SCIENTIFIC HIGHLIGHTS

SPECIAL EDITION

Topic-specific overview of scientific evidence

Roxolid® SLActive®

Edited by Dr. Marcin Maj

straumann

IN THIS ISSUE we present a thorough review of the existing scientific literature on the Straumann® implant material and surface, Roxolid®/SLActive®, providing evidence-based analysis of their clinical applications and outcomes.

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IN VITRO STUDIES

Forum Implantologicum 2009, 5(1), 30-39

The Binary TiZr Alloy – A Newly Developed Ti Alloy for Use in Dental Implants

Nicolai Bernhard, Simon Berner, Michael de Wild, Marco Wieland

ABSTRACT

Dental implant therapy is a well documented and scientifically accepted treatment in partially and completely edentulous patients. The implant material most often used is commercially pure titanium (cpTi) and its alloys Ti6Al7Nb and Ti6Al4V1–3. The properties of these materials, such as excellent corrosion resistance and low rates of metal ion release, biocompatibility, little or no tendency to cause adverse cell or tissue reactions, low specific weight, overall good mechanical properties, processability and availability, make them particularly suitable

Adapted from N Bernhard et al., Forum Implantologicum 2009, 5(1), 30-39

J Mech Behav Biomed Mater. 2016 Sep:62:384-398

Microstructure and mechanical properties of Ti-15Zr alloy used as dental implant material

Alexander E Medvedev, Andrey Molotnikov, Rimma Lapovok, Rolf Zeller, Simon Berner, Philippe Habersetzer, Florian Dalla Torre

STUDY OBJECTIVES AND METHODS

The purpose of this study was to compare mechanical properties of a new Ti-15Zr alloy to those of commercially pure titanium Grade4 in two surface conditions - machined and modified by sand-blasting and etching (SLA).

RESULTS

- As a result of significantly smaller grain size in the initial condition (1-2μm), the strength of Ti-15Zr alloy was found to be 10-15% higher than that of Grade4 titanium without reduction in the tensile elongation or compromising the fracture toughness.
- The fatigue endurance limit of the alloy was increased by around 30% (560MPa vs. 435MPa and 500MPa vs. 380MPa for machined and SLA-treated surfaces, respectively).
- Additional implant fatigue tests showed enhanced fatigue performance of Ti-15Zr over Ti-Grade4.

Adapted from AE Medvedev et al., J Mech Behav Biomed Mater. 2016 Sep:62:384-398, for more info about this publication click **HERE**

Materials Transactions, 2005, 46(10) 2260 - 2267

Improved Biocompatibility of Titanium–Zirconium (Ti–Zr) Alloy: Tissue Reaction and Sensitization to Ti–Zr Alloy Compared with Pure Ti and Zr in Rat Implantation Study

Yoshiaki Ikarashi, Kazuhiro Toyoda, Equo Kobayashi, Hisashi Doi,Takayuki Yoneyama, Hitoshi Hamanaka and Toshie Tsuchiya

FREE full text

STUDY OBJECTIVES AND METHODS

The purpose of this study was to determine the biocompatibility of Ti–Zr alloy by an implantation test in animal bodies in comparison with pure Ti, Zr, and chromium (Cr) implants as positive controls. Sample specimens were placed in a subcutaneous position in rats for 8 months.

RESULTS

- No significant decreases in body weight, the weight of any organ, or the weight of any organ relative to body weight were found in the implant groups compared to a no-implant control group.
- On hematological examination, small differences in several parameters were found in some groups, but these changes were not attributable to the materials implanted.
- Mitogen-induced blastogenesis was observed in similar degrees among all implant groups. These results suggest that the implantation of test samples did not cause systemic toxicity or a decrease in immune activity.
- The fibrous capsule membranes around the Ti and Ti–Zr alloy implants were thinner than those around Cr implants.
- The numbers of macrophages, inflammatory cells, and other cells involved in immune responses in and around the fibrous capsules of the Cr- and Ti-implant groups were higher than those of the Ti–Zr alloy- and Zr-implant groups.
- The Ti–Zr alloy had the lowest total score of tissue responses among the materials tested.
- None of the animals from the Ti-, Zr-, and Ti–Zr alloy-implant groups exhibited a skin reaction following exposure to Ti or Zr salt solutions.

CONCLUSIONS

These results indicate the Ti–Zr alloy has better biocompatibility than Ti for use as an artificial surgical implant.

Adapted from Y Ikarashi et al., Materials Transactions, 2005, 46(10) 2260 - 2267

J Biomed Mater Res A. 2006 Feb;76(2):323-34

Enhancing surface free energy and hydrophilicity through chemical modification of microstructured titanium implant surfaces

F Rupp, L Scheideler, N Olshanska, M de Wild, M Wieland, J Geis-Gerstorfer

ABSTRACT

Roughness-induced hydrophobicity, well-known from natural plant surfaces and intensively studied toward superhydrophobic surfaces, has currently been identified on microstructured titanium implant surfaces. Studies indicate that microstructuring by sandblasting and acid etching (SLA) enhances the osteogenic properties of titanium. The undesired initial hydrophobicity, however, presumably decelerates primary interactions with the aqueous biosystem. To improve the initial wettability and to retain SLA microstructure, a novel surface modification was tested. This modification differs from SLA by its preparation after acid etching, which was done under protective gas conditions following liquid instead of dry storage. We hypothesized that this modification should have increased wettability due to the prevention of contaminations that occurs during air contact. The main outcome of dynamic wettability measurements was that the novel modification shows increased surface free energy (SFE) and increased hydrophilicity with initial water contact angles of 0 degrees compared to 139.9 degrees for SLA. This hydrophilization was kept even after any drying. Reduced hydrocarbon contaminations were identified to play a possible role in altered surface thermodynamics. Such surfaces aim to retain the hydrophilicity and natural high surface energy of the Ti dioxide surface until surgical implants' insertion and are compared in this in vitro study with structural surface variants of titanium to compare roughness and chemically induced wettability.

Adapted from F Rupp et al., J Biomed Mater Res A. 2006 Feb;76(2):323-34, for more info about this publication click **HERE**

Clin Oral Implants Res. 2013 Feb;24(2):203-9

Spontaneously formed nanostructures on titanium surfaces

Ann Wennerberg, Lory Melin Svanborg, Simon Berner, Martin Andersson

STUDY OBJECTIVES AND METHODS

The purpose of this study was to investigate the evolution of nanostructures on the SLActive surface, as a function of time, storage conditions, material dependence and to identify the step in which the reorganization of the outermost titanium oxide layer into well defined nanostructures takes place. Titanium grade 2 discs were surface modified in seven different modes; (1) SLA (sand blasted, large grit, acid etched) protocol. (2) SLActive protocol (SLA stored in 0.9% NaCl solution), (3) SLActive, but stored in water instead of 0.9% NaCl solution, (4) pmod SLA: SLA discs subjected to oxygen plasma cleaning and stored in 0.9% NaCl solution, (5) SLAnano: SLActive discs aged for several months and then dried, (6) Mod A: same etching procedure and storage as for SLActive, but no sand blasting prior to etching, (7) pmod P: the discs were polished, oxygen plasma cleaned and stored in 0.9% NaCl solution. In addition TiZr alloy discs were prepared like the Ti SLActive samples. The surfaces were evaluated with SEM, interferometry, contact angle measurements and XPS.

RESULTS

- The samples stored dry were hydrophobic whereas the discs stored in liquid were hydrophilic.
- The evolution of nanostructures took 2 weeks, thereafter they were stable over time.
- The nanostructures occured after storage both in water and NaCl solution.
- Nanostructures were formed on Ti and TiZr although the morphology and distribution was quite different between the two materials.

CONCLUSIONS

Acid etching in conjunction with storage in aqueous solution is responsible for the reorganization of the outermost titanium oxide layer into well defined nanostructures.

Adapted from A Wennerberg et al., Clin Oral Implants Res. 2013 Feb;24(2):203-9, for more info about this publication click **HERE**

J Biomed Mater Res A. 2015 Aug;103(8):2661-72

The role of nanostructures and hydrophilicity in osseointegration: In-vitro protein-adsorption and blood-interaction studies

Brigitte S Kopf, Sylvie Ruch, Simon Berner, Nicholas D Spencer, Katharina Maniura-Weber

STUDY OBJECTIVES AND METHODS

The purpose of this study was to systematically investigate the influence of different surface properties on the adsorption of the blood proteins fibrinogen and fibronectin and the degree of early blood coagulation. Experiments on custom-made and commercially available, microroughened hydrophobic titanium (Ti) surfaces (Ti SLA-Hphob), hydrophilic (Hphil) microroughened Ti surfaces with nanostructures (Ti SLActive-Hphil NS), and on bimetallic Ti zirconium alloy (TiZr, Roxolid®) samples were performed, to study the biological response in relation to the surface wettability and the presence of nanostructures (NS).

RESULTS

- Protein adsorption on the different substrates showed a highly significant effect of surface NS.
- Hydrophilicity alone did not significantly enhance protein adsorption.
- Overall, the combination of NS and hydrophilicity led to the highest adsorption levels; independent of whether Ti or TiZr were used.
- Hydrophilicity induced a strong effect on blood coagulation, whereas the effect of NS alone was weak.
- The combination of both surface characteristics led to early and most pronounced blood-coagulation.

CONCLUSIONS

Nanostructured, hydrophilic Ti and TiZr surfaces may perform better in terms of osseointegration due to continuous protein adsorption and the formation of a layer of blood components on the implant surface.

Adapted from BS Kopf et al., J Biomed Mater Res A. 2015 Aug;103(8):2661-72, for more info about this publication click **HERE**

Clin Oral Implants Res. 2017 Apr;28(4):414-423

Dental implant surface chemistry and energy alter macrophage activation in vitro

Kelly M Hotchkiss, Nancy B Ayad, Sharon L Hyzy, Barbara D Boyan, Rene Olivares-Navarrete

STUDY OBJECTIVES AND METHODS

The purpose of this study was to determine the effects of dental implant surface chemistry and energy on macrophage activation in vitro. Disks made from two clinically used implant materials (titanium [Ti], titanium zirconium alloy [TiZr]) were produced with two different surface treatments (sandblast/acid-etch [SLA], hydrophilic-SLA [modSLA]). Surface roughness, energy, and chemistry were characterized. Primary murine macrophages were isolated from 6- to 8-week-old male C57Bl/6 mice and cultured on test surfaces (Ti SLA, TiZr SLA, Ti modSLA, TiZr modSLA) or control tissue culture polystyrene. mRNA was quantified by quantitative polymerase chain reaction after 24 h of culture. Pro- (IL-1 β , IL-6, and TNF- α) and anti-inflammatory (IL-4, IL-10) protein levels were measured by ELISA after 1 or 3 days of culture.

RESULTS

- Quantitatively, microroughness was similar on all surfaces.
- Qualitatively, nanostructures were present on modSLA surfaces that were denser on Ti than on TiZr. modSLA surfaces were determined hydrophilic (high-energy surface) while SLA surfaces were hydrophobic (low-energy surface).
- Cells on high-energy surfaces had higher levels of mRNA from anti-inflammatory markers characteristic of M2 activation compared to cells on low-energy surfaces.
- This effect was enhanced on the TiZr surfaces when compared to cells on Ti SLA and Ti modSLA.
- Macrophages cultured on TiZr SLA and modSLA surfaces released more anti-inflammatory cytokines.

CONCLUSIONS

The combination of high-energy and altered surface chemistry present on TiZr modSLA was able to influence macrophages to produce the greatest anti-inflammatory microenvironment and reduce extended pro-inflammatory factor release.

Adapted from KM Hotchkiss et al., Clin Oral Implants Res. 2017 Apr;28(4):414-423, for more info about this publication click **HERE**

Dent Mater. 2019 Jan;35(1):176-184

Novel in vitro comparative model of osteogenic and inflammatory cell response to dental implants

Kelly M Hotchkiss, Kegan T Sowers, Rene Olivares-Navarrete

FREE full text

STUDY OBJECTIVES AND METHODS

The purpose of this study was to to characterize the macrophage inflammatory response and MSC osteogenesis across different commercially available implants in vitro. Six commercially available rough implants [OsseoSpeed™ (Astra-Tech™, Implant A); Osseotite® (Biomet 3i™, Implant B); TiUnite™ (Nobel-Biocare®, Implant C); Ti-SLA®, (Implant D), Roxolid® (RXD-SLA, Implant E), RXD-SLActive® (Implant F) (Straumann®)] were examined. Macrophages and MSCs were seeded directly on implants and cultured in custom vials. mRNA and protein levels of pro- (IL1B, IL6, IL17A, CXCL10, TNFa) and anti- (IL4, IL10, TGFB1) inflammatory markers were measured after 24 and 48h in macrophages. Osteoblastic differentiation of MSCs was assessed after seven days by alkaline phosphatase activity, osteocalcin, and angiogenic, osteogenic, and inflammatory markers by ELISA and qPCR (n=6/variable, ANOVA, post hoc Tukey HSD with α =0.05).

RESULTS

- Hydrophilic implant F induced the highest level of osteogenic factor released from MSCs and anti-inflammatory factors from macrophages with the lowest level of pro-inflammatory factors.
- Alternatively, implants A and C supported lower levels of osteogenesis and increased secretion of pro-inflammatory factors.

CONCLUSIONS

In this study, we successfully evaluated differences in cell response to commercially available clinical implants using an in vitro model. Data from this model suggest that not all surface modification procedures generate the same cell response.

Adapted from KM Hotchkiss et al., Dent Mater. 2019 Jan;35(1):176-184, for more info about this publication click **HERE**

Dent Mater. 2008 Jan;24(1):102-10

Differentiation and cytokine synthesis of human alveolar osteoblasts compared to osteoblast-like cells (MG63) in response to titanium surfaces

Xiaohui Rausch-fan, Zhe Qu, Marco Wieland, Michael Matejka, Andreas Schedle

STUDY OBJECTIVES AND METHODS

The purpose of this study was to investigate the influence of different implant surface topographies and chemistries on the expression of differentiation/proliferation markers on MG63 cells and primary human alveolar osteoblasts. Hydrophobic acid-etched (A) and hydrophobic coarse-grit-blasted, acid-etched (SLA) surfaces and hydrophilic acid-etched (modA) and hydrophilic coarse-grit-blasted (modSLA) surfaces were produced. Thereby, modA and modSLA surfaces were rinsed under nitrogen protection and stored in a sealed glass tube containing isotonic NaCl solution at pH 4-6. Tissue culture plates without specimens served as controls. The behavior of MG63 cells and primary human alveolar osteoblasts (AOB) grown on all surfaces was compared through determination of alkaline phosphatase (ALP) activity, cell proliferation ((3)H-thymidin incorporation, MTT colorimetric assay) and expression of osteocalcin (OC), osteoprotegerin (OPG), transforming growth factor-beta1 (TGF-beta(1)) and vascular endothelial growth factor (VEGF), detected with commercial available test kits.

RESULTS

- Proliferation of MG63 and primary cells was highest on controls, followed by A surfaces, modA and SLA surfaces being almost on the same level and lowest on modSLA surfaces.
- modSLA surfaces exhibited highest ALP and OC production, followed by SLA, modA and A surfaces.
- Proliferation and OC production were comparable for MG63 cells and AOB. OPG, TGF-beta(1) and VEGF produced on primary cells showed a slightly different rank order on different surfaces compared to MG63 cells.
- modSLA still showed the highest production of OPG, TGF-beta(1) and VEGF, but was followed by modA, SLA and A.

CONCLUSIONS

MG63 cells and primary human alveolar osteoblasts showed similar proliferation and differentiation characteristics on different titanium surfaces. Only modA surfaces showed enhanced expression of OPG, TGF-beta(1) and VEGF on MG63 cells compared to primary human alveolar osteoblasts. Overall, the lowest proliferation rates and the highest expressions of differentiation markers and growth factor productions were observed on modSLA.

Adapted from X Rausch-fan et al., Dent Mater. 2008 Jan;24(1):102-10, for more info about this publication click **HERE**

Clin Implant Dent Relat Res. 2019 Aug;21(4):550-564

Biological responses of human bone mesenchymal stem cells to Ti and TiZr implant materials

Lihua Yin, Yaoren Chang, Yuanhe You, Chun Liu, Jie Li, Hong-Chang Lai

STUDY OBJECTIVES AND METHODS

The purpose of this study was to investigate the biological responses of hBMSCs to implant holes affected by the physicochemical properties of oral implants (TiSLA , TiSLActive , TiZrSLA , and TiZrSLActive). Grade 4 Ti and TiZr (13-17% Zr) substrates were modified by sand-blasted large-grit acid-etched (SLA) or hydrophilic sand-blasted large-grit acid-etched (SLActive), resulting in four types of surface with complex microstructures corresponding to the commercially-available implants SLA, RoxolidSLA, SLActive, and RoxolidSLActive (Institute Straumann AG, Basel, Switzerland). Physicochemical properties were detected and the biological responses of hBMSCs were observed.**RESULTS**

- Surface morphology characterization by scanning electron microscopy and atomic force microscopy revealed differences between the four groups.
- SLActive had higher surface energy/wettability than SLA, indicating that increased surface energy/wettability can promote the absorption of osteogenic proteins and enhance osseointegration.
- hBMSCs seeded on SLActive substrates exhibited better performance in terms of cell attachment, proliferation and osteoblastic differentiation than cells seeded on SLA.

CONCLUSIONS

Because of their more suitable physicochemical properties, TiSLActive and TiZrSLActive materials demonstrated more pronounced effects on the biological responses of hBMSCs compared with TiSLA and TiZrSLA

Adapted from L Yin et al., Clin Implant Dent Relat Res. 2019 Aug;21(4):550-564, for more info about this publication click **HERE**

J Biomed Mater Res A. 2005 Jul 1;74(1):49-58

High surface energy enhances cell response to titanium substrate microstructure

G Zhao, Z Schwartz, M Wieland, F Rupp, J Geis-Gerstorfer, D L Cochran, B D Boyan

ABSTRACT

Titanium (Ti) is used for implantable devices because of its biocompatible oxide surface layer. TiO2 surfaces that have a complex microtopography increase bone-to-implant contact and removal torque forces in vivo and induce osteoblast differentiation in vitro. Studies examining osteoblast response to controlled surface chemistries indicate that hydrophilic surfaces are osteogenic, but TiO2 surfaces produced until now exhibit low surface energy because of adsorbed hydrocarbons and carbonates from the ambient atmosphere or roughness induced hydrophobicity. Novel hydroxylated/hydrated Ti surfaces were used to retain high surface energy of TiO2. Osteoblasts grown on this modified surface exhibited a more differentiated phenotype characterized by increased alkaline phosphatase activity and osteocalcin and generated an osteogenic microenvironment through higher production of PGE2 and TGF-beta1. Moreover, 1alpha,25OH2D3 increased these effects in a manner that was synergistic with high surface energy. This suggests that increased bone formation observed on modified Ti surfaces in vivo is due in part to stimulatory effects of high surface energy on osteoblasts.

Adapted from G Zhao et al., J Biomed Mater Res A. 2005 Jul 1;74(1):49-58, for more info about this publication click **HERE**

J Long Term Eff Med Implants. 2025;35(1):45-49

In Vitro Evaluation of Bacterial Adhesion of Streptococcus mutans and Enterococcus faecalis on Sand-Blasted, Acid-Etched, and Anodized Titanium Dental Implants

Vamshi Nizampuram, Arvina Rajasekar

STUDY OBJECTIVES AND METHODS

This study aimed to compare the bacterial adhesion of S. mutans and Enterococcus faecalis on sand-blasted acid-etched and anodized titanium dental implants. Three commercially available implants, namely SLA (n = 3), SLActive (n = 3), and TiUnite (n = 3), were inoculated with the prepared broth suspension of S. mutans and E. faecalis, and were incubated at 37°C for 48 h. After incubation, the colonies were counted using direct microscopy and the results were recorded as colony forming units/mL (CFU/mL). Mean CFUs were compared between the three implants by ANOVA and pairwise comparison by Tukey's HSD post hoc test using SPSS Software. p value of < 0.05 was considered to be statistically significant.

RESULTS

- TiUnite implant showed the highest bacterial adherence for S. mutans (3.49 ± 0.53 × 102 CFU/mL) and E. faecalis (35.14 ± 1.54 × 102 CFU/mL) followed by SLA and SLActive. These data demonstrated statistically significant differences between the three types of implants (P < 0.05).
- Pairwise comparison showed that there was a statistically significant difference between SLA and TiUnite (P = 0.004) and SLActive and TiUnite (P = 0.001) in terms of S. mutans colony count.
- In terms of E. faecalis colony count, there was a statistically significant difference between SLA and SLActive (P = 0.000), SLA and TiUnite (P = 0.000) and SLActive and TiUnite (P = 0.000).

CONCLUSIONS

Compared with sand-blasted and acid-etched dental implants, anodized dental implants showed higher adhesion of S. mutans and E. faecalis.

Adapted from V Nizampuram et al., J Long Term Eff Med Implants. 2025;35(1):45-49, for more info about this publication click **HERE**

Acta Biomater. 2025 Jan 15;192:473-486

Obesity prolongs the pro-inflammatory response and attenuates bone healing on titanium implants.

Derek Avery, Lais Morandini, Luke Sheakley, Asmaa Alajmi, Leah Bergey, Henry J Donahue, Rebecca K Martin, Rene Olivares-Navarrete

STUDY OBJECTIVES AND METHODS

This study aimed to determine how obesity induced by a high-fat diet (HFD) affects the inflammatory response to modified titanium (Ti) implants and subsequent bone formation.

RESULTS

- Obese mice had significantly more neutrophils, pro-inflammatory macrophages, and T cells and fewer anti-inflammatory macrophages and mesenchymal stem cells (MSCs) in the peri-implant tissue than lean mice.
- Obesity also increased circulating adipokines and pro-inflammatory cytokines when compared to lean animals.
- Bone formation around Ti implants was reduced in obese mice compared to controls.
- Adoptive transfer of bone marrow cells isolated from obese mice into wild-type mice demonstrated the localized impact of obesity on immune cell function and phenotype, promoting a pro-inflammatory peri-implant microenvironment and attenuating bone formation post-implantation.

CONCLUSIONS

These results show that obesity significantly affects the inflammatory response to modified Ti implants, prolonging the pro-inflammatory response to the implanted biomaterial and compromising bone formation.

Adapted from D Avery et al., Acta Biomater. 2025 Jan 15;192:473-486, for more info about this publication click **HERE**

J Prosthet Dent. 2025 May 3:S0022-3913(25)00358-0

Comparative evaluation of osteoblastic cell adhesion on titanium and titanium zirconium alloyed implants using confocal microscopy: An in vitro study

Ann Mary Varghese, Kurien Varghese, Smita Sara Manoj

STUDY OBJECTIVES AND METHODS

This study aimed to evaluate and compare the initial osteoblastic cell adhesion at 3 different locations (peak or top, flank, and valley) on the surface of CpTi and Ti-Zr alloy implants.Commercially available Grade IV cpTi and Ti-Zr alloy implants (Ø4.1×16-mm) were tested. Each implant was sectioned into two 4-mm portions above the tapered area. The 20 implant specimens (n=10) thus obtained were categorized into 2 groups: cpTi and Ti-Zr alloy. MG63 osteoblast-like cells were cultured and seeded onto the implant specimens. After 48 hours of incubation, cell adhesion was examined using confocal microscopy and quantified at peak or top, flank, and valley locations with an automated cell counting software program. Statistical analysis was performed using 2-way ANOVA followed by a parameter estimate test (α =.05).

RESULTS

- The Ti-Zr alloy implant specimens showed significantly higher osteoblastic cell adhesion across all 3 surface locations compared with cpTi implant specimens (P<.05).
- For both implant types, the valley area demonstrated significantly higher cell adhesion compared with the top and flank areas (P<.001).

CONCLUSIONS

Ti-Zr alloyed implant surfaces demonstrated enhanced osteoblastic cell adhesion compared with cpTi surfaces. The implant thread geometry, particularly the valley area, showed the most significant cell adhesion, which may contribute to improved osseointegration.

Adapted from AM Varghese et al., J Prosthet Dent. 2025 May 3:S0022-3913(25)00358-0, for more info about this publication click **HERE**

ANIMAL STUDIES

J Periodontol. 2007 Nov;78(11):2171-84

Effects of surface hydrophilicity and microtopography on early stages of soft and hard tissue integration at non-submerged titanium implants: an immunohistochemical study in dogs

Frank Schwarz , Daniel Ferrari, Monika Herten, Ilja Mihatovic, Marco Wieland, Martin Sager, Jürgen Becker

STUDY OBJECTIVES AND METHODS

The purpose of this study was to investigate the effects of surface hydrophilicity and microtopography on soft and hard tissue integration at non-submerged titanium implants. Implantation of conventional sand-blasted large grit and acid-etched (SLA) and chemically modified SLA (modSLA) titanium implants with differently structured transmucosal surfaces (SLA implants: machined [M-SLA] or SLA [SLA-SLA]; modSLA implants: mod acid-etched [modA] [modA-modSLA] or modSLA [modSLA-modSLA]) was performed bilaterally in the upper and lower jaws of 15 beagle dogs. The animals were sacrificed after 1, 4, 7, 14, or 28 days. Tissue reactions were assessed histomorphometrically and immunohistochemically using monoclonal antibodies to transglutaminase II (angiogenesis) and osteocalcin.

RESULTS

- Although the junctional epithelium commonly was separated from M-SLA and SLA-SLA implants by a gap, the epithelial cells appeared to be in close contact with modA-modSLA surfaces after 14 days of healing.
- Moreover, modA-modSLA and modSLA-modSLA groups showed a well-vascularized subepithelial connective tissue exhibiting collagen fibers that started to extend and attach partially perpendicular to the implant surface.
- The highest and statistically significant mean bone-to-implant contact areas were observed in the modA-modSLA and modSLA-modSLA groups at days 7, 14, and 28.

CONCLUSIONS

Within the limits of this study, it may be concluded that soft and hard tissue integration was influenced mainly by surface hydrophilicity rather than by microtopography.

Adapted from F Schwarz et al., J Periodontol. 2007 Nov;78(11):2171-84, for more info about this publication click **HERE**

Clin Oral Investig. 2007 Sep;11(3):245-55

Histological and immunohistochemical analysis of initial and early subepithelial connective tissue attachment at chemically modified and conventional SLA titanium implants. A pilot study in dogs

Frank Schwarz, Monika Herten, Martin Sager, Marco Wieland, Michel Dard, Jürgen Becker

STUDY OBJECTIVES AND METHODS

The purpose of this study was to histologically/immunohistochemically investigate initial and early subepithelial connective tissue attachment at transmucosal parts of modified (mod) and conventional sandblasted, large grit and acid-etched (SLA) titanium implants. Implantation of modSLA and SLA implants was performed bilaterally in both the mandible and maxilla of four beagle dogs. The implants were submerged to prevent bacterial contamination. The animals were killed after 1, 4, 7 and 14 days. Peri-implant tissue reactions were assessed histologically (Masson Goldner Trichrome stain-MG) and immunohistochemically (IH) using monoclonal antibodies to fibronectin (FN) and proliferating cell nuclear antigen (PCNA).

RESULTS

- The surgical procedure of implant submerging resulted in the formation of an artificial gap in the transmucosal area of both types of implants.
- After 14 days of healing, MG stain revealed the formation of well-organized collagen fibres and numerous blood vessels in a newly formed loose connective tissue zone adjacent to modSLA.
- While some fibres were oriented in a parallel direction, others have started to extend and attach partially perpendicular to the implant surface.
- In contrast, SLA implants appeared to be clearly separated by a dense connective tissue zone with parallel-running collagen fibres and rare blood vessel formation.
- First signs of a positive FN and PCNA staining adjacent to both implant surfaces were observed at day 4.

CONCLUSIONS

Within the limits of a pilot study, it might be concluded that modSLA titanium surfaces might possess the potential to promote subepithelial connective tissue attachment at the transmucosal part of the implant.

Adapted from F Schwarz et al., Clin Oral Investig. 2007 Sep;11(3):245-55, for more info about this publication click **HERE**

J Clin Periodontol. 2008 Jan;35(1):64-75

Bone regeneration in dehiscence-type defects at non-submerged and submerged chemically modified (SLActive) and conventional SLA titanium implants: an immunohistochemical study in dogs

Frank Schwarz, Martin Sager, Daniel Ferrari, Monika Herten, Marco Wieland, Jürgen Becker

STUDY OBJECTIVES AND METHODS

The purpose of this study was to evaluate bone regeneration in dehiscence-type defects at non-submerged and submerged titanium implants with chemically modified (mod) and conventional sandblasted/acid-etched (SLA) surfaces. Standardized buccal dehiscence defects were surgically created following implant site preparation in both the upper and lower jaws of 12 beagle dogs. Both types of implants were randomly assigned to either a non-submerged or a submerged healing procedure. After 1, 2, 4, and 8 weeks, dissected blocks were processed for histomorphometrical [e.g. new bone height (NBH), per cent linear fill (PLF), percentage of bone to implant contact (BIC-D), area of new bone fill (BF)] and immunohistochemical analysis.

RESULTS

- At 8 weeks, non-submerged and submerged SLA implants revealed significantly lower mean NBH (1.1+/-0.8-1.9+/-1.2 mm), PLF (27.7+/-20.3-46.0+/-28.5%), BIC-D (26.8+/-10.4-46.2+/-16.2%), and BF (1.3+/-0.9-3.4+/-2.8 mm(2)) values than respective modSLA implants [NBH (2.6+/-0.8-4.3+/-0.1 mm), PLF (64.2+/-19.4-107.2+/-4.7%), BIC-D (67.5+/-18.8-82.1+/-14.8%), BF (2.9+/-1.0-6.7+/-1.1 mm(2))].
- Within modSLA groups, significantly highest BF values were observed at submerged implants.

CONCLUSIONS

It was concluded that (i) modSLA titanium surfaces promoted bone regeneration in acute-type buccal dehiscence defects and (ii) a submerged healing procedure improved the outcome of healing additionally.

Adapted from F Schwarz et al., J Clin Periodontol. 2008 Jan;35(1):64-75, for more info about this publication click **HERE**

Clin Oral Implants Res. 2011 Apr;22(4):406-15

The effect of SLActive surface in guided bone formation in osteoporotic-like conditions

Nikos Mardas, Frank Schwarz, Aviva Petrie, Ahmad-Reza Hakimi, Nikolaos Donos

STUDY OBJECTIVES AND METHODS

The purpose of this study was to evaluate new bone formation under etched titanium (SLA) and modified-etched hydrophilic titanium (modSLA) domes placed on the calvarium of healthy, osteoporotic and osteoporotic treated with bisphosphonates rabbits. Experimental osteoporosis was induced by ovariectomy (OV) and calcium-deficient diet in 24 New Zealand female rabbits. Twelve OV rabbits were treated with weekly dozes of alendronate (Fosamax(®)) (B) while 12 OV rabbits received no treatment (O). Another 12 rabbits were sham operated and used as healthy controls (C). At 6 weeks following OV, one modSLA and one SLA titanium dome were placed in the parietal bones of each rabbit. The animals were sacrificed at 30 and 120 days following the dome placement. Various histomorphometric measurements were performed in the most central of the undecalcified sections produced.

RESULTS

- After 30 days of healing, in the C group, the total bone (TB) area was 37.6% and 37.0% under the modSLA and SLA domes, respectively.
- In the O group, the TB was 35.7% and 24.8%. In the B group, TB was 37.0% and 32.1%, respectively. After 120 days of healing, in the C group TB was 40.1% and 36.4%, respectively.
- In the O group, TB was 29.6% and 27.9%, respectively. In the B group, TB was 49.7% and 42.5%, respectively.
- Hierarchical analysis of variance showed that the type of titanium dome significantly influenced new bone and the amount of new bone being in contact with inner surface of the dome (BIC) independently of the observation period and group ($P<0.05$).
- The administration of bisphosphonates influenced the BIC ($P<0.05$).

CONCLUSIONS

The use of modSLA surface may promote bone healing and osseointegration in osteoporotic rabbits, whereas administration of bisphosphonates may compromise the osseointegration of the newly formed bone at the early healing period.

Adapted from N Mardas et al., Clin Oral Implants Res. 2011 Apr;22(4):406-15, for more info about this publication click **HERE**

Clin Oral Implants Res. 2014 Sep;25(9):1041-50

Nanostructures and hydrophilicity influence osseointegration: a biomechanical study in the rabbit tibia

Ann Wennerberg, Ryo Jimbo, Stefan Stübinger, Marcel Obrecht, Michel Dard, Simon Berner

STUDY OBJECTIVES AND METHODS

The purpose of this study was to investigate how nanostructures and wettability influence osseointegration and to identify whether the wettability, the nanostructure or both in combination play the key role in improved osseointegration. Twenty-six adult rabbits each received two Ti grade 4 discs in each tibia. Four different types of surface modifications with different wettability and nanostructures were prepared: hydrophobic without nanostructures (SLA), with nanostructures (SLAnano); hydrophilic with two different nanostructure densities (low density: pmodSLA, high density: SLActive). All four groups were intended to have similar chemistry and microroughness. The surfaces were evaluated with contact angle measurements, X-ray photoelectron spectroscopy, scanning electron microscopy, atomic force microscopy and interferometry. After 4 and 8 weeks healing time, pull-out tests were performed.

RESULTS

- SLA and SLAnano were hydrophobic, whereas SLActive and pmodSLA were super-hydrophilic.
- No nanostructures were present on the SLA surface, but the three other surface modifications clearly showed the presence of nanostructures, although more sparsely distributed on pmodSLA.
- The hydrophobic samples showed higher carbon contamination levels compared with the hydrophilic samples.
- After 4 weeks healing time, SLActive implants showed the highest pull-out values, with significantly higher pull-out force than SLA and SLAnano.
- After 8 weeks, the SLActive implants had the highest pull-out force, significantly higher than SLAnano and SLA.

CONCLUSIONS

The strongest bone response was achieved with a combination of wettability and the presence of nanostructures (SLActive).

Adapted from A Wennerberg et al., Clin Oral Implants Res. 2014 Sep;25(9):1041-50, for more info about this publication click **HERE**

Clin Oral Implants Res. 2017 Oct;28(10):1234-1240

Chemically modified titanium-zirconium implants in comparison with commercially pure titanium controls stimulate the early molecular pathways of bone healing

Silvia Galli, Ryo Jimbo, Yoshihito Naito, Simon Berner, Michel Dard, Ann Wennerberg

STUDY OBJECTIVES AND METHODS

The purpose of this study was to identify the genetic response of bone around TiZr implants compared to pure Ti. Microtextured and hydrophilic TiZr implants (tests) and cpTi implants grade IV (controls) were placed in the tibia of 30 New Zealand white rabbits. At 2, 4 and 12 weeks, the implants were subjected to removal torque test (RTQ). The expression of a panel of genes involved in the process of osseointegration was measured in the bone around the test and control implants by means of quantitative real-time polymerase chain reaction (PCR) and compared to the control

RESULTS

- The controls yielded statistically significant higher RTQ at 4 weeks, but the RTQ of the tests had a larger increase between 4 and 12 weeks, when both groups reached similar values.
- The gene expression analysis showed that all selected markers for bone formation, bone remodeling and cytokines were significantly upregulated around TiZr implants after 2 weeks.
- After 4 weeks of healing, two bone formation markers were significantly more expressed in the test samples, while at 12 weeks, the expression of all genes was similar in the two groups.

CONCLUSIONS

TiZr implants showed comparable biomechanical outcomes to cpTi up to 12 weeks of healing. However, at early healing stages, they showed a significant upregulation of osteogenesis and osteoclastogenesis markers.

Adapted from S Galli et al., Clin Oral Implants Res. 2017 Oct;28(10):1234-1240, for more info about this publication click **HERE**

Clin Implant Dent Relat Res. 2012 Aug;14(4):538-45

Evaluation of a new titanium-zirconium dental implant: a biomechanical and histological comparative study in the mini pig

Jan Gottlow, Michel Dard, Fred Kjellson, Marcel Obrecht, Lars Sennerby

STUDY OBJECTIVES AND METHODS

The purpose of this study was to test the hypothesis that TiZr1317 and Ti implants show comparable osseointegration and stability. The mandibular premolars (P1, P2, P3) and the first molar (M1) in 12 adult miniature pigs were extracted 3 months prior to the study. Six specially designed implants made from Ti (commercially pure, Grade 4) or TiZr1317 (Roxolid®, Institut Straumann AG, Basel, Switzerland) with a hydrophilic sandblasted and acid-etched (SLActive, Institut Straumann AG, Basel, Switzerland) surface were placed in each mandible; three standard implants modified for evaluation of removal torque (RT) in one side and three bone-chamber implants for histologic observations in the contralateral side. RT tests were performed after 4 weeks when also the bone chamber implants and surrounding tissue were biopsied for histologic analyses in ground sections.

RESULTS

- The RT results indicated significantly higher stability (p=0.013) for TiZr1317 (230.9±22.4Ncm) than for Ti implants (204.7±24.0Ncm).
- The histology showed similar osteoconductive properties for both implant types.
- Histomorphometric measurements showed a statistically significant higher (p=0.023) bone area within the chamber for the TiZr1317 implants (45.5±13.2%) than did the Ti implants (40.2±15.2%).
- No difference was observed concerning the bone to implant contact between the groups with 72.3±20.5% for Ti and 70.2±17.3% for TiZr1317 implants.

CONCLUSIONS

It is concluded that the TiZr1317 implant with a hydrophilic sandblasted and acid-etched surface showed similar or even stronger bone tissue responses than the Ti control implant.

Adapted from J Gottlow et al., Clin Implant Dent Relat Res. 2012 Aug;14(4):538-45, for more info about this publication click **HERE**

Clin Oral Implants Res. 2014 Jul;25(7):819-25

The osseointegration behavior of titanium-zirconium implants in ovariectomized rabbits

Bo Wen, Feng Zhu, Zhen Li, Peng Zhang, Xingnan Lin, Michel Dard

STUDY OBJECTIVES AND METHODS

The purpose of this study was to compare the osseointegration behavior of titanium (Ti) and titanium-zirconium (TiZr) implants in ovariectomized (OVX) rabbits. Twelve ovariectomized New Zealand rabbits submitted to a hypocalcic diet and 12 sham-aged rabbits were used. After the bone mass loss induction period, TiZr or Ti implants both benefiting from a SLActive surface treatment were randomly inserted in the tibia and femur of each animal. The total of 24 rabbits were divided in four groups (n = 6): SHAM + Ti, OVX + Ti, SHAM + TiZr,OVX + TiZr. The animals were respectively sacrificed 3 and 6 weeks after dental implant placement. Six implants in each group at each time point were subjected to removal torque testing, and the remaining implants were prepared for histomorphometric analysis.

RESULTS

- At the end of the healing period, all implants were osseointegrated.
- The removal torque value of the SHAM-TiZr group was significantly higher than those of the SHAM-Ti group ($P < 0.001$).
- The removal torque of the OVX-Ti group was significantly lower than those of the OVX-TiZr group.
- All groups demonstrated an increase in the peak torque value after 6 weeks: 46.0 and 50.8 Ncm for the OVX and the SHAM animals, respectively, in the case where Ti implants were used.
- When TiZr implants were inserted, the values reached 60.7 and 76.2 Ncm with a similar group configuration. The BIC and the BA/TA analysis showed an increase between week 3 and 6 in the case of nonovariectomized animals.
- From week 3 to 6, the BIC went from 37.1 ± 14.3 to 47.7 ± 8.7 for the SHAM + Ti group and from 37.6 ± 10.9 to 50.4 ± 11 for the SHAM + TiZr group.
- The BIC values were not significantly different between groups.

CONCLUSIONS

The parameters intended to be representative of the bone morphology (BIC & BATA) did not help to discriminate between Ti and TiZr which appeared to behave similarly in this experimental model. However, the removal torque values for the TiZr group were statistically higher than those of the Ti group in both the SHAM and the ovariectomized animals. That likely reflected an increased quality of bone around the TiZr implants.

Adapted from B Wen et al., Clin Oral Implants Res. 2014 Jul;25(7):819-25, for more info about this publication click **HERE**

Clin Oral Implants Res. 2022 Nov;33(11):1135-1146

Benchmark performance of anodized vs. sandblasted implant surfaces in an acute dehiscence type defect animal model

Shakeel Shahdad, Dieter Bosshardt, Mital Patel, Nahal Razaghi, Anuya Patankar, Mario Roccuzzo

FREE full text

STUDY OBJECTIVES AND METHODS

The purpose of this study was to analyze the effect of implant surface and implant geometry on de novo crestal bone formation and osseointegration. Histological and histomorphometrical analysis was performed to compare three implant groups, that is, (1) a novel, commercially available, gradient anodized implant, (2) a custom-made geometric replica of implant "1," displaying a superhydrophilic micro-rough large-grit sandblasted and acid-etched surface, and (3) a commercially available implant, having the same surface as "2" but a different implant geometry. The study applied a standardized buccal acute-type dehiscence model in minipigs with observation periods of 2 and 8 weeks of healing.

RESULTS

- The amount of newly formed crestal bone (BATA) around control groups (2) and (3) was significantly increased when compared to the test group (1) at the 8 weeks of healing time point.
- Similar results were obtained for all parameters related to osseointegration and direct bone apposition, to the implant surface (dBIC, VBC, and fBIC), demonstrating superior osseointegration of the moderately rough, compared to the gradient anodized functionalization.
- After 2 weeks, the osseointegration (nBIC) was found to be influenced by implant geometry with group (3) outperforming groups (1) and (2) on this parameter.
- At 8 weeks, nBIC was significantly higher for groups (2) and (3) compared to (1).

CONCLUSIONS

The extent (BATA) of de novo crestal bone formation in the acute-type dehiscence defects was primarily influenced by implant surface characteristics and their ability to promote osseointegration and direct bone apposition. Osseointegration (nBIC) of the apical part was found to be influenced by a combination of surface characteristics and implant geometry. For early healing, implant geometry may have a more pronounced effect on facilitating osseointegration, relative to the specific surface characteristics.

Adapted from S Shahdad et al., Clin Oral Implants Res. 2022 Nov;33(11):1135-1146, for more info about this publication click **HERE**

Clin Oral Implants Res. 2025 Jan;36(1):127-141

Osseointegration of Anodized vs. Sandblasted Implant Surfaces in a Guided Bone Regeneration Acute Dehiscence-Type Defect: An In Vivo Experimental Mandibular Minipig Model

Shakeel Shahdad, Simon Rawlinson, Nahal Razaghi, Anuya Patankar, Mital Patel, Mario Roccuzzo, Thomas Gill

FREE full text

STUDY OBJECTIVES AND METHODS

the effect of implant surface characteristics on osseointegration and crestal bone formation in a grafted dehiscence defect minipig model. A standardized 3 mm × 3 mm acute-type buccal dehiscence minipig model grafted with deproteinized bovine bone mineral and covered with a porcine collagen membrane after 2 and 8 weeks of healing was utilized. Crestal bone formation was analyzed histologically and histomorphometrically to compare three implant groups: (1) a novel, commercially available, gradient anodized (NGA) implant, to two custom-made geometric replicas of implant "1," (2) a superhydrophilic micro-rough large-grit sandblasted and acid-etched surface, and (3) a relatively hydrophobic micro-rough large-grit sandblasted and acid-etched surface.

RESULTS

- At 2 and 8 weeks, there was no difference between the amount and height of newly formed bone (NBH, new bone height; BATA, bone area to total area) for any of the groups ($p > 0.05$).
- First bone-to-implant contact (fBIC) and vertical bone creep (VBC) at 2 and 8 weeks were significantly increased for Groups 2 and 3 compared to Group 1 ($p < 0.05$).
- At 8 weeks, osseointegration in the dehiscence (dehiscence bone-implant-contact; dBIC) was significantly higher for Groups 2 and 3 compared to Group 1 ($p < 0.05$).

CONCLUSIONS

The amount of newly formed bone (BATA) and NBH was not influenced by surface type. However, moderately rough surfaces demonstrated significantly superior levels of osseointegration (dBIC) and coronal bone apposition (fBIC) in the dehiscence defect compared to the NGA surface at 2 and 8 weeks.

Adapted from S Shahdad et al., Clin Oral Implants Res. 2025 Jan;36(1):127-141, for more info about this publication click **HERE**

Int J Oral Maxillofac Implants. 2019 March/April;34(2):443–450

Osseointegration of Superhydrophilic Implants Placed in Defect Grafted Bones

Edgard El Chaar, Lei Zhang, Yongsheng Zhou, Rebecca Sandgren, Jean-Christoph Fricain, Michel Dard, Benjamin Pippenger, Sylvain Catros

STUDY OBJECTIVES AND METHODS

In this study, new bone growth around implants with a superhydrophilic modSLA (SLActive) and hydrophobic SLA (SLA) surface were compared in circumferential defects when grafted in conjunction with mineralized cancellous bone allograft (MCBA, maxgraft) or sintered bovine bone mineral (SBBM, cerabone). The osseointegration and bone formation in circumferential defects in minipig mandibles around Straumann Roxolid, Ø 3.3 mm, length 8 mm; either SLA or SLActive, were evaluated. Following implant placement, the 2-mm circumferential defects around the implants were filled with MCBA or SBBM. Distance from implant shoulder to first bone-to-implant contact (f-BIC), percentage of bone-to-implant contact (BIC), and bone aggregate percentage (amount of new bone and remaining graft) within the defect area were evaluated after 8 weeks of healing.

RESULTS

- In the SBBM group, lingual fBIC and buccal BIC were significantly lower for SLA (mean -0.404 ± 0.579 mm for modSLA versus -1.191 ± 0.814 mm for SLA, P = .021 and mean 62.61% ± 9.49% for modSLA versus 34.67% ± 24.41% for SLA, P = .047, respectively).
- Bone aggregate percentage was significantly higher for modSLA versus SLA implants in SBBM (77.84% ± 6.93% versus 64.49% ± 13.12%; P = .045).
- The differences between implant surfaces in MCBA showed a similar trend but were less pronounced than in the SBBM group and did not reach a statistically significant level.

CONCLUSIONS

The results suggest that implants with a superhydrophilic modSLA surface are more conducive to faster osseointegration even in conjunction with simultaneous bone grafting procedures.

Adapted from E El Chaar et al., Int J Oral Maxillofac Implants. 2019 March/April;34(2):443–450, for more info about this publication click **HERE**

CLINICAL STUDIES

Clin Oral Implants Res. 2011 Apr;22(4):349-56

Early osseointegration to hydrophilic and hydrophobic implant surfaces in humans

Niklaus P Lang, Giovanni E Salvi, Guy Huynh-Ba, Saso Ivanovski, Nikolaos Donos, Dieter D Bosshardt

STUDY OBJECTIVES AND METHODS

The purpose of this study was to evaluate the rate and degree of osseointegration at chemically modified moderately rough, hydrophilic (SLActive) and moderately rough, hydrophobic (SLA) implant surfaces during early phases of healing in a human model. The devices used for this study of early healing were 4 mm long and 2.8 mm in diameter and had either an SLActive chemically modified or a moderately rough SLA surface configuration. These devices were surgically installed into the retro-molar area of 49 human volunteers and retrieved after 7, 14, 28 and 42 days of submerged healing. A 5.2-mm-long specially designed trephine with a 4.9 mm inside diameter, allowing the circumferential sampling of 1 mm tissue together with the device was applied. Histologic ground sections were prepared and histometric analyses of the tissue components (i.e. old bone, new bone, bone debris and soft tissue) in contact with the device surfaces were performed.

RESULTS

- All device sites healed uneventfully. All device surfaces were partially coated with bone debris.
- A significant fraction of this bone matrix coating became increasingly covered with newly formed bone.
- The process of new bone formation started already during the first week in the trabecular regions and increased gradually up to 42 days.
- The percentage of direct contact between newly formed bone and the device (bone-to-implant contact) after 2 and 4 weeks was more pronounced adjacent to the SLActive than to the SLA surface (14.8% vs. 12.2% and 48.3% vs. 32.4%, respectively), but after 42 days, these differences were no longer evident (61.6% vs. 61.5%).

CONCLUSIONS

While healing showed similar characteristics with bone resorptive and appositional events for both SLActive and SLA surfaces between 7 and 42 days, the degree of osseointegration after 2 and 4 weeks was superior for the SLActive compared with the SLA surface.

Adapted from NP Lang et al., Clin Oral Implants Res. 2011 Apr;22(4):349-56, for more info about this publication click **HERE**

Int J Periodontics Restorative Dent. 2024 May 24;44(3):321-329

Increased Peri-implant Bone Formation Around Simultaneously Grafted Hydrophilic Microrough Titanium Implants: An Exploratory Human Histometric Analysis in Four Patients

Alexandre Perez, Carla Patricia Martinelli-Klay, Tommaso Lombardi

STUDY OBJECTIVES AND METHODS

The purpose of this study was to investigate the influence of implant surface hydrophilicity on early osseointegration and peri-implant bone formation around simultaneously grafted immediate implants. Hydrophilic test (SLAactive) or hydrophobic control (SLA) implants were immediately placed in maxillary molar extraction sites and simultaneously grafted with mineralized cancellous bone allograft (MCBA). Core biopsy samples were obtained at 3 weeks postplacement and histometrically compared for bone-to-implant contact, quantity of graft material, new bone formation, tissue reaction, and inflammatory scores.

RESULTS

- Test implants showed a more pronounced implant-bone apposition, peri-implant bone formation, and bone aggregate than control implants.
- Trabecular bone formation and maturation were also qualitatively advanced around test implants.

CONCLUSIONS

These results indicate that the combination of implant surface and bone graft may affect periimplant bone formation.

Adapted from A Perez et al., Int J Periodontics Restorative Dent. 2024 May 24;44(3):321-329, for more info about this publication click **HERE**

Chin J Dent Res. 2019;22(4):265-272

Survival of Titanium-Zirconium and Titanium Dental Implants in Cigarette-smokers and Never-smokers: A 5-Year Follow-up.

Abdulaziz Alsahhaf, Rana Saud Alshagroud, Khulud Abdulrahman Al-Aali, Raneem S Alofi, Fahim Vohra, Tariq Abduljabbar

STUDY OBJECTIVES AND METHODS

The purpose of this study was compare the peri-implant clinical and radiographic status around bone-level narrow-diameter titanium-zirconium (TiZr) implants and titanium (Ti) implants placed in cigarette-smokers (CS) and never-smokers (NS). Partially edentulous CS and NS rehabilitated with TiZr and Ti implants were included. Demographic data and information regarding smoking habits were collected. Participants were divided into four groups: group-1, CS with TiZr implants; group-2, NS with TiZr implants; group-3, CS with Ti implants; and group-4, NS with Ti implants. 36, 30, 31 and 33 implants were placed in 24, 23, 24 and 25 male individuals in groups 1, 2, 3 and 4, respectively. Peri-implant plaque index (PI), bleeding on probing (BOP), probing depth (PD) and mesial and distal crestal bone loss (CBL) were measured. All patients were enrolled in biannual routine oral prophylaxis care at least until the fifth year of follow-up and oral hygiene instructions were reinforced at each recall appointment. $P < 0.05$ was considered statistically significant.

RESULTS

- At the 3- and 5-year follow-ups, there was no statistically significant difference in the peri-implant PI, BOP, PD and CBL between individuals in all groups.
- In all groups, the implant success and survival rates were 100% and 100%, respectively, at the 5-year follow-up.

CONCLUSIONS

The TiZr and Ti dental implants can remain clinically and radiographically stable in CS in a manner similar to NS. Routine oral hygiene maintenance plays an essential role in this regard.

Adapted from A Alsahhaf et al., Chin J Dent Res. 2019;22(4):265-272, for more info about this publication click **HERE**

Clin Oral Investig. 2020 Jul;24(7):2477-2486.

Clinical performance of titanium-zirconium implants with a hydrophilic surface in patients with controlled type 2 diabetes mellitus: 2-year results from a prospective case-control clinical study

José J Cabrera-Domínguez , Lizett Castellanos-Cosano, Daniel Torres-Lagares, Manuel Pérez-Fierro, Guillermo Machuca-Portillo

STUDY OBJECTIVES AND METHODS

The purpose of this study was analyze the 2-year clinical performance of single-unit titanium-zirconium (TiZr) alloy narrow-diameter (3.3 mm) dental implants with a hydrophilic surface (Straumann® Roxolid®, SLActive®) in patients with controlled type 2 diabetes mellitus (T2DM), measured using the glycated hemoglobin A (HbA1c) concentration test, compared with results in individuals without T2DM. he studied sample consisted of 28 patients, 14 with T2DM (study group) and 14 without (control group). The plaque index, bleeding on probing, probing depth, clinical attachment level, gingival biotype, and marginal bone loss (MBL) at the site of the implants were assessed. HbA1c levels were assessed in all patients during each checkup.

RESULTS

- Two years after implant placement and prosthetic restoration no implant failures were reported in either group, resulting in 100% survival and success rates in both groups.
- No statistically significant differences in MBL were found between the control and study groups ($p > 0.05$).

CONCLUSIONS

The narrow implants placed in patients with T2DM with well-controlled glycemia (HbA1c) showed a marginal bone loss and success and survival rates similar to those of the control group without DM2, in the medium term.

Adapted from JJ Cabrera-Domínguez et al., Clin Oral Investig. 2020 Jul;24(7):2477-2486., for more info about this publication click **HERE**

J Periodontol. 2022 May;93(5):745-757

Clinical performance of hydrophilic, titanium-zirconium dental implants in patients with well-controlled and poorly controlled type 2 diabetes: One-year results of a dual-center cohort study

Jessica M Latimer, Katherine L Roll, Diane M Daubert, Hai Zhang, Tamir Shalev; ABCD study collaborators; Larry F Wolff, Georgios A Kotsakis

STUDY OBJECTIVES AND METHODS

The purpose of this study was to assess the clinical performance of hydrophilic dental implants in a patient cohort with type 2 diabetes mellitus (T2DM). Subjects with T2DM of ≥2-years duration were allocated to either the well-controlled (WC; HbA1c ≤ 7.0%,) or poorly-controlled (PC; 7.5 < HbA1c < 10%) groups in a dual-center, prospective cohort study. Each subject received a single, titanium-zirconium (Ti-Zr) dental implant with a chemically-modified, hydrophilic (modSLA) surface in a posterior mandibular site. Postoperatively, subjects were followed at 1, 2, 4, 8, and 12-week intervals. Post-loading, subjects were followed at 3, 6, and 12-months. Clinical and radiographic parameters of implant success, and dental patient-reported outcomes were collected.

RESULTS

- Twenty-one dental patients (NWC = 11; NPC = 10; mean age: 66.8 ± 7.5 years) were enrolled and the 1-year implant success rate was 100%.
- Peri-implant bone levels were stable with 0.15 ± 0.06 mm mean marginal loss at 1 year without significant inter-group differences (P = 0.79).
- Postoperative pain was minimal at 1-week, and OHIP-5 scores decreased significantly over time as compared with preoperative levels (P < 0.001) suggesting significant improvement in patient-perceived oral health following implant therapy.

CONCLUSIONS

Elevated HbA1c levels > 7.5% did not compromise 1-year success rates, or oral health-related quality of life in PC patients receiving modSLA, Ti-Zr implants. Given that implant placement up to 10% HbA1c significantly enhanced oral health-related quality of life without complications or morbidity, the safety and efficacy of implants to improve oral function in T2DM is supported, even without ideal glycemic control.

Adapted from JM Latimer et al., J Periodontol. 2022 May;93(5):745-757, for more info about this publication click **HERE**

Clin Oral Investig. 2021 Dec;25(12):6707-6715

One-year performance of posterior narrow diameter implants in hyperglycemic and normo-glycemic patients-a pilot study

Anton Friedmann, Marianna Winkler, Daniel Diehl, Mehmet Selim Yildiz, Hakan Bilhan

FREE full text

STUDY OBJECTIVES AND METHODS

The purpose of this study was to compare the performance of narrow diameter implants in patients with uncontrolled diabetes mellitus type 2 (T2DM) and normo-glycemic individuals during the first 12 months after implant loading. In 16 T2DM patients with HbA1C > 6.5% (test group) and 16 normo-glycemic patients (HbA1C < 6.0%; control group), one to two narrow diameter tissue level implants were placed in the posterior maxilla or mandible. After 3-month lasting integration period, implants were loaded by fixed dentures. The clinical parameters probing depth (PD), bleeding on probing (BOP), attachment loss (CAL), recession and papilla bleeding index (PBI) were assessed manually at loading and after 12 months of function. The paired digital periapical radiographs were analyzed with regard to the change in marginal bone level (MBL) from baseline to 12 months' control. The mean values calculated for both patient groups were statistically analyzed. The technical complications were recorded.

RESULTS

- The T2DM group accounted 13 patients due to 3 dropouts.
- The overall implant survival rate after 12 months was 100%.
- The differences in means for the clinical parameters and the MBL were statistically non-significant between the T2DM and normo-glycemic patients for the short period of loaded function reported here.
- No technical complications were recorded.

CONCLUSIONS

The study demonstrated an encouraging clinical outcome with narrow diameter implants in patients with uncontrolled T2DM compared to non-diabetics after 12 months post loading. For the short observation period, no biological and technical complications were reported regardless the glycemic status.

Adapted from A Friedmann et al., Clin Oral Investig. 2021 Dec;25(12):6707-6715, for more info about this publication click **HERE**

J Oral Rehabil. 2015 Jan;42(1):57-64

Rehabilitation of irradiated patients with chemically modified and conventional SLA implants: five-year follow-up

C Nack, J-D Raguse, A Stricker, K Nelson, S Nahles

STUDY OBJECTIVES AND METHODS

The purpose of this study was to evaluate the clinical and radiological parameters of standard SLA surface implants compared to chemically modified hydrophilic SLActive implants in irradiated patients after the initial 12-month loading period up to 5 years. Twenty patients with a mean age of 61·1 years were treated with dental implants after ablative surgery and radio-chemotherapy of oral cancer. All patients were non-smokers. The placement of 102 implants (50 SLA, 52 SLActive) was performed bilaterally according to a split-mouth design. Mean crestal bone changes were evaluated using standardised orthopantomographies and clinical parameters. Data were analysed using a Kaplan-Meier curve, Mann-Whitney U-test and two-factorial non-parametric analysis.

RESULTS

- The average observation period was 60 months.
- The amount of bone loss at the implant shoulder of SLA implants was mesial and distal 0·7 mm.
- The SLActive implants displayed a bone loss of mesial 0·6 mm as well as distal 0·7 mm after 5 years. Two SLA implants were lost before loading. One patient lost five implants due to recurrence of a tumour.
- The overall cumulative 12-month, 3-year and 5-year survival rate of SLA implants was 92%, 80% and 75·8% and of SLActive implants 94·2%, 78·8% and 74·4%, respectively.
- Eighteen implants were considered lost because the patients had died. Sandblasted acid-etched implants with or without a chemically modified surface can be used in irradiated patients with a high predictability of success. Lower implant survival rates in patients with irradiated oral cancer may be associated with systemic effects rather than peri-implantitis.

CONCLUSIONS

Sandblasted acid-etched implants with or without a chemically modified surface can be used in irradiated patients with a high predictability of success. Lower implant survival rates in patients with irradiated oral cancer may be associated with systemic effects rather than peri-implantitis.

Adapted from C Nack et al., J Oral Rehabil. 2015 Jan;42(1):57-64, for more info about this publication click **HERE**

IMPORTANT NOTE: *This publication should be always addressed together with Nelson K et al J Oral Rehabil. 2016 Nov;43(11):871-872*

J Oral Rehabil. 2016 Nov;43(11):871-872

Rehabilitation of irradiated patients with chemically modified and conventional SLA implants: a clinical clarification

K Nelson, A Stricker, J-D Raguse, S Nahles

Adapted from Nelson K et al., J Oral Rehabil. 2016 Nov;43(11):871-872, for more info about this publication click **HERE**

Clin Oral Implants Res. 2017 Jan;28(1):109-115

Development of Implant Stability Quotient values of implants placed with simultaneous sinus floor elevation - results of a prospective study with 109 implants

Ulrike Kuchler, Vivianne Chappuis, Michael M Bornstein, Marta Siewczyk, Reinhard Gruber, Laura Maestre, Daniel Buser

STUDY OBJECTIVES AND METHODS

The purpose of this study was to determine what percentage of implants placed with SFE reach a threshold Implant Stability Quotient (ISQ) of ≥70 after 8 weeks of healing using Resonance Frequency Analysis (RFA). A total of 109 dental implants were placed in 97 patients. SFE was carried out with a lateral window approach and a mixture of autogenous bone chips and deproteinized bovine bone mineral (DBBM). Titanium screw-type, tissue-level implants with a chemically modified SLA surface were used. ISQ values were measured after implant insertion (ISQBL) and after 8 weeks of healing (ISQ8 wk). Patients showing ISQ8 wk ≥ 70 subsequently underwent restoration. Implants with an ISQ value < 70 were recalled at 2-week intervals.

RESULTS

- The ISQ at baseline had a mean value of 68.3 (SD ± 9.8).
- At 8 weeks, the mean ISQ value was 73.6 (SD ± 6.4). This increase was statistically significant (P < 0.001). An $ISQ8_{wk}$ value ≥70 was observed for 91 implants (83%).
- One implant (0.9%) with a peri-implant infection and severe bone loss at 8 weeks was considered an early failure.

CONCLUSIONS

This study showed that 83% of implants reached the threshold level of ISQ ≥ 70 after 8 weeks, allowing an early loading protocol. The early failure rate was considered low with 0.9%. The RFA technology is a suitable method to objectively monitor implant stability longitudinally.

Adapted from U Kuchler et al., Clin Oral Implants Res. 2017 Jan;28(1):109-115, for more info about this publication click **HERE**

Clin Oral Implants Res. 2016 May;27(5):591-6

Survival and patient satisfaction of short implants during the first 2 years of function: a retrospective cohort study with 694 implants in 416 patients

Andreas Hentschel, Jan Herrmann, Ingmar Glauche, Armin Vollmer, Karl Andreas Schlegel, Rainer Lutz

STUDY OBJECTIVES AND METHODS

The purpose of this study was to evaluate the influence of implant length on implant survival and patient satisfaction during the first 24 months in function. A retrospective cohort of 312 "short" Straumann(®) SLActive(®) implants (length ≤ 8 mm) in 224 patients, which were inserted between 2008 and 2010 in private practice, were evaluated. The mean observation period was 26.7 ± 9.7 months. Three hundred and eighty-two Straumann SLActive(®) implants in 192 patients with a length ≥ 12 mm served as control group. The mean observation period in the control group was 28.3 ± 10.1 months. Implant survival rate, crown-to-implant ratio, resonance frequency analysis, and patient satisfaction were evaluated.

RESULTS

- Implant survival rate was 99% in the test vs. 98.7% in the control group.
- The crown-to-implant ratio was significantly higher in the control group ($P < 0.0001$).
- Resonance frequency analysis showed slightly higher values for the short implants.
- There was a tendency to higher satisfaction (Oral Health Impact Profile [OHIP]) in the test group without statisticaly significant differences but a high overall satisfaction in both groups.

CONCLUSIONS

Within the limits of the present investigation, implant length had no significant influence on implant survival during the first 24 months of function of the specific implant system with hydrophilic surface (SLActive(®)). Further follow-up studies are required to evaluate long-term results of the reduced implant length

Adapted from A Hentschel et al., Clin Oral Implants Res. 2016 May;27(5):591-6, for more info about this publication click **HERE**

Clin Oral Implants Res. 2024 Jan;35(1):77-88

Small-diameter titanium grade IV and titanium-zirconium implants in edentulous mandibles: Ten-year results from a double-blind, randomised controlled split-mouth core-trial

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FREE full text

STUDY OBJECTIVES AND METHODS

The purpose of this study was to compare the 10-year outcome of 3.3 mm diameter titanium-zirconium (TiZr) or grade IV titanium (Ti) implants in mandibular implant-overdentures.

Materials and methods: This study is the 10-year follow-up from a randomised, controlled, double-blind, split-mouth multicentre clinical trial. Patients with edentulous mandibles had received two implants in the interforaminal region (bone-level, diameter 3.3 mm, microrough surface), one of TiZr (test) and one of Ti (control). Implant survival and success, plaque and sulcus bleeding indices, probing pocket depth, gingival margin, clinical attachment level and radiographic crestal bone levels were evaluated.

RESULTS

- Fifty of 91 patients with implants were available for the 10-year examination and 36 patients were valid for the intent-to-treat (ITT) analysis.
- The implant success rate was calculated as 94.6% and 91.9% for the TiZr implants and the Ti implants respectively.
- Four implants were lost (TiZr = 1; Ti = 3) in the entire study period.
- Kaplan-Meier survival analyses estimated 10- year implant survival rate for TiZr to 98.9% and Ti 95.8%.
- The mean of total and functional crestal bone loss was 1.49 mm (±1.37 mm) and 0.82 mm (±1.09 mm) in the TiZr group and 1.56 mm (±1.34 mm) and 0.85 mm (±1.16 mm) in the Ti group.

CONCLUSIONS

This split-mouth design RCT on mandibular implant-overdentures evidenced, bearing in mind its follow-up time-related reduced cohort size, high 10-year implant success- and survival rates. These results confirm TiZr as well-suited implant material for realising small-diameter implants.

Adapted from F Müller et al., Clin Oral Implants Res. 2024 Jan;35(1):77-88, for more info about this publication click **HERE**

Quintessence Int. 2019 Jan 25;50(2):114-124

10-year outcomes with immediate and early loaded implants with a chemically modified SLA surface

Pedro Nicolau, Fernando Guerra, Rita Reis, Tim Krafft, Korbinian Benz, Jochen Jackowski

STUDY OBJECTIVES AND METHODS

The purpose of this study was to valuate long-term outcomes in a 10-year follow-up study of patients who previously completed a 3-year multicenter randomized controlled trial of immediate and early loading of dental implants with a hydrophilic and chemically active surface (SLActive) in the posterior maxilla or mandible. The patients received implants to replace at least one missing tooth, with provisional restoration on the day of surgery (immediate loading) or 28 to 34 days later (early loading). Implant survival, change in crestal bone level, and patient satisfaction were evaluated.

RESULTS

- In total, 56 patients (with 72 implants) were available after 10 years and fulfilled the criteria for the radiographic bone level evaluation.
- The mean crestal bone level change from implant surgery to 10 years was -2.00 ± 1.19 mm and -1.37 ± 1.06 mm in the immediate and early groups, respectively.
- The corresponding change between 5 to 6 months' post-surgery (permanent fixed restoration placement) and 10 years was -1.25 ± 0.99 mm and -0.89 ± 1.11 mm in the immediate and early groups.
- After the initial remodeling phase (5 to 6 months) where the depth of implant placement had an influence on the initial bone remodeling, no significant differences between the two treatment groups were detected.
- Mean implant survival was 97.6% (98.2% and 97.1% in the immediate and early loading groups, respectively).

CONCLUSIONS

Implants with the SLActive surface show successful long-term outcomes following immediate or early loading in posterior maxillae and mandibles.

Adapted from P Nicolau et al., Quintessence Int. 2019 Jan 25;50(2):114-124, for more info about this publication click **HERE**

REVIEW ARTICLES

Int J Oral Maxillofac Surg. 2016 Jul;45(7):842-50

Clinical evidence on titanium-zirconium dental implants: a systematic review and meta-analysis

P Altuna, E Lucas-Taulé, J Gargallo-Albiol, O Figueras-Álvarez, F Hernández-Alfaro, J Nart

ABSTRACT

The use of titanium implants is well documented and they have high survival and success rates. However, when used as reduced-diameter implants, the risk of fracture is increased. Narrow diameter implants (NDIs) of titanium-zirconium (Ti-Zr) alloy have recently been developed (Roxolid; Institut Straumann AG). Ti-Zr alloys (two highly biocompatible materials) demonstrate higher tensile strength than commercially pure titanium. The aim of this systematic review was to summarize the existing clinical evidence on dental NDIs made from Ti-Zr. A systematic literature search was performed using the Medline database to find relevant articles on clinical studies published in the English language up to December 2014. Nine clinical studies using Ti-Zr implants were identified. Overall, 607 patients received 922 implants. The mean marginal bone loss was 0.36±0.06mm after 1 year and 0.41±0.09mm after 2 years. The follow-up period ranged from 3 to 36 months. Mean survival and success rates were 98.4% and 97.8% at 1 year after implant placement and 97.7% and 97.3% at 2 years. Narrow diameter Ti-Zr dental implants show survival and success rates comparable to regular diameter titanium implants (>95%) in the short term. Long-term follow-up clinical data are needed to confirm the excellent clinical performance of these implants.

Adapted from P Altuna et al., Int J Oral Maxillofac Surg. 2016 Jul;45(7):842-50, for more info about this publication, click **HERE**

Implant Dent. 2017 Apr;26(2):316-323

Clinical Performance of Narrow-Diameter Titanium-Zirconium Implants: A Systematic Review

Zahi Badran, Xavier Struillou, Nicolas Strube, David Bourdin, Michel Dard, Assem Soueidan, Alain Hoornaert

ABSTRACT

Implant-supported prosthetic rehabilitations are in constant augmentation in everyday dental practice. This is largely due to increasing demand from patients for fixed or implant-stabilized prosthesis, although they are frequently reticent to complex preimplant bone augmentation surgeries, whenever bone volume is lacking. Narrow-diameter implants (NDI; ≤3.5 mm) have been developed to offer relatively simple implant solutions in challenging bone-deficient sites. However, concerns regarding their mechanical properties have been raised. Special titanium-zirconium material (Ti-Zr), with superior mechanical resistance, compared with pure titanium alloys has been introduced into the market. The purpose of this systematic review was to determine the available data on clinical performance of Ti-Zr NDI.

A literature search of all available clinical articles dealing with Ti-Zr NDI has been carried out. After including only prospective clinical trials, 14 papers were retrieved for thorough reviewing.

Short-term results from preliminary clinical reports are quite promising, although the number of published studies and the follow-up periods are still insufficient to determine the real benefit of this hybrid material compared with titanium, especially when using NDI.

Adapted from Z Badran et al., Implant Dent. 2017 Apr;26(2):316-323, for more info about this publication, click **HERE**

Clin Cosmet Investig Dent. 2011 Sep 5:3:59-67

Current knowledge about the hydrophilic and nanostructured SLActive surface

Ann Wennerberg, Silvia Galli, Tomas Albrektsson

FREE full text

ABSTRACT

This review summarizes the present documentation for the SLActive surface, a hydrophilic and nanostructured surface produced by Straumann Company in Switzerland, and covers the results from 15 in vitro, 17 in vivo, and 16 clinical studies. The SLActive surface is a development of the large grit-blasted and acid-etched SLA surface, and is further processed to a high degree of hydrophilicity. In general, the in vitro and in vivo studies of the SLActive surface demonstrate a stronger cell and bone tissue response than for the predecessor, the SLA surface, produced by the same company. However, in most studies, this difference disappears after 6-8 weeks. In the clinical studies, a stronger bone response was reported for the SLActive surface during the early healing phase when compared with the SLA surface. However, the later biological response was quite similar for the two surfaces and both demonstrated very good clinical results.

Adapted from A Wennerberg et al., Clin Cosmet Investig Dent. 2011 Sep 5:3:59-67, for more info about this publication click **HERE**

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