1 (Romeo 2005)	100 % (19/19)	87.5 % (14/16)		Neither
			mBI		0.88±0.33	1.00±0.63	p<.05	**Surf mod**
			PPD		3.58±1.06 mm	5.50±1.47 mm	p<.05	**Surf mod**
			Mucosal recession		2.30±1.45 mm	1.64±1.29 mm	p<.05	**Surgery**
			PAL		5.89±2.02 mm	7.04±1.67 mm	p<.05	**Surf mod**
	Bone substitute with vs. without resorb membrane	II	Intrabony Defect Change	1 (Roos-J 2007)	1.52±1.16 mm	1.44±1.27 mm	NR	Neither
			PPD Change		2.86±2.00 mm	3.44±1.58 mm	p>05	Neither
			Mucosal recession		-1.28±1.51 mm	-1.61±1.61 mm	p>05	Neither
			PAL Change		1.59±2.00 mm	1.80±1.37 mm	p>05	Neither
	Bone+resorb membrane vs. bone substitute	II	mPI Change	1 (Schwarz 2008)	0.7±0.5	0.4±0.5	NR	Neither
			BOP Change		36 %	44 %	NR	Neither
			PPD Change		1.5±0.6 mm	2.4±0.8 mm	NR	Neither
			Mucosal recession		0.5±0.5 mm	0.4±0.4 mm	NR	Neither
			PAL Change		1.0±0.4 mm	2.0±0.8 mm	NR	Neither

* p<.05, bold indicates statistical significance
mBI = modified bleeding sulcus index (bleeding tendency of marginal peri-implant tissues), PPD = periodontal probing depth (linear distance from the peri-implant gingival margin to the bottom of the peri-implant pocket), PAL = probing attachment level (distance from the implant shoulder to the bottom of the peri-implant pocket), BOP = bleeding on probing (presence of bleeding within 30 seconds after the pocket had been probed), MBL = marginal bone loss on radiographs, mPI = modified plaque index (plaque accumulation)

Table 2. Summary of studies evaluating outcomes associated with diameter of endosseous dental implants

LoE	Outcome	No. of Studies	Narrow Diameter	Standard Diameter	Large Diameter	Effect Size-Narrow/ Standard RR (95 % CI)	Favors*
	Peri-Implantitis	Romeo	5.7 % (7/122)	3.4 % (7/208)		1.7 (0.6, 4.7)	Neither
	Implant Failure due to Peri-Implantitis		2.5 % (3/122)	1.0 % (2/208)		2.6 (0.4, 15.1)	Neither
	Peri-Implant bone resorption due to Peri-Implantitis		2.5 % (3/122)	1.0 % (2/208)		2.6 (0.4, 15.1)	Neither
III			**Narrow Diameter Mean ± SD**	**Standard Diameter Mean ± SD**		**Effect Size**	**Favors***
	Modified Bleeding Index		0.3 ± 0.5	0.4 ± 0.5		NR	Neither
	Periodontal Probing Depth		2.2 ± 1.6 mm	2.1 ± 1.7 mm		NR	Neither
	Marginal Bone Loss		1.5 ± 1.5 mm	1.4 ± 1.1 mm		NR	Neither
IV	**Peri-Implantitis**	Zinsli	2.3 % (7/298)				
	Peri-Implantitis	Prosper			0.0 % (0/111)		

* p<.05, bold indicates statistical significance

Table 3. Summary of studies evaluating outcomes associated with surface structure of endosseous dental implants

LoE	Outcome	Author	Machined	Roughened		Effect Size-Machined/ Roughened RR (95 % CI)		Favors*
I	**Peri-Implantitis**	Esposito				0.80 (0.67, 0.98)		**Machined**
III	**Retrograde Peri-Implantitis**	Quirynen	0.4 % (2/459)	10.0 % (8/80)		0.04 (0.01, 0.20)		**Machined**
III			**Hollow Screw [56]**	**Hollow Cylinder (HC)**	**Angulated Hollow Cylinder (AHC)**	**Effect Size-HC/HS RR (95 % CI)**	**Effect Size-AHC/HS RR (95 % CI)**	**Favors***
	Peri-Implantitis	Karoussis	10.0 % (11/112)	29.0 % (14/49)	12.0 % (2/18)	2.9 (1.4, 5.9)	1.13 (0.3, 4.7)	**Hollow Screw**
			Mean ± SD HS	**Mean ± SD HS**	**Mean ± SD HS**	**Effect Size-HC/HS**	**Effect Size-AHC/HS**	**Favors***
	Modified Plaque Index	1 (Karoussis 2004)	2.6 ± 0.9 mm	2.2 ± 1.6 mm	2.1 ± 1.7 mm	NR	NR	Neither
	Periodontal Probing Depth		2.6 ± 0.9 mm	3.1 ± 1.4 mm	3.1 ± 1.1 mm	HC>HS, p<.05	NR	**Hollow Screw**
	Bleeding on Probing		0.4 ± 0.4 mm	0.5 ± 0.3 mm	0.5 ± 0.3 mm	HC>HS, p<.05	NR	**Hollow Screw**

* p<.05, bold indicates statistical significance

Table 4. Rating of overall strength of evidence for each key question.

			Domain Criterion Quality: > 80 % of studies LoE I or II Quantity: 3+ studies adequately powered Consistency: Results lead to similar conclusions		
	Strength of evidence	**Conclusions/Comments**	**Quality**	**Quantity**	**Consistency**
Question 1: What are the outcomes of treatment for peri-implant disease?					
Outcomes chemical	**Low evidence** (Further research is likely to change the results or the confidence in the results)	• A beneficial change in gingival parameters was reported with the use of Atridox with mechanical debridement in 1 study, and 0.12 % chlorhexidine with mechanical debridement in another study.	+	-	-
mechanical	**Low evidence** (Further research is likely to change the results or the confidence in the results)	• Two studies reported no differences in gingival parameters when comparing the Vector System to mechanical debridement for treatment of peri-implant disease.	+	-	-
surgical	**Low evidence** (Further research is likely to change the results or the confidence in the results)	• Gingival parameters improved after implant surface modification compared to resective surgery in one study.	+	-	-
Question 2: What is the relationship between implant diameter and peri-implant disease?					
Narrow Diameter	**Very low evidence** (any result reported is uncertain)	• The rate of peri-implantitis in narrow diameter implants was 2.3-5.7 %.	-	-	+
Large Diameter	**Very low evidence** (any result reported is uncertain)	• One case series reported a 0 % rate of peri-implantitis associated with large diameter (5.9 mm) implants	-	-	+
Question 3: What is the relationship between implant surface structure and peri-implant disease?					
Roughened Microstructure	**Moderate evidence** (Likely to have an important impact on the results and may change the results)	• A meta-analysis reported an increased risk of peri-implantitis in roughened compared to machined surface implants. A greater rate of retrograde periimplantitis was reported in implants with roughened surfaces (10.0 %) compared to machined-surface implants (0.4 %).	+	-	+
Macrostructure	**Low evidence** (Further research is likely to change the results or the confidence in the results)	• One study reported a 29 % rate of peri-implantitis in hollow cylinder implants, 12 % in angulated hollow cylinder, and 10 % in hollow screw implants.	+	-	-

Table 5. Level of Evidence grade for studies comparing treatments for periimplant disease associated with endosseous dental implants

Methodological Principle	Buchter 2004	Karring 2005	Khoury 2001	Porras 2002	Renvert 2006	Renvert 2008	Romeo 2005	Romeo 2007	Roos-Jansakar 2007	Schenk 1997
Study design										
Randomized controlled trial	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Prospective cohort study										
Retrospective cohort study										
Case control										
Patients at similar point in the course of their disease or treatment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Patients followed long enough for outcomes to occur	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Complete follow-up of >80 %	✓	✓	✓	✓	✓	✓	✓	v	✓	✓
Controlling for extraneous prognostic factors*										
Evidence Level	II	II	II	II	II	II	II	II	II	II

Methodological Principle	Schwarz 2005	Schwarz 2006a	Schwarz 2006b	Schwarz 2008	Tang 2002
Study design					
Randomized controlled trial	✓	✓	✓	✓	✓
Prospective cohort study					
Retrospective cohort study					
Case Control					
Patients at similar point in the course of their disease or treatment	✓	✓	✓	✓	✓
Patients followed long enough for outcomes to occur	✓	✓	✓	✓	✓
Complete follow-up of >80 %	✓	✓	✓	✓	✓
Controlling for extraneous prognostic factors*	✓	✓	✓	✓	✓
Evidence Level	II	II	II	II	II

Table 6. Level of Evidence grade for studies evaluating the association between implant diameter and peri-implant disease in endosseous dental implants

Methodological Principle	Romeo 2006	Zinsli 2004	Prosper 2003
Study design			
Randomized controlled trial			
Prospective cohort study	✓		
Retrospective cohort study			
Case Control			
Case Series		✓	✓
Patients at similar point in the course of their disease or treatment	✓	✓	✓
Patients followed long enough for outcomes to occur	✓	✓	✓
Complete follow-up of >80 %	✓	✓	✓
Controlling for extraneous prognostic factors			
Evidence Level	**III**	**IV**	**IV**

Table 7. Level of Evidence grade for studies evaluating the association between implant surface structure and peri-implant disease in endosseous dental implants

Methodological Principle	Esposito 2005	Karoussis 2004	Quirynen 2005	Tang 2000	Teixeira 1997
Study design					
Randomized controlled trial	✓				
Prospective cohort studyv		✓	✓		
Retrospective cohort study			✓		✓
Case Control					
Case Series				✓	
Patients at similar point in the course of their disease or treatment	✓	✓		✓	✓
Patients followed long enough for outcomes to occur	✓	✓	✓	✓	✓
Complete follow-up of >80 %	✓	✓	✓	✓	✓
Controlling for extraneous prognostic factors	✓	✓	✓		
Evidence Level	**I**	**II**	**II-III**	**IV**	**III**

Detailed Tables

Table 8. Detailed information on studies comparing treatments for peri-implant disease associated with endosseous dental implants

AUTHOR (YEAR)	STUDY DESIGN	LOE	POPULATION	POPULATION/IMPLANT CHARACTERISTICS	TREATMENT / INTERVENTION	RESULTS (OUTCOMES)	COMPLICATIONS
Buchter (2004)	Randomized controlled trial	II	N=28 Male: 21.4 % Mean age: 55±16 (25-78) years F/U: 18 weeks F/U %: NR	Diagnosis of chronic periimplantitis. Bone defects ≥50 % implant length. Full-mouth debridement and subgingival irrigation of peri-implant defects with 0.2 % chlorhexidine digluconate solution 2-18 weeks before baseline examination	Subgingival local debridement (controls, N=14) or local debridement with topical application of 8.5 % doxycycline hyclate (Atridox; Block Drug Corp, Jersey City, NJ) (cases, N=14)	BOP change (18 wk), p=.01 Atridox: 0.27 ± 0.06 mm Control: 0.13 ± 0.08 mm PPD change (18 wk), p<.05 Atridox: 1.15 ± 0.23 mm Control : 0.56 ± 0.30 mm PAL change (18 wk), p<.03 Atridox: 1.17 ± 0.27 mm Control : 0.56 ± 0.30 mm	NR
Karring (2005)	Randomized controlled trial	II	N=11 Male: 45.5 % Age range: 50-78 years F/U: 6 months F/U %: NR	At least 2 screw-type implants of the same brand with periimplantitis. Diagnosis of peri-implantitis: BOP, PPD ≥5 mm, ≥1.5 mm radiographic bone loss	One implant treated with Vector system (case; hydrodynamic flow system combined with fine polishing particles), and the other implant was treated with submucosal debridement with a carbon fiber curette (control)	BOP (6 mo), p>.05 Vector: 36.4 % (n=4) Control: 81.8 % (n=9) PPD (6 mo), p>.05 Vector: 5.8 ± 1.2 mm Control : 6.3 ± 2.2 mm MBL change (6 mo), p>.05 Vector: -0.3 ± 1.0 mm Control : -0.3 ± 0.8 mm	NR
Khoury (2001)	Randomized controlled trial	II	N=25; Ni=41 Male: 12 % Mean age 48.2±6.3 (43-53) years F/U: 3 years F/U %: NR	Peri-implant disease with intrabony defects >50 % implant length; history of mechanical debridement + 0.2 % CHX gel	Peri-implant defects augmented with flap surgery and autogenous bone grafts along (control; N=7) or, in addition, non-resorbable (test 1; N=11) or bioabsorbable barrier membranes (test 2; N=7).	PPD change (3 yr), p<.05 Test 2 vs. Control Test 1: 5.4 ± 3.0 mm Test 2: 2.6 ± 1.6 mm Control : 5.1 ± 2.7 mm Intrabony defect height change (3 yr), p>.05 Test 1: 2.8 ± 3.1 mm Test 2: 1.9 ± 3.2 mm Control : 2.4 ± 2.7 mm	Dehiscence Test 1: 36.3 % (n=4/11) Test 2: 28.6 % (n=2/7) Fistula Test 1: 18.2 % (n=2/11) Sequestra Test 1: 9.1 % (n=1/11) Test 2: 28.6 % (n=2/7)
Porras (2002)	Randomized controlled trial	II	N=16 Male: NR Mean age 58.9±8.4 (34- 76) years F/U: 3 mo F/U %: NR	One or more plasmasprayed titanium, commercially pure titanium, or hydroxyapatite-coated dental implants and periimplant mucositis.	Mechanical scaling only (control, N=8) or mechanical scaling, supplemented by local irrigation with chlorhexidine (CHX) 0.12 % and topical	mPI, mBI, BOP (3 mo), p>.05 PPD (3 mo), p<.05 CHX: 0.56b mm Control : 0.93 mm PAL (3 mo), p<.05 CHX: 0.33 mm	NR

				Diagnosis of mucositis: supra- and sub-gingival plaque, PPD ≤5 mm, and inflammation measured with mBI	application of CHX gel 2x/day for 10 days (case, N=8).	Control : 1.07 mm	
Renvert (2006) [overlapping population with Renvert 2008]	Randomized controlled trial	II	N=30 Male: 40 % Mean age: 63.6 ± 8.6 (41-75) years F/U: 12 months F/U %: NR	At least one implant placed 10-12 years previously with bone loss ≤3 threads on radiograph, PPD ≥4 mm, bleeding and/or purulence on probing, microbial sample of anaerobic bacteria	Mechanical debridement followed by: single dose of Arestin (OraPharma, Warminster, PA) (case, N=16), or one-time 1 % topical CHX gel application (control, N=14)	*Plaque score (12 mo), p>.05* Case: 27 ± 24 % Control : 21 ± 18 % *BOP (12 mo), p>.05* Case: 71 ± 22 % Control : 78 ± 13 % *PPD (12 mo), p<.001* Case: 3.6 ± 0.6 mm Control : 3.9 ± 0.4 mm	NR
	Randomized controlled trial	II	N=32; Ni=95 Male: 31.3 % Mean age: 61.4 ± 10.2 (41-75) years F/U: 12 months F/U %: NR	At least one implant placed 10-12 years previously with bone loss ≤3 threads on radiograph, PPD ≥4 mm, bleeding and/or purulence on probing, microbial sample of anaerobic bacteria	Mechanical debridement followed by: single dose of Arestin (OraPharma, Warminster, PA) (case, N=17 ;Ni=58), or onetime 1 % topical CHX gel application (control, N=15 ; Ni=37)	*Plaque score (12 mo), p>.05* Case: 22 ± 42 % Control : 27 ± 45 % *BOP (12 mo), p<.001* Case: 48.1 ± 20.7 % Control : 63.5 ± 19.2 % *PPD (12 mo), p>.05* Case: 3.55 ± 0.98 mm Control : 3.72 ± 1.02 mm *MBL (12 mo), p>.05* Case : 0.70 ± 0.85 mm Control: 0.46 ± 0.76 mm *# bacteria (12 mo), p>.05* Case: 1.6 ± 4.5 Control : 1.4 ± 4.2	NR
	Randomized controlled trial	II	N=31 Male: 54.8 % Mean age: 61.4 ± 12.5 years F/U: 6 months F/U %: NR	At least one implant with bone loss <2.5 mm on radiograph, PPD ≥4 mm, bleeding and/or purulence on probing	Mechanical debridement using Vector system (Durr Dental AG, Bietigheim-Bissingen, germany) (case, N=14) or mechanical debridement using currettes (control, N=17)	*Plaque score (6 mo), p>.05* Case: 51.3 ± 23.9 % Control : 54.9 ± 29.5 % *BOP (6 mo), p>.05* Case: 28.7 ± 26.4 % Control : 34.3 ± 28.2 % *PPD (6 mo), p>.05* Case: 3.9 ± 0.8 mm Control : 4.0 ± 0.8 mm Overall, mean plaque score (p<.01) and BOP (p<.03) decreased over time	NR
	Randomized controlled trial	II	N=17; Ni=35 Male: NR	Diagnosis of periimplantitis: suppuration	Resective surgery and modification of surface	*Cumulative survival (36 mo)* Case: 100 % (n=19/19)	NR

	trial		Mean age: NR F/U: 36 months % F/U: NR	or sulcus bleeding, PPD >4 mm, radiographic evidence of horizontal peri-implant radiolucency, no mobility Solid screw (Ni=24) or hollow screw (Ni=11) implants with titanium plasma-sprayed (TPS) surface	topography (cases, N=10 ; Ni=19) or resective surgery only (controls, N=7 ; Ni=16)	Control : 87.5 % (n=14/16) *mBI (24 mo), p<.05* Case : 0.88 ± 0.33 Control: 1.00 ± 0.63 *PPD (24 mo), p<.05* Case: 3.58 ± 1.0 6mm Control : 5.50 ± 1.47 mm *Mucosal recession (24 mo), p<.05* Case: 2.30 ± 1.45 mm Control : 1.64 ± 1.29 mm *PAL (24 mo), p<.05* Case: 5.89 ± 2.02 mm Control : 7.04 ± 1.67 mm	
Romeo (2007)	Randomized controlled trial	II	N=19; Ni=38 Male: NR Mean age: NR F/U: 36 months % F/U: NR	Diagnosis of periimplantitis: suppuration or sulcus bleeding, PPD >4 mm, radiographic evidence of horizontal peri-implant radiolucency, no mobility Solid screw (Ni=27) or hollow screw (Ni=11) implants with titanium plasma-sprayed (TPS) surface and periimplantitis	Resective surgery and modification of surface topography (cases, N=10 ; Ni=20) or resective surgery only (controls, N=9 ; Ni=18)	*MBL (36 mo), p<.05* Case : 0.01 ± 0.41 mm Control: 1.54 ± 0.70 mm	NR
Roos-Jansa-kar (2007)	Prospective Cohort	II	N=36; Ni=65 Male: 38.9 % Mean age: 66.0 ± 7.0 F/U: 1 year % F/U: NR	At least one implant placed 9-14 years previously with periimplantitis. Diagnosis of peri-implantitis: ≥3 exposed threads, bleeding and/or pus on probing.	Surgical treatment with bone substitute (Algipore, Friadent, Malmo, Sweden) alone (controls, N=19; Ni=36) or bone substitute with resorbable membrane (cases, N=17; Ni=29) in defects.	*Defect fill (1 yr), p=.04* Membrane: 1.52 ± 1.16 mm Control : 1.44 ±1.27 mm *PPD reduction (1 yr), p>.05* Membrane: 2.86 ± 2.00 mm Control : 3.44 ± 1.58 mm *Mucosal recession (1 yr), p>.05* Membrane: -1.28 ± 1.51 mm Control : -1.61 ± 1.61 mm *PAL gain (1 yr), p>.05* Membrane: 1.59 ± 2.00 mm Control : 1.80 ± 1.37 mm	*Pain* Mem*brane:* 5.9 % (1/17) *Cont*rol: 5.3 % (1/19) *Swelling* Membrane: 5.9 % (1/17) Control: 10.5 % (2/19)
Schenk (1997)	Randomized controlled trial	II	N=8; Ni=24 Male: 37.5 % Mean age: 62 (53-69) yrs	At least 2 implants with clinical signs of periimplant mucositis (PPD	Supra- and sub- gingival mechanical scaling alone (controls; N=8; Ni=12),	*mPI change (12 wk), p>.05* Case: 0.11 ± 0.15 Control : 0.01 ± 0.53	*No adverse effects reported*

	trial		F/U: 12 wks F/U %: NR	≥4mm and BOP) and/or peri-implant mucosal hyperplasia, without detectable peri-implant bone loss on radiographs	or with locally delivered tetracycline HCl fibers (Actisite, ALZA Corp, Palo Alto, CA) (cases; N=8; Ni=12)	*BOP change (12 wk), p>.05* Case: -17 ± 25 % Control : 15 ± 37 % *PPD, PAL (12 mo), p>.05*	
Schwarz (2005) [duplicate data with Schwarz 2006]	Randomized controlled trial	II	N=20; Ni=32 Male: 60 % Mean age: 48 yrs (cases), 51 yrs (controls) F/U: 6 months F/U %: NR	At least one dental implant with periimplantitis. Definition of peri-implantitis: ≥4 mm PPD, bleeding and/or pus on probing, bone loss, no implant mobility.	Er:YAG laser instrumentation (cases, N=10; Ni=16) or mechanical debridement plus 0.2 % CHX gel (controls, N=10; Ni=16)	*BOP reduction (6 mo): significatnly greater in cases than controls (p<.001)* *PPD, PAL, mucosal recession (6 mo): no significant differences btwn groups (p>.05)*	No complications were observed
Schwarz (2006) [duplicate data with Schwarz 2005]	Randomized controlled trial	II	N=20; Ni=40 Male: 45 % Mean age: 56±14 yrs (cases), 52±11 yrs (controls) F/U: 12 months F/U %: NR	At least one dental implant with periimplantitis. Definition of peri-implantitis: ≥4 mm PPD, bleeding and/or pus on probing, bone loss, no implant mobility.	Er:YAG laser instrumentation (cases, N=10; Ni=20) or mechanical debridement plus 0.2 % CHX gel (controls, N=10; Ni=20)	*BOP reduction (12 mo): significatnly greater in cases than controls (p<.01)* *PPD, PAL, mucosal recession, MBL (12 mo): no significant differences btwn groups (p>.05)*	No complications were observed
Schwarz (2006)—JCP [duplicate data with Shwarz 2008]	Randomized controlled trial	II	N=22; Ni=22 Male: 36.4 % Mean age: 54.4±12.5 yrs F/U: 6 months F/U %: NR	At least one dental implant with history of mechanical debridement + 0.2 % CHX gel and current intra-bony defect: >6mm PPD, >3 mm intrabony loss on radiograph, no implant mobility.	Peri-implant defects were treated using either nanocrystalline hydroxyapatite (Ostim, Heraeus, Hanau, Germany) (cases, N=11) or a natural bone mineral plus collagen membrane (controls ; N=11)	*mPI difference (6 mo), p=NR* Case: 0.1 ± 0.5 Control : 0.1 ± 0.3 *BOP decrease (6 mo), p=NR* Case: 52 % Control : 50 % *PPD decrease (6 mo), p=NR* Case: 2.1 ± 0.5mm Control : 2.6 ± 0.4mm *Mucosal recession decrease (6 mo), p=NR* Case: 0.3 ± 0.2 mm Control : 0.3 ± 0.2 mm *PAL increase (6 mo), p=NR* Case: 1.8 ± 0.6 mm Control : 2.3 ± 0.6 mm	NR
Schwarz (2008) [duplicate data with Shwarz 2006-JCP]	Randomized controlled trial	II	N=22; Ni=22 Male: 36.4 % Mean age: 54.4±12.5 yrs F/U: 2 years F/U %: NR	At least one dental implant with history of mechanical debridement + 0.2 % CHX gel and current intra-bony defect: >6 mm PPD, >3 mm intrabony loss on	Peri-implant defects were treated using either nanocrystalline hydroxyapatite (Ostim, Heraeus, Hanau, Germany) (cases, N=11) or a natural bone mineral	mPI difference (2 yr), p=NR Case: 0.7 ± 0.5 Control : 0.4 ± 0.5 BOP decrease (2 yr), p=NR Case: 36 % Control : 44 % PPD decrease (2 yr), p=NR	NR

	trial		F/U: 12 wks F/U %: NR	radiograph, no implant mobility.	plus collagen membrane (controls, N=11)	*BCase: 1.5 ± 0.6 mm* *Control : 2.4 ± 0.8 mm* *Mucosal recession decrease (2 yr), p=NR* *Case: 0.5 ± 0.5 mm* *Control : 0.4 ± 0.4 mm* *PAL increase (2 yr), p=NR* *Case: 1.0 ± 0.4 mm* *Control : 2.0 ± 0.8 mm*	
Tang (2002) [Obtained from Cochrane Review, 2009]*	Randomized controlled trial	II	N=27 Male: NR Mean age: NR F/U: 3 months F/U %: 90 %	1 stable IMZ or Frialit-2 implant with periimplantitis: peri-implant bone loss <4 mm, PPD ≤6 mm with BOP	Metronidazole gel 25 % injected into pocket at a depth of 3 mm (N=14) vs. subgingival mechanical debridement (N=13). Both procedures were performed at baseline and 1 wk later.	*PPD change (3 mo), p>.05* *Metro: 0.7 ± 1.0 mm* *Control : 0.9 ± 1.6 mm*	NR

N = Number of subjects; Ni = Number of implants; NR = Not reported; F/U = follow-up; PPD = periodontal probing depth
mBI = modified bleeding sulcus index (bleeding tendency of marginal peri-implant tissues), PPD = periodontal probing depth (linear distance from the peri-implant gingival margin to the bottom of the peri-implant pocket)
PAL = probing attachment level (distance from the implant shoulder to the bottom of the peri-implant pocket), BOP = bleeding on probing (presence of bleeding within 30 seconds after the pocket had been probed), MBL = marginal bone loss on radiographs, mPI = modified plaque index (plaque accumulation)
Er:YAG = erbium-doped:yttrium, aluminum and garnet
* Article in Chinese; data presented was obtained from Cochrane Review, 2009

Table 9. Detailed information on studies evaluating peri-implantitis associated with endosseous dental implant diameter

AUTHOR (YEAR)	STUDY DESIGN	LOE	POPULATION	POPULATION/IMPLANT CHARACTERISTICS	TREATMENT / INTERVENTION	RESULTS (OUTCOMES)	COMPLICATIONS
Romeo (2006)	Prospective cohort	III	N=188; Ni=330 Male: 44.1% Mean age: 55.8 (21-74) years F/U: 1-6 years F/U %: NR	Titanium plasma-sprayed ITI (Institute Straumann, Waldenburg/BL, Switzerland) implants were placed. Patients with narrow buccolingual ridge width received smalldiameter implants, and other patients received standard-diameter implants. Peri-implantitis criteria not stated.	Patients were consecutively treated with the following: 68 patients were treated with 122 small-diameter (3.3 mm) implants, and 120 patients received 208 standard-diameter (4.1 mm) implants.	*Peri-Implantitis (PI)* Narrow: 5.7 % Standard: 3.4 % *Implant failure due to PI* Narrow: 2.5 % Standard: 1.0 % *Peri-implant bone resorption due to PI (no implant failure)* Narrow: 2.5 % Standard: 1.0 % *mBI (last eval), p>.05* Narrow: 0.3 ± 0.5 Standard: 0.4 ± 0.5 *PPD (last eval), p>.05* Narrow: 2.2 ± 1.6 mm Standard : 2.1 ± 1.7 mm *MBL (last eval), p>.05* Vector: 1.5 ± 1.5 mm Control : 1.4 ± 1.1 mm	NR
Zinsli (2004)	Case series	IV	N=154; Ni=298 Male: 32 % Median age: 62 (19 to 87) yrs F/U: up to 10 years F/U %: NR	Narrow diameter implants were used for the following indications: a) narrow buccolingual width of edentulous ridge, and b) small single-tooth gaps.	2-part ITI implants with a reduced diameter of 3.3- mm and intraosseous length of 8, 10, or 12 mm were placed.	Implant failure due to PI: 1.0 % (n=3/298) Peri-implant inflammation (no failure): 1.3 % (n=4/298) Peri-implant disease: 2.3 % (n=7/298)	NR
Prosper (2003)	Case series	IV	N=83; Ni=111 Male: 47.0 % Mean age: 46.2 ± 14.3 F/U: 12 months F/U %: 100 %	Cylindric, sandblasted, screw-type titanium implants with large diameter (5.9 mm) and length of 11 or 13 mm	Large diameter (5.9 mm) implants were placed in fresh extraction sockets with synthetic hydroxyapatite or a bioabsorbable membrane	Success rate: 97.3 % (n=108/111) Peri-Implantitis : 0 % (n=0/111) Mobility : 0 % (n=0/111) Bone loss : 0 % (n=0/111)	NR

mBI = modified bleeding sulcus index (bleeding tendency of marginal peri-implant tissues), PPD = periodontal probing depth (linear distance from the peri-implant gingival margin to the bottom of the peri-implant pocket), MBL = marginal bone loss on radiographs

Table 10. Detailed information on studies evaluating peri-implantitis associated with endosseous dental implant surface structure

AUTHOR (YEAR)	STUDY DESIGN	LOE	POPULATION	POPULATION/IMPLANT CHARACTERISTICS	TREATMENT / INTERVENTION	RESULTS (OUTCOMES)	COMPLICATIONS
Esposito (2005))	Metaanalysis of RCTs (Astrand 1999; Astrand 2002; Moberg 2001)	III	N=NR; Ni=NR Male: NR Mean age: NR F/U: 3 years F/U %: NR	Turned (machined) and roughened surface implants were placed. Peri-implantitis: advanced marginal bone loss with signs of infection such as suppuration	The frequency of periimplantitis was compared between implant systems	*Incidence of PI, rough>machined, p<.05* Turned vs. Machined: RR=0.80, 95 % CI 0.67-0.96	NR
Karoussis (2004)	Prospective cohort	IV	N=89; Ni=179 Male: 38.2 % Mean age: 49.3 (19-78) yrs F/U: 8-12 years F/U %: 70 %	Hollow cylinder (HC; n=49), hollow screw (HS; n=112), and angulated hollow cylinder (AHC; n=18) ITI implants (Institute Straumann, Waldenburg, Switzerland) were placed. Periimplantitis: PPD ≥5 mm, BOP and radiographic signs of bone loss	Implants were followed for peri-implantitis	*Incidence of PI, HC>HS, p<.03* HC: 29 % (n=14/49) HS: 10 % (n=11/112) AHC: 12 % (n=2/18) All implants: 15.4 % (n=27/179) *mPI, p>.05* HC: 2.2 ± 1.6 mm HS: 2.6 ± 0.9 mm AHC: 2.1 ± 1.7 mm *PPD, HC>HS, p<.05* HC: 3.1 ± 1.4 mm HS: 2.6 ± 0.9 mm AHC: 3.1 ± 1.1 mm *BOP, HC>HS, p<.05* HC: 0.5 ± 0.3 mm HS: 0.4 ± 0.4 mm AHC: 0.5 ± 0.3 mm	NR
Quirynen (2005)	Retrospective and prospective cohort	IV	N=NR; Ni=539 Male: NR Mean age: NR F/U: 1-6 years F/U %: NR	Cylindric, sandblasted, screw-type titanium implants with large diameter (5.9 mm) and length of 11 or 13 mm	Implants with retrograde peri-implantitis were followed prospectively	*Incidence of retrograde PI, TiUnite>Machined, p<.0001* Machined: 0.4 % (n=2/459) TiUnite: 10.0 % (n=8/80) All implants: 1.9 %	Fistula associated with retrograde PI: n=10 % (n=1) Implant loss due to retrograde PI: n=10 % (n=1)
				implantitis. Retrograde PI criteria not stated.			
Tang (2000)	Case series	IV	N=70; Ni=108 Male: 51.4 % Mean age: 36.2 (17-64) years F/U: 1 year F/U %: NR	Titanium (IMZ and Frialit-2; Friatic, Germany) dental implants were placed	Peri-implant conditions were assessed	MBL: 0.63 ± 0.78 mm Plaque index: 0: 7.6 % ≥ 1: 92.4 % Sulcus Bleeding index (indicator of peri-implant mucosal inflammation): 0: 67.1 % ≥ 1: 32.9 %	NR
Teixeira (1997)	Retrospective cohort	III	N=22; Ni=32 Male: 40.5 % Mean age: 54.2 years F/U: mean 3.5 years F/U %: NR	Patients received 2-stage hydroxyapatite-coated dental implants. Patients were divided into controls with no inflammatory signs, borderline group with moderate inflammation, gingivitis group with peri-implant mucositis	Peri-implant conditions were assessed	Mean bone loss, gingivitis>borderline; gingivitis>control Gingivitis: 3.22±1.92 Borderline: 1.37±0.99 Control: 1.15±0.81	

mBI = modified bleeding sulcus index (bleeding tendency of marginal peri-implant tissues), PPD = periodontal probing depth (linear distance from the peri-implant gingival margin to the bottom of the peri-implant pocket), MBL = marginal bone loss on radiographs

Table 11. Definition of the different levels of evidence for articles on therapy and prognosis

Studies of Therapy			Studies of Prognosis		Studies of Diagnosis	
Level	**Study design**	**Criteria**	**Study design**	**Criteria**	**Study design**	**Criteria**
I	Good quality RCT	• Concealment • Blind or independent assessment for important outcomes • Co-interventions applied equally • F/U rate of 80%+ • Adequate sample size	Good quality cohort	• Prospective design • Patients at similar point in the course of their disease or treatment • F/U rate of 80 % + • Patients followed long enough for outcomes to occur • Controlling for extraneous prognostic factors**	Good quality prospective cohort	• Prospective validation of previous criteria • Consecutive series of patients • Broad spectrum of persons with the expected condition • Adequate description of test and reference for replication • Blinded comparison of tests with appropriate reference standard • Reference standard performed independently of diagnostic test
II	Moderate or poor quality RCT	• Violation of any of the criteria for good quality RCT	Moderate quality cohort	• Prospective design, with violation of one of the other criteria for good quality cohort study • Retrospective design, meeting all the rest of the criteria in level I	Moderate quality prospective cohort study	• Violation of any one of the criteria for a good quality prospective study (LoE I)
	Good quality cohort	• Blind or indepedent assessment in a prospective study, or use of reliable data* in a retrospective study • Co-interventions applied equally • F/U rate of 80 % + • Adequate sample size • Controlling for possible confounding†			Good quality retrospective cohort study	• Validation of previous criteria, with violation of one of the other criteria for a good quality prospective cohort
III	Moderate or poor quality cohort	• Violation of any of the criteria for good quality cohort	Poor quality cohort	• Prospective design with violation of 2 or more criteria for good quality cohort, or • Retrospective design with violation of 1 or more criteria for good quality cohort	Poor quality prospective cohort study	• Violation of any two or more of the criteria for a good quality prospective study (LoE I)
	Case-control	• Any case-control design	Case-control	• Any case-control design	Moderate quality retrospective cohort study	• Violation of any criteria for a good quality retrospective study (LoE II)
IV	Case series	• Any case series design	Case series	• Any case series design	Poor quality retrospective cohort study	• Violation of any criteria for a good quality retrospective study (LoE II)
					Case-control study	• Violation of two or more of the criteria for a good quality retrospective study (LoE II)

*Reliable data are data such as mortality or reoperation.

**Authors must provide a description of robust baseline characteristics, and control for those that are unequally distributed between treatment groups for studies assessing prognostic factors. For studies of risk, results must reflect the risk of obtaining the outcome of interest stratified by other prognostic factors.

Educational Video Series

Maxillary Implant Placement

1 Crestal & Basal Implants
Order Nr. 6667

2 And Replacing Replace®
Order Nr. 6669

Each DVD contains approx. 20 minutes of oral surgery. With explanations in english and german language.

€ 35,00

Please send your order via e-mail to:
publishing@implantfoundation.org
www.implantfoundation.org

or via regular postage mail to:
International Implant Foundation
Leopoldstr. 116, DE-80802 München

Guide for Authors

ID publishes articles, which contain information, that will improve the quality of life, the treatment outcome, and the affordability of treatments.
The following types of papers are published in the journal:
Full length articles (maximum length abstract 250 words, total 2000 words, references 25, no limit on tables and figures). Short communications including all case reports (maximum length abstract 150 words, total 600 words, references 10, figures or tables 3) Technical notes (no abstract, no introduction or discussion, 500 words, references 5, figures or tables 3). Interesting cases/lessons learned (2 figures or tables, legend 100 words, maximum 2 references).

Literature Research and Review articles are usually commissioned.
Critical appraisals on existing literature are welcome.

Direct submissions to:
publishing@implantfoundation.org.
The text body (headline, abstract, keywords, article, conclusion), tables and figures should be submitted as separate documents. Each submission has to be accompanied by a cover letter. The cover letter must mention the names, addresses, e-mails of all authors and explain, why and how the content of the article will contribute to the improvement of the quality of life of patients.