

FRIADENT® plus | DENSPLY
FRIADENT
Bibliography

Treatment success –
clinically documented

Order no. 2-002015/005

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2 FRIADENT®plus | Introduction

This Bibliography provides an overview of the publications which document the properties of the FRIADENT® plus surface together with the DENTSPLY Friadent implant systems. The aim of this overview is to scientifically document the successful use of the FRIADENT® plus surface. In addition, the bibliography offers support in searching for relevant articles on the FRIADENT® plus surface.

Publications documenting the research necessary prior to the clinical application of a new implant surface are to be found in the first two chapters of the bibliography (Basic Principles and Pre-clinical Documentation). Chapter 3 (Clinical Documentation) documents the successful clinical (long-term) application of the FRIADENT® plus surface. Chapter 4 of the Bibliography (Systematic Reviews) lists publications which provide information on the topic of surface transcending system boundaries.

DENTSPLY Friadent has briefly summarised all the articles in the bibliography on the following pages. The original studies can be accessed at the specified source.

Bibliographies on the XiVE® implant system, the ANKYLOS® implant system and the FRIALIT® implant system are also available. Further publications on the systems and the surface can be found in relevant databases (e.g. PubMed).

For additional information, please contact your DENTSPLY Friadent partner or info@friadent.de. We will be pleased to help you.

DENTSPLY Friadent

User notes:

The instructions for use that we supply for every product are the final authority for the use of our products with the approved indications. It is possible that the applications and indications described in this bibliography are not yet scientifically accepted or not recommended by us in our instructions for use. The therapist is solely responsible for the selection of a treatment method in every individual case. We cannot accept any liability for the selection of an unsuitable treatment method.

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P8 |Sammons RL, Lumbikanonda N, Gross M, Cantzler P: Comparison of osteoblast spreading on microstructured dental implant surfaces and cell behaviour in an explant model of osseointegration. A scanning electron microscopic study. *Clin Oral Implants Res*; 2005; 16 (6): 657 – 666. **13**

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Clinical studies

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- P17** | Degidi M, Piattelli A, Gehrke P, Carinci F: Clinical outcome of 802 immediately loaded and 2-stage submerged implants with a new grit-blasted and acid-etched surface: 12-month follow-up. *Int J Oral Maxillofac Implants*; 2006; 21 (5): 763 – 768. 25
- P18** | Gehrke P, Jansen R, Eisenmann E, Dhom G, Neugebauer J: Preliminary results of a prospective clinical study on the FRIADENT® plus surface: A two-year follow-up. *EDI*; 2005; 1 (4): 52 – 56. 26

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- P19** | Degidi M, Scarano A, Iezzi G, Piattelli A: Histologic analysis of an immediately loaded implant retrieved after 2 months. *J Oral Implantol* 2005; 31 (5): 247 – 254. 27
- P20** | Iezzi G, Degidi M, Scarano A, Perrotti V, Piattelli A: Bone response to submerged, unloaded implants inserted in poor bone sites: A histological and histomorphometrical study of 8 titanium implants retrieved from man. *J Oral Implantol* 2005; 31 (5): 225 – 233. 28
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- P22** | Degidi M, Piattelli A, Shibli JA, Perrotti V, Iezzi G: Bone formation around immediately loaded and submerged dental implants with a modified sandblasted and acid-etched surface after 4 and 8 weeks: A histologic and histomorphometric analysis. *Int J Oral Maxillofac Implants*; 2009; 24 (5): in press. 30

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Roughness induced dynamic changes of wettability of acid etched titanium implant modifications.

Rupp F, Scheideler L, Rehbein D, Axmann D, Geis-Gerstorfer J: Roughness induced dynamic changes of wettability of acid-etched titanium implant modifications. *Biomaterials* 2004; 25 (7-8): 1429 – 1438.

INTRODUCTION:

The aim of the experiments was to investigate the time-dependent wettability changes of grit-blasted and acid-etched, technically pure titanium implant modifications during their initial contact with aqueous systems compared with a macrostructured reference surface. Dynamic contact angle analysis (DCA) was used for this purpose. Surface topography analysis by scanning electron-microscopy and by contact stylus profilometry.

RESULTS:

The microstructured Ti surfaces were found to be initially extremely hydrophobic. This hydrophobic configuration can shift to a completely wettable surface behavior with water contact angles of 0 degrees after the first emersion loop during DCA experiments. It is suggested that a hierarchically structured surface topography could be responsible for this unexpected wetting phenomenon. Roughness spatial and hybrid parameters could describe topographical features interfering with dynamic wettability significantly better than roughness height parameters. The Ti modifications which shift very sudden from a hydrophobic to a hydrophilic state adsorbed the highest amount of immunologically assayed fibronectin.

CONCLUSION:

The results suggest that microstructuring greatly influences both the dynamic wettability of Ti implant surfaces during

the initial host contact and the initial biological response of plasma protein adsorption. The microstructured surfaces, once in the totally wettable configuration, may improve the initial contact with host tissue after implantation, due to the drastically increased hydrophilicity.

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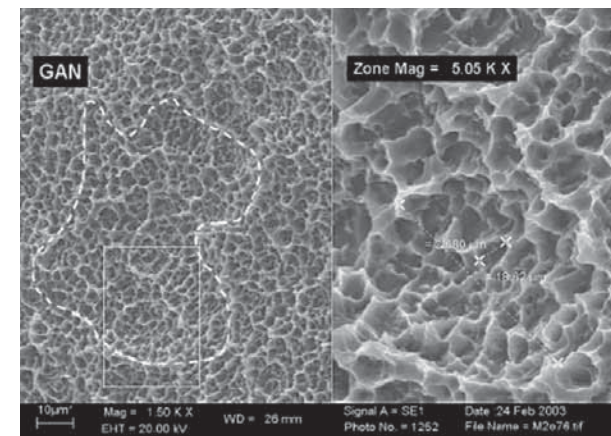


Fig. P1-1: SEM photographs of the microetched GAN surface (= FRIADENT® plus) revealing a hierarchical structure in several ordered levels. In the left photograph, the dotted line encloses a pit, which contains further porous pits. This is further highlighted with the photograph on the right, which is a magnification of the framed area on the left.

Effect of intermittent loading and surface roughness on peri-implant bone formation in a bone chamber model.

Duyck J, Slaets E, Sasaguri K, Vandamme K, Naert I: Effect of intermittent loading and surface roughness on peri-implant bone formation in a bone chamber model. *J Clin Periodontol*; 2007; 34 (11): 998 – 1006.

OBJECTIVE:

This study is intended to clarify the influence of roughness of the implant surface on the formation of peri-implant bone under controlled loading. It is assumed that a rough surface accelerates bone formation.

MATERIAL AND METHODS:

The bone chamber implanted in the tibia of a rabbit consists of two interlocking wooden cylinders. The outer chamber was implanted first. The hollow space for the inner chamber is filled with a placeholder made of Teflon. After three months healing time the placeholder is exchanged for the inner chamber. The implant is placed in the hollow space. Bone can grow in through the openings in the chamber wall. The implant is loaded with the following parameters: 30 µm excursion, load frequency

1 Hz and 400 load cycles. Loading of the implant starts immediately after insertion. It was repeated three times a week at the same time interval over a period of six weeks. Unloaded implants served as the control group. After decalcifying the bone blocks, the samples were prepared for histological and histomorphological evaluation.

RESULTS:

The bone density around the loaded implants was higher than around the unloaded implants.

CONCLUSION:

The mechanical load simulates the formation of bone, significantly increasing with rough implant surfaces. However, further basic research is necessary to better understand the processes (bone formation) and influencing factors (load, implant surface).

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FRIADENT®plus | Basic Research

In-vitro studies

In vitro osteogenesis on a microstructured titanium surface with additional submicron-scale topography.

Schwartz Fo HO, Novaes AB, Jr., de Castro LM, Rosa AL, de Oliveira PT:

In-vitro osteogenesis on a microstructured titanium surface with additional submicron-scale topography.
Clin Oral Implants Res; 2007; 18 (3): 333–344.

OBJECTIVE:

This in-vitro study is aimed at using primary bone forming cell cultures to clarify the key parameters for the formation of bone-like tissue on the surface of pure titanium with microscopic and sub-microscopic topographical features.

MATERIAL AND METHODS:

Discs made of grade 2 titanium with a diameter of 10 mm and thickness of 2 mm were used as the test objects. The test discs were divided into three groups depending on the surface processing. The first two surfaces served as the control group:

- Machined surface (Fig. 1A)
- Sand-blasted and etched surface (Deep Profile Surface – DPS, Fig. 1B)
- Sand-blasted and high-temperature etched surface (FRIADENT® plus surface, Fig. 1C)

All surfaces were analysed with respect to their topography, chemistry and wettability.

The bone forming cells originate from the skullcap of newborn Wistar rats. They were applied to the surface of the test discs. The cells grew for 17 days in a culture medium. The following parameters were investigated:

- Cell adhesion – by direct fluorescence after 30 min, 4 and 24 hours
- Bone sialoprotein (BSP), Fibronectin (FN) and Osteopontin (OPN) – by indirect immunofluorescence after one day and 24 days
- Growth curve and survivability – determined enzymatically after 4, 7 and 11 days
- Total protein content with modified Lowry method after 11 and 17 days
- Alkaline phosphatase (ALP) activity
- Mineralised bone-like nodule formation – optical evaluation after 11 and 17 days

RESULTS:

The topography of the three surfaces differs significantly. The FRIADENT® plus surface shows the most pronounced structuring. The chemical composition is the same for all surfaces. The FRIADENT® plus surface shows significantly better results for wettability. It tends to have hydrophilic properties.

The tests showed no major differences between the three surfaces in terms of cell adhesion, growth curve, survivability, ALP activity or protein content. In contrast to the other surfaces, a mineralised matrix could be observed after eleven days with the FRIADENT® plus surface.

CONCLUSION:

The FRIADENT® plus surface has a positive influence on the differentiation of osteoblasts through the improved wettability with blood (also see P7) and early mineralization.

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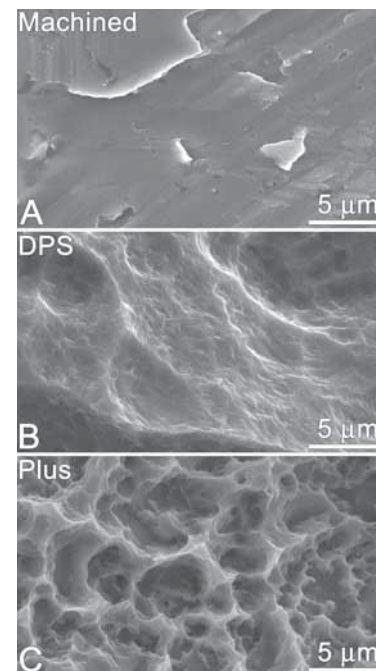


Fig. P3-1: The differences in implant surface structuring are shown with magnification (SEM photograph): machined (A); sand-blasted and etched (B); sand-blasted and high-temperature etched (C).

FRIADENT®plus | Basic Research

In-vitro studies

In vitro screening of micro-structured titanium implant surfaces.

Geis-Gerstorfer J, Rupp F, Scheideler L, Lindemann W:
Das in-vitro Screening von mikrostrukturierten Implantatoberflächen aus Titan.
Lecture (abstract available), 10th International FRIADENT Symposium, 16. – 17. May 2003.

INTRODUCTION:

In the past 25 years, numerous in vivo studies have demonstrated that titanium implants achieve osseointegration predictable. It has been claimed that microstructured titanium surfaces generated by etching processes are able to enhance healing processes and osseointegration even further. We investigated different new FRIADENT® experimental titanium surface modifications generated by etching with respect to surface morphology, protein/surface interactions and biocompatibility. The experimental surfaces were compared to implant surface FRIADENT® DPS.

MATERIALS AND METHODS:

Experimental surface treatments (M1 – M4 and M1 GE) consisted of sand-blasting with grit, etching with HCl, H₂SO₄, HF and oxalic acid and different neutralizing and oxidizing steps. The surfaces were physicochemically and biologically characterized by profilometry, scanning electron microscopy (SEM), dynamic contact angle analysis (DCA) by means of the multiloop Wilhelmy technique and cell culture tests (cell vitality, metabolic activity, cell adhesion, spreading and proliferation) with SAOS-2 osteoblasts.

RESULTS:

DCA-Analysis: The microstructured modifications are initially hydrophobic but turn to a maximum in hydrophilicity in equilibrium. In contrast, the wetting behavior of FRIADENT® DPS is constantly moderate hydrophilic. The adsorption of bovine serum albumin (BSA) and fibronectin (Fn) changed the hydrophilic properties of the material/biosystem-interface in a dynamic way. Dependent on both, the etching process and the respective protein, the surface/ protein-interaction results in a shift to either a hydrophilic or hydrophobic direction.
Biocompatibility: Cytotoxicity tests in direct contact and with extracts of the samples showed no impairment of cell vitality or metabolic activity (XTT-Test) by the etching process and different subsequent treatments. The initial cell adhesion could be improved the most on M2 (= FRIADENT® plus).

CONCLUSION:

DCA results suggest a delayed, but in equilibrium enhanced hydrophilicity of the microstructured surfaces compared to FRIADENT® DPS. The DCA data revealed that binding mechanisms of the serum proteins BSA and Fn are strongly influenced by the respective surface modifications. The etched surfaces, especially M2, enhanced cell adhesion considerably in comparison to the commercial implant surface FRIADENT® DPS. The surface modifications tested show potential to enhance biocompatibility by reducing the healing time.

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In-vitro studies

Initial biological responses to newly developed microstructured titanium implant surfaces.

Rupp F, Rehbein D, Lindemann W, Scheideler L, Weber H, Geis-Gerstorfer J:

Initial biological responses to new developed microstructured titanium implant surfaces.

J Dent Res 2003; 82 (Spec Iss B): 1; Poster at the IADR 81st General Session, Goteborg, Sweden.

OBJECTIVE:

The initial host response at the interface of osseo-implanted biomaterials is determined by their physicochemical surface characteristics, e.g. wettability. The purpose of this in vitro study was to evaluate hydrophilicity and surface/protein interactions of two newly developed micro structured titanium surfaces.

MATERIALS AND METHODS:

Cp titanium (grade 2) implant cylinders were modified by grit blasting and acid etching procedures (HCl/H₂SO₄ and HF/HCl/H₂SO₄/C₂H₂O₄), resulting in two different surface modifications M1 and M2. As a reference, the commercial deep profile surface (DPS) of the FRIALIT®-2 implant (DENTSPLY Friadent GmbH, Mannheim, Germany) was used. The surface texture was analyzed by scanning electron microscopy (SEM). Water wettability and protein/surface interactions with serum fibronectin (FN) were investigated by dynamic contact angle analysis (DCA) using the tensiometric multiloop Wilhelmy method.

RESULTS:

M1 and M2 show a similar microporous topography in SEM. In contrast, the deep profiled reference surface (DPS) showed no micropores. IO-loop Wilhelmy experiments initially showed a strong hydrophobicity of M1 with mean contact angles of 120.1° +/- 15.2° and of M2 with 140.9° +/- 14.4° (n = 5). After the first immersion loop both modifications become strongly hydrophilic with mean equilibrium contact angles of 0°. The hydrophilicity of the reference surface was time-independent with constant mean water contact angles of 81.7° +/- 8.2° from loop 1 – 10. DCA-measurements revealed that serum protein (FN) adsorption increases the hydrophilicity of the reference, whereas the hydrophilicity is decreased on M1 and M2.

CONCLUSION:

The physical-chemical characteristics of the implant surfaces are subject to rapid changes due to interactions with water and serum proteins during implantation. The increased equilibrium wettability and differing FN-mediated hydrophilicity-shifts of the micro-structured surfaces compared to the reference suggest a surface-dependent variety of initial biological responses. Since FN influences the adhesion of osteoblasts, microstructuring may be of clinical relevance by modulating the process of osseo-integration.

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In-vitro studies

Biocompatibility of microstructured titanium implant surfaces.

Scheideler L, Rupp F, Lindemann W, Axmann D, Gómez-Román G, Weber H, Geis-Gerstorfer J:
Biocompatibility of microstructured titanium implant surfaces.
J Dent Res 2003; 82 (Spec Iss B): 1; Poster at the IADR 81st General Session, Goteborg, Sweden.

OBJECTIVE:

Chemical modification (acid etching) of the titanium implant surfaces may be used to enhance biocompatibility. The influence of several experimental surface modifications on protein/surface-interactions (binding strength of fibrin fibrils, fibronectin adsorption) and cellular reactions was investigated.

MATERIALS AND METHODS:

Experimental surface modifications (M1-M4 and M1GE) of titanium (Grade 2) were achieved by sand-blasting with grit, etching with HCl, H₂SO₄, HF and oxalic acid and different neutralizing and oxidizing steps. The commercial „deep profile surface“ (DPS) of the FRIALIT® implant (FRIADENT GmbH, Mannheim, Germany) served as a reference. The adhesion strength between the fibrin fibrils of freshly clotted blood and the implant surfaces was measured by tensile testing. Adsorption of human plasma fibronectin (FN) to the surfaces was determined by ELISA. Proliferation of SAOS-2 osteoblasts was tested by bromodeoxyuridine (BrdU) incorporation in the logarithmic growth phase.

Statistical significance was evaluated by repeating experiments and calculation of 95 % confidence intervals (CI) of means.

RESULTS:

The adhesion strength of fibrin fibrils increased from 4 (CI = 1.7) N/cm² for DPS to 15 (10 – 19) N/cm² for M2 and 22 (14 – 29) N/cm² for M1GE. The amount of adsorbed fibronectin on acid-etched surfaces was enhanced from 49 (CI = 43 – 55) µg/sample on DPS up to 70 (66 – 74) µg/cm² on M1. The proliferation rate of osteoblasts on micro structured surface modifications was enhanced 1.41 fold (CI = 1.24 – 1.53) on modification M1GE and by a factor of 1.27 (1.16 – 1.40) on M2. Cell adhesion was enhanced up to 1.6 fold on M2.

CONCLUSION:

Acid microstructuring led to enhanced cell adhesion and proliferation. Variations of the treatment following acid etching influenced the biological response to a large extent. This is probably caused by physicochemical surface properties, which modulate initial protein/surface-interactions. The surface modifications tested may have the potential to enhance biocompatibility of implants in vivo.

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FRIADENT® plus | Basic Research

In-vitro studies

P7

Quantitative evaluation of the fibrin clot extension on different implant surfaces: An in vitro study.

Di Iorio D, Traini T, Degidi M, Caputi S, Neugebauer J, Piattelli A:

Quantitative evaluation of the fibrin clot extension on different implant surfaces: An in vitro study. *J Biomed Mater Res B Appl Biomater*; 2005; 74 (1): 636–642.

OBJECTIVE:

The aim of the present study was a quantitative evaluation of the in vitro fibrin clot extension on different implant surfaces.

MATERIALS AND METHODS:

Forty-five disk-shaped titanium (grade 2) samples with three different surface topographies: machined, deep profile structure (DPS), and FRIADENT® plus were used as test objects. For the quantitative evaluation of the fibrin clot, 30 specimens were used (10 per group); human whole blood was employed. Freshly taken blood from three healthy adult volunteers, and 0.2 ml were dropped onto the surface of each specimen with a syringe. Contact time was 5 min at room temperature. Then the samples were rinsed with saline solution and fixed in a buffered solution of glutaraldehyde and paraformaldehyde. Samples were washed again with buffer and dehydrated in an ascending alcohol series. Specimens belonging to all groups were observed under SEM at a magnification of 1000x. From each sample, 50 random micrographs were collected with an N x M 1024 x 768 grid of pixels.

RESULTS:

The results for the quantitative analysis of the fibrin clot extension are shown in Table 1. The ANOVA resulted in significant differences between the groups. The Tukey test revealed that the extension of the fibrin clot of FRIADENT® plus samples was statistically higher compared to both machined and DPS samples.

CONCLUSION:

The results of this in vitro study indicate that there is a correlation between implant surface morphology and fibrin clot extension. Improvement in surface micro texture complexity seems to determine the formation of a more extensive and three dimensionally complex fibrin scaffold. Further investigations are necessary to explain in more detail the mechanisms that regulate fibrin clot formation on different implant surfaces.

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| Group / surface | N | Pixels | SD |
|------------------------------|----|----------|----------|
| Machined | 10 | 345987.2 | 63747.7 |
| Deep Profile Structure (DPS) | 10 | 375930.9 | 54726.86 |
| FRIADENT® plus | 10 | 612333.6 | 46268.42 |

Table P7-1: Size of the blood clots in pixels.

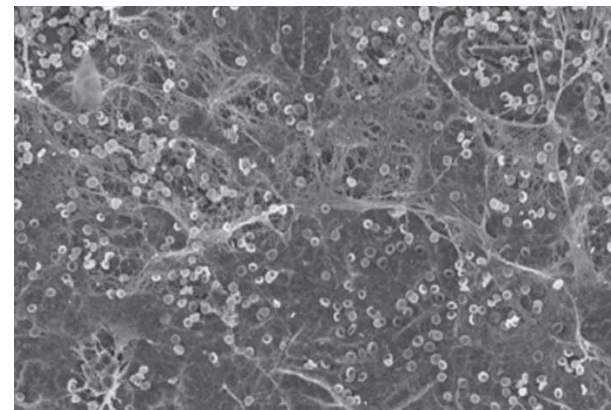


Fig. P7-1: Fibrin and red blood cells on DPS surface: Fibrin scaffold is thin (SEM image 1000 x original magnification).

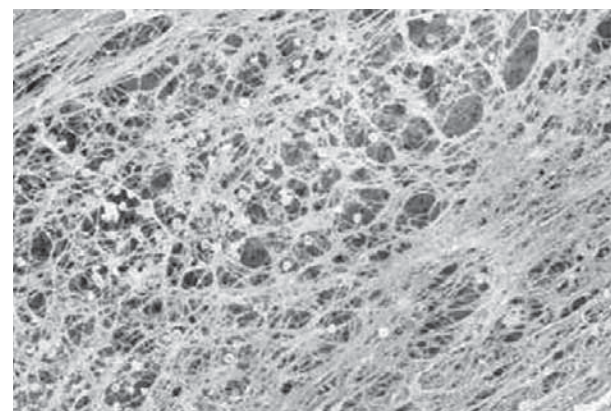


Fig. P7-2: Fibrin and red blood cells on FRIADENT® plus specimen (SEM image 1000 x original magnification).

FRIADENT® plus | Basic Research

In-vitro studies

P8

Comparison of osteoblast spreading on microstructured dental implant surfaces and cell behavior in an explant model of osseointegration. A scanning electron microscopic study.

Sammons RL, Lumbikanonda N, Gross M, Cantzler P: Comparison of osteoblast spreading on microstructured dental implant surfaces and cell behaviour in an explant model of osseointegration. A scanning electron microscopic study. *Clin Oral Implants Res*; 2005; 16 (6): 657–666.

Clin Oral Implants Res; 2005; 16 (6): 657–666.

Supplemented by placed information from posters published prior to the article:

Sammons R, Lumbikanonda N, Cantzler P: In vitro Comparison of Mineralisation on FRIALIT® and ANKYLOS® Implant Surfaces. *Poster Abstract, 11. Internationales Friadent Symposium, Dresden, 22. – 23. April 2005;*

Sammons R, Cantzler P, Lumbikanonda N: Cell attachment to FRIALIT®-2 and ANKYLOS® microstructured dental implant surfaces. *Clinical Oral Implants Research*; 2004; 15 (4): lxvi-lxvii. *Poster presentation at the 13th EAO Paris;*

Sammons R, Lumbikanonda N, Cantzler P: Osteoblast interactions with different microstructured dental implant surfaces: Comparative study of cell attachment, migration, proliferation, and differentiation. *J Dent Res*; 2003; 82 (Spec Iss B): Abstract No. 1840. *Poster at the IADR 81st General Session, Goteborg, Sweden.*

INTRODUCTION:

The surfaces of titanium dental implants are sand-blasted to produce a rough primary structure. This promotes mechanical anchoring in the bone. Subsequent acid-etching leads to a secondary microstructure. This can accelerate osseointegration. It is known that a three-dimensional closed environment favours bone formation. An environment of this nature can be created by a rough microstructure on the implants surrounded by cells and collagen. Implant surfaces with a differentiated microstructure can therefore influence the shape, localisation and composition of the mineralised tissue.

The initial interactions of proteins and cells with the surfaces of dental implants for the basis for the subsequent processes which lead to osseointegration. The macro-roughness caused by blasting or spraying with titanium plasma leads to surface depressions of several micrometers thickness. This enlarges the surface and thus the contact area to the bone. This has a favourable effect on anchoring the implant in the bone. Further extension of the roughened surfaces in the range 1 – 5 µm can influence the attachment and morphology of pre-osteoblasts, as well as their proliferation and differentiation to a mature osteoblast phenotype. Optimisation of surface properties plays an important role for the promotion of rapid osseointegration, especially for early-loaded implants.

OBJECTIVE:

The effect of mineralisation on blasted and acid-etched implant surfaces with different secondary microstructures was investigated in this study.

| Manufacturer | DENTSPLY FRIADENT® (Mannheim, Germany) | Straumann (Basel, Switzerland) | 3i (Palm Beach, FL, USA) | Nobel Biocare (Gothenburg, Sweden) |
|---------------------|--|--------------------------------|---------------------------|------------------------------------|
| Surface | DPS | TPS | SLA | TiUnite |
| Surface treatment | Grit-blasted, acid-etched, neutralised | Plasma-sprayed | Grit-blasted, Acid-etched | Anodised |
| R _a (µm) | 2.41 | 3.5 | 2.93 | 0.76 |
| St. dev. | 0.32 | 0.47 | 0.46 | 0.14 |
| Lot. no. | 102189-310755 | 9990099 | 101619-110696 | 157228 |
| | | | | 631748 |
| | | | | 632065 |

Fig. P8-1: Implants used in the study.

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FRIADENT®plus | Basic Research In-vitro studies

MATERIALS AND METHODS:

Seven commercially available implant types were used in this study (Fig. P8-1). The surfaces were sprayed, grit-blasted and/or acid etched, machined or they consisted of anodised titanium. The cell behaviour was compared with two different methods:

- (1) Determination of cell propagation, where by the percentage fractions of cells were identified in four different stages of attachment (Fig. P8-2) using a scanning electron microscope and quantified in an attachment period of 30 minutes.
- (2) The implants were set in a “pocket culture”. Rat calvarial bone fragments were placed on the implants and stored in a culture medium for two to four weeks in nylon pockets. This enabled the bone cells to migrate onto the implant surfaces. The cultures were stored in a medium with and without ascorbic acid, β -glycerophosphate and dexamethasone to promote mineralization. The samples were fixed and dehydrated in preparation for the investigation by SEM and energy dispersive X-ray spectroscopy. The nylon material and the bone fragments were then removed to investigate the underlying tissue.

RESULTS:

Surfaces combining grit-blasted and acid-etched with porous microstructure showed significantly enhanced rates of cell spreading compared with the other surfaces (Fig. P8-3). The highest percentages were on the FRIADENT® plus surface and the surfaces of the Straumann implants. Differentiated cell morphology was observed in both experimental set-ups. After two weeks, multicellular layers with extracellular matrix (ECM) were present between the layers and on the material surfaces. After 4 weeks, cell layers were more consolidated, and microstructures were obscured by layers of cells and ECM. Mineralized tissue was seen in association with ECM on grit-blasted surfaces of rough and smooth microtopography. Mineralization: Mineral occurred in at least 2 different forms: “nodules” of calcium phosphate were seen within the cell sheets and smaller discrete particles termed “calcospherites” were seen within collagen fibres or (on DPS) beneath collagen adherent to the implant surface.

CONCLUSION:

The two methods provided complementary information: a rough surface of porous microstructure may enhance the rate of cell spreading. Differentiation and calcification occurred on surfaces of both rough and smooth microstructure. Implant surface microstructure influenced cell

morphology and apposition, extracellular collagen matrix and associated mineral deposits relative to the surface. Evidence of fusion of collagen fibres was also seen and fusion of calcospherites within the extracellular matrix (as occurs with matrix vesicles) was observed. This could facilitate the local concentration of calcium and phosphate ions and regulatory molecules and thus promote crystal nucleation and growth. This could facilitate the local concentration of calcium and phosphate ions and regulatory molecules and thus promote crystal nucleation and growth. This could partially explain how grit-blasted and acid-etched surfaces may accelerate bone formation in addition to providing a means of promoting mechanical interlocking with bone.

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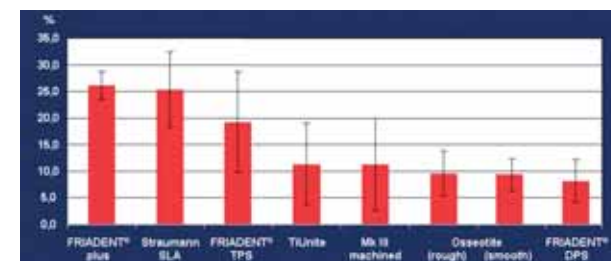


Fig. P8-2: The four different stages of cell attachment.

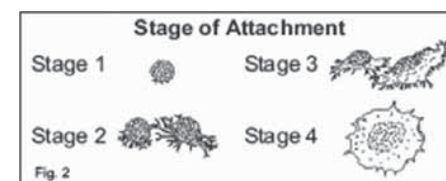


Fig. P8-3: Average percentage of cells in the fourth stage on each of the implant surfaces.

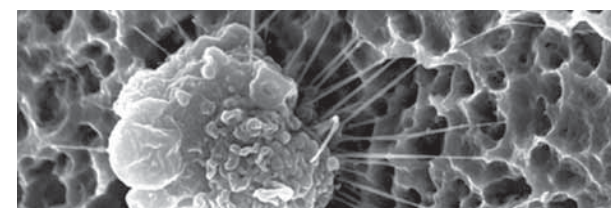


Fig. P8-4: Initial contact and anchoring of an osteoblast with filiform projections (filopodia) on the FRIADENT® plus surface.

FRIADENT®plus | Preclinical documentation

Bone remodeling around dental implant surfaces in regional bone by means of polyfluorochrome marking in beagle dogs.

Weibrich G, Kleis W, Buch RSR, Hansen T, Streckbein P: Bone remodeling around dental implant surfaces. *zzi Zahnärztl Impl; 2009; 25 (3): 238 – 248.*

OBJECTIVE:

This study compares the different surface structures of four implants with respect to the resulting peri-implant bone remodeling and the bone-implant contacts (BIC) in the medium-term and late osseointegration process.

MATERIAL AND METHODS:

- Four different titanium screw implants were investigated:
- Branemark (MK III) – anodized surface
 - 3i Osseotite – surface acid-etched twice
 - XiVE® – grit-blasted and high temperature etched FRIADENT® plus surface
 - Compress – surface machined and sand-blasted in the apical third

In twelve beagles all four types of implant were inserted in the mandible according to the manufacturer's specifications (Fig. P9-1)

Sequential intravital marking of the regenerating bone was performed postoperatively with 3% alizarin (application on the day of surgery), 1% calcein green was injected 7 and 14 days postoperatively and 6% xylenol orange 21 and 28 postoperatively. The results of healing were analyzed histologically and histomorphologically for five animals after six weeks and for six animals after twelve weeks (Fig. P9-2).

RESULTS:

After a six-weeks healing period no statistically significant difference was shown between the four implant surfaces investigated both in regard to the analyzed peri-implant bone regeneration rate or the resulting BIC. This was also the case for the results after twelve weeks of healing, with one exception. The only significant different in the bone regeneration rate could be shown in this group for the Compress implant vs. Branemark. The bone-implant contact (BIC) for XiVE® was 72.36% (\pm 8.21%), Branemark 53.37% (\pm 9.74%), Osseotite 47.47% (\pm 11.95%) and Compress 42.7% (\pm 5.7%). There was no statistically significant difference.

CONCLUSION:

This study supports the thesis that the implant surface investigated makes no statistically significant difference to peri-implant bone generation and the implant-bone contact (BIC).

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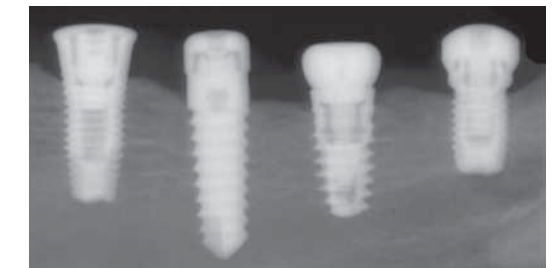


Fig. P9-1: Four implants were placed per mandible.



Fig. P9-2: Reduced image of the histological preparation of four different implant types/surfaces labeled to measure the bone-implant contact rate after six weeks. (top left: Branemark, top right: Osseotite, bottom left: XiVE® and bottom right Compress).

Peri-implant bone organization under immediate loading state

Neugebauer J, Traini T, Thams U, Piattelli A, Zoller JE: Peri-Implant Bone Organization Under Immediate Loading State. Circularly Polarized Light Analyses: A Minipig Study. *Journal of Periodontology*; 2006; 77 (2): 152 – 160.

Supplemented by information from posters published prior to the article:

Neugebauer J, Thams U, Románm S, Steveling H: Clinical procedure and first results of immediately restored implants – A study in mini-pigs. *Scientific poster, 10th Meeting der European Association for Osseointegration, 13 – 15 September 2001.*

Neugebauer J, Thams U, Roman SF, Cantzler P, Zoeller JE, Traini T, Piattelli A: Collagen fiber and osteons presence next to immediate loaded implants. *Scientific poster, 13th Meeting of the European Association for Osseointegration, 9 – 12 October 2003.*

BACKGROUND:

Immediate loading of dental implants is one of currently most examined topics in implant dentistry. Utilizing screw implants with a micro-structured surface and bone quality adapted insertion procedures, osseointegration is achieved when implants are initially stable and when splinted with the superstructure. Despite reported success, there is a shortage of information relating to remodeling and the peri-implant bone formation with immediately loaded implants.

MATERIAL AND METHODS:

Four to six immediately loaded and unloaded dental implants with a micro-structured surface (XiVE®) were placed in the mandible and the maxilla in seven mini-pigs.

A total of 85 implants were placed. The implants were immediately loaded with plastic bridges. After a four-months healing period all implants were retrieved. Histomorphometry was performed using a light microscope in transmitted polarized light (Laborlux S, Leitz, Wetzlar, Germany) connected to a high-resolution video camera interfaced to a monitor and PC. The analysis was done with a digitizing pad (Matrix Vision GmbH) and a histomorphometry software package (Image-Pro Plus 4.5, MediaCybernetics, Immagini & Computer Snc, Milan, Italy). The bridge insertion torque (BIT) was calculated from the sum of the insertion torques of the implants divided by their number.

RESULTS:

Implants showed osseointegration if the average insertion torque of the implants within one bridge (BIT) was above 35 Ncm. If the primary stability of the bridge was below 35 Ncm all implants of this quadrant were lost after four months. The multivariant discriminate analysis showed the highest correlation for implant stability by bridge insertion torque (BIT), localization (mandible or maxilla) and implant insertion torque (IIT) as success parameter.

The loaded implants displayed a high degree of bone-implant contact. The collagen fibers, were oriented in a more transverse or circular way. In addition a higher quantity of secondary osteons was present. In comparison, the unloaded implants had collagen fibers with a more parallel orientation and a higher quantity of marrow spaces was present.

CONCLUSION:

This animal study demonstrated that immediately loaded implants with the FRIADENT® plus surface showed a higher degree of bone formation with improved bone-implant contact and bone remodeling than non-loaded implants. The number of secondary osteons was also higher. Implants with microstructured surfaces show qualitatively improved bone remodeling. The immediately loaded implants also showed a prevalence of transversal collagen

fiber in the peri-implant bone. Implants were shown to be successful in this animal study for which the average insertion torque was greater than 35 Ncm per bridge construction.

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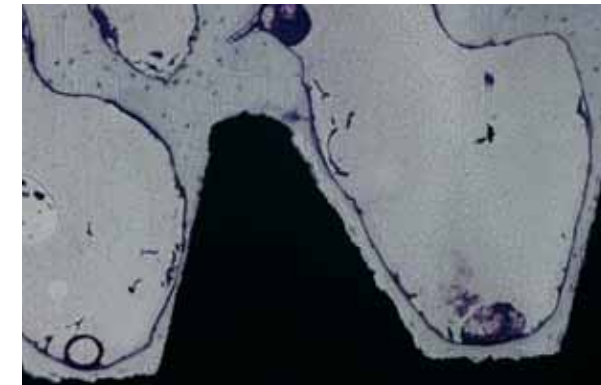


Image P10-1: Unloaded implant illustrates close bone-to-implant contact at the apical threads. The bone between the threads shows large marrow spaces.

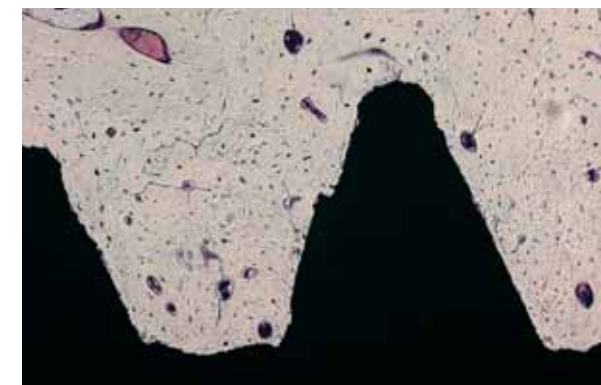


Image P10-2: Loaded implant shows new bone formation within the threads. Active osteocytes are seen between the threads.

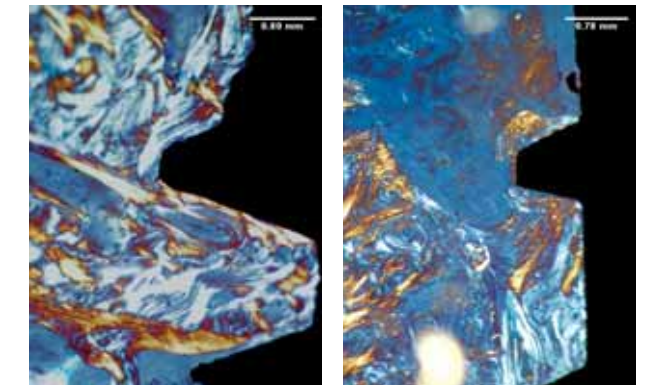


Image P10-3: 4 months after immediate loading of XiVE® implants: Change of crestal to apical thread transverse collagen fibers appear yellow.

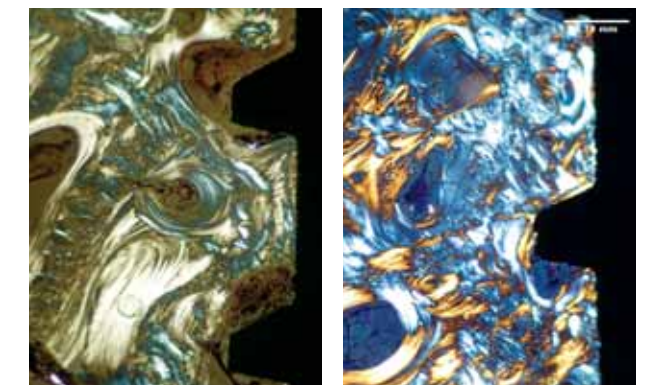


Image P10-4: Unloaded XiVE® implants after four months healing: Crestal thread area with longitudinal fibers in white/grey.

P11

Influence of implant microstructure on the osseointegration of immediate implants placed into periodontally infected sites. A histomorphometric study in dogs.

- [1] Novaes Jr AB, Marcaccini AM, Souza SL, Taba M, Jr., Grisi MF:
Immediate placement of implants into periodontally infected sites in dogs: a histomorphometric study of bone-implant contact.
Int J Oral Maxillofac Implants; 2003; 18 (3): 391 – 398.
- [2] Novaes AB, Jr., Papalexiou V, Grisi MF, Souza SS, Taba M, Jr., Kajiwaru JK:
Influence of implant microstructure on the osseointegration of immediate implants placed in periodontally infected sites. A histomorphometric study in dogs
Clin Oral Implants Res; 2004; 15 (1): 34 – 43.
- [3] Novaes AB, Jr., Papalexiou V, Grisi MF, Souza SS, Taba M, Jr., Kajiwaru JK: Influence of implant microstructure on the osseointegration of immediate implants placed in periodontally infected sites. A histomorphometric study in dogs.
Clin Oral Implants Res; 2004; 15 (1): 34 – 43.

OBJECTIVE:

In an initial pilot study it was investigated, in comparison with a healthy control group, whether it is possible to immediately placed implants (FRIALIT®-2) with a blasted and etched surface in fresh extraction alveoli in periodontally infected sites. The results of this pilot study showed that immediate implantation in periodontally infected sites is possible provided the appropriate pre and post-operative care is provided [1]. In a subsequent study, the influence of the implant microstructure on osseointegration of immediate implants was evaluated with two different surfaces in periodontally infected sites [2, 3].

MATERIAL AND METHODS [2, 3]:

Periodontal disease was induced during 12 weeks bilaterally from P1 to P4 in six dogs. The teeth were extracted and a total of 36 FRIALIT® implants were immediately placed in the fresh extraction alveoli. Implant placement was randomly assigned so that for each side in the mandible a different implant surface (Group 1: blasted and etched; Group 2: titanium plasma sprayed, TPS) was implanted (Fig. P11-1). During the healing period, fluorescent bone markers (oxytetracyclin hydrochloride; calcein green; alizarin red) were injected to later study the bone remodeling around the implants (Fig. P11-2). The animals were anesthetized and killed 12 weeks after implant placement and the mandibles were removed. The percentage of newly formed bone surrounding the implant was determined using a confocal laser scanning microscope. The bone-implant contact (BIC in %) and the bone density (directly next to the implant surface and in the implant environment, BD in %).

RESULTS [2, 3]:

| Parameter | Group 1: sandblasted/ etched | Group 2: TPS |
|---|------------------------------|-----------------|
| BIC | 52.7% (± 13.8) | 42.7% (± 18.0) |
| BD (near surface) | 66.6% (± 13.3) | 58.8% (± 15.9) |
| BD (implant environment) | 58.7% (± 15.4) | 55.8% (± 13.3) |
| New bone formation 3 days (blue) | 5.28% (± 2.24) | 3.36% (± 1.46) |
| New bone formation 4 weeks (yellow-green) | 10.3% (± 1.99) | 9.58% (± 1.09) |
| New bone formation 8 weeks (blue) | 21.14% (± 8.19) | 14.57% (± 4.39) |
| New bone formation 12 weeks (red) | 6.98% (± 5.02) | 7.08% (± 3.99) |

There were no significant statistical differences in bone formation between the two surfaces. However, covariance analysis showed that the percent of marked bone was statistically greater in Group 1 when compared to the Group 2, between the 3-day and 8-week periods of evaluation. The mean differences of BIC were verified through the Mann-Whitney test and differences in bone density through the Kruskal-Wallis test: The differences were not statistically significant (P > 0.05).

CONCLUSION:

The results show that also in a critical situation, such as immediate implantation in a periodontally pre-damaged region, a high degree of reliability can be achieved with the FRIADENT® plus surface.

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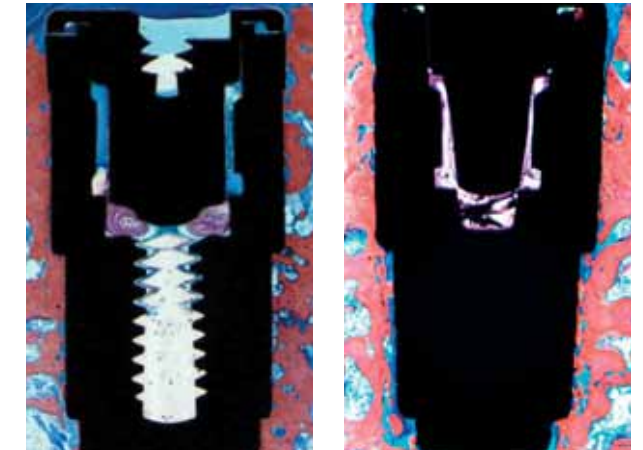


Image P11-1: Bone-to-implant contact of the grit-blasted/acid-etched surface (experimental surface; left site) and of the titanium plasma sprayed surface (right site).

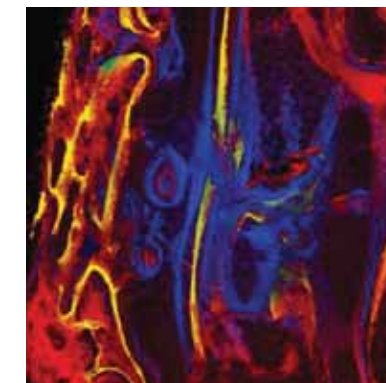


Image P11-2: Projection images obtained by CLSM of the three fluorochromes administered 3 days, 4 weeks, 8 weeks after implant placement. The different colors show the bone formation that occurred at different time periods.

P11

Mechanical and histological evaluation of immediate loaded implants with various surfaces and designs.

Weinländer M, Lekovic V, Neugebauer J, Plenk Jr H, Zöller JE: Mechanical and histological evaluation of immediate-loaded implants with various surfaces and designs. *Scientific Poster, 18th Annual Meeting of the Academy of Osseointegration, February 27 – March 1, 2003.*

INTRODUCTION:

Immediate loading is stated to be the most innovative technique in implant therapy. Various designs claim to reduce time for the implant treatment protocol. Various implants are available with diverse modifications to the macro and micro morphology. Different surgical approaches are under discussion for achieving osseointegration under immediate loading.

OBJECTIVE:

The RFA values are compared with the histological findings in order to determine the relevant factors for implant success.

MATERIALS AND METHODS:

In two mongrel dogs a edentulous alveolar ridge was prepared by extracting all premolars in general anesthesia. After a regeneration phase of three months, the following implants were placed per quadrant:

- Mark 3, TiUnite, Nobelbiocare
- ITI Screw, TPS-Coating ITI-Straumann
- 3i Osseotite, Implant innovation
- XiVE®, experimental surface M2.1, DENTSPLY Friadent

Immediate loading with gold casted bridges was achieved a week post implantation. Postoperative injection of Oxytetracyclin (10 d), Xylenolorange (30 d), Alizarinrot (90 d) and Calceingrün (110 d) served to present the different growth phases of the bone. The ISQ-values (Osstell, Integration Diagnostic) were measured after implant placement and after sacrifice respectively.

RESULTS:

All 16 bridges were in function after a five months loading period. No implant was lost, all implants showed success-

ful osseointegration. Crestal bone loss was observed in a small amount mainly up to the first thread. Depending on the surgical protocol this bone loss was different for each system. The ISQ values showed an increase between surgery and recall in average 9.25. In spongy bone early formation of new bone was observed. In cortical bone new bone formation could only be noticed after 3 months of loading. At the loading area of the threads some less intensive bone contact is detectable by micro-radiography.

CONCLUSION:

Bone remodeling starts in the spongiosa and later in the cortical bone. All implant surfaces showed the same good bone-implant contact.

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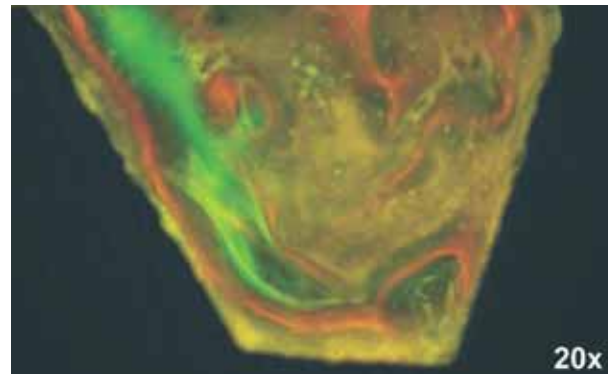


Fig. P12-1: Intensive bone formation on implant surface at early stage.

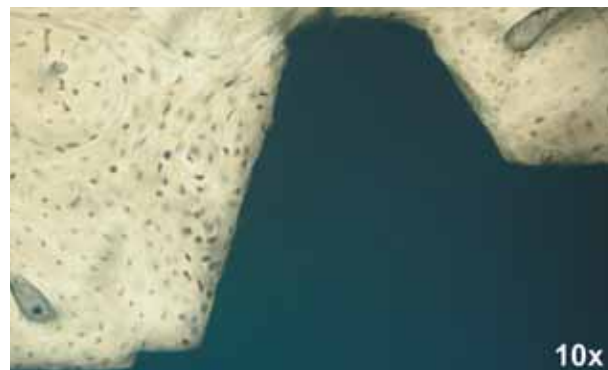


Fig. P12-2: Good bone contact along implant surface in region of change of thread designs.

Prospective study of the “FRIADENT® plus” implant surface: two-year clinical experience.

Gehrke P, Jansen R, Dhom G, Neugebauer J: Prospective study of the “FRIADENT® plus” implant surface: two-year clinical experience. *zzi Zahnärztl Impl; 2006; 22 (1): 29–34*

OBJECTIVE:

The initial processes of osseointegration are positively influenced by microstructured implant surfaces. An intensive bond is formed between bone and implant. The objective of this study was to evaluate the clinical results of the new grit-blasted and high-temperature etched FRIADENT® plus surface.

MATERIAL AND METHODS:

In a multi-centre study, 155 root-analogous FRIALIT® plus implants were placed in 77 patients (17 – 78 years) between July 2003 and July 2005. Twenty-six implants (17%) were immediately loaded and 129 (83%) were loaded in two-stage procedure. The following variables were investigated: Implant length (minimum 10 mm), implant diameter (minimum 3.8 mm), position of the implant (anterior and posterior region in the maxilla and mandible), bone quality and prosthetic care. In all patients the peri-implant, crestal bone level was determined with a peri-apical X-ray in a calibrated investigation. The measurements and data acquisition were each performed immediately after implantation, on reentry, after 12 and 24 months.

RESULTS:

A success rate of 97.37% was attained over the 24-month period of observation following placement of the implants. Only three of the 155 implants were lost. The mean crestal bone loss after one year was 0.99 mm and after two years 1.16 mm.

DISCUSSION:

Besides the surgical and prosthetic procedures, the macro and micro design of an implant is of significant importance for the success of long-term treatment. The positive result of this study is attributable to the use of implants with a microstructured surface.

CONCLUSION:

This evaluation of the two-year results demonstrates that implants with the FRIADENT® plus surface attain a high rate of integration. They remained stable during the functional duration of the implants. With a success rate of 97.37% and a mean marginal bone loss of 1.16 mm after two years of loading, the implants investigated showed a predictable clinical result. Furthermore, the high predictability of prosthetic restoration of implant-supported reconstructions in partially and fully edentulous patients is attributable to the FRIADENT® plus surface.

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Clinical experiences with the FRIADENT® plus surface in immediate implantation and early loading.

- P14**
- [1] Jansen R, Kielhorn J, Schmenger K, Neugebauer J:
First clinical experience with stepped cylinder-design implants with high temperature etched surface for immediate implant placement and early loading.
Scientific poster, 19th Meeting of the Academy of Osseointegration, 18 – 20 March 2004, San Francisco.
- [2] Jansen R, Kielhorn J, Schmenger K, Eisenmann E, Neugebauer J:
[P] Clinical results after 2-year experience with a three-dimensional surface on screw-type implants.
Scientific poster, 20th Meeting of the Academy of Osseointegration, 10 – 12 March 2005.

OBJECTIVE:

Recent clinical studies indicate that the micromorphology of the implant surface has a positive influence on the initial cell contact and the bone quality. The impact of a blasted and high-temperature etched surface on the insertion and healing behaviour of implants was evaluated in a two-year clinical study. FRIALIT® plus implants were placed in 10 international implantology centres. The results immediately after attaining osseointegration, after four months [1] and two years after insertion were collected and evaluated on the basis of peri-implant bone parameters.

MATERIAL AND METHODS:

The surface was structured by blasting with grit particles and a high-temperature etching process with subsequent neutralization (FRIADENT® plus surface). The data of 77 patients and 140 FRIALIT® plus implants were collected

and evaluated. The implants were immediately placed in extraction sites, as well as delayed and late insertion. Augmentation procedures were performed on 29% of the patients prior to the implant placement and on 49% concurrently with implant placement. Following an average healing time of seven to eight weeks, the implants were exposed, the soft tissue adapted and prosthetic restoration performed. The majority of patients (83%) received a fixed restoration (26% single crowns, 55% bridges, 2% in combination with natural teeth). Removable prosthetic solutions (11% bars, 6% ball-head anchor) represented the minority.

RESULTS:

All implants showed good wettability during insertion. Even if the surface seems to be rougher, the insertion torque were similar to the standard implants with low temperature etched surface. All implants showed good osseointegration. After prosthetic loading of 4 months, 3 implants failed in 2 patients. No further losses occurred over the course of the study. The osseointegrated implants showed a mean crestal bone loss of less than 1.5 mm both in the first follow-up examination as well as after 2 years. No differences in the peri-implant parameters were found between the different regions of the jaw.

CONCLUSION:

The insertion and the management of the implant with the new surface characteristics was not influenced by the new surface preparation. The initial results show a high level of reliability for the FRIADENT® plus surface for all indications.

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Clinical experiences with the FRIADENT® plus surface in immediate implantation and early loading.

- Khoury F, Becker C, Hanser T, Berger F, Neugebauer J:
[P] A prospective study on immediate loading of dental implants.
Scientific poster, International Congress on Reconstructive Preprosthetic Surgery, 5 – 7 April, 2003, Palm Springs.
- Hanser T, Stavola J, Neugebauer J, Khoury F:
Immediate loading of implants: Influence of surface characteristics.
Clinical Oral Implants Research; 2004; 15 (4): Iv.; Scientific poster, 13th Meeting of the European Association for Osseointegration, 16 – 18 September 2004, Paris.

INTRODUCTION:

Recent clinical studies indicate that an implant with a roughened surface may be loaded sooner than traditional healing protocols have recommended. This study shows the clinical performance of immediate loading of dental implants with a porous microstructured, grit-blasted / acid-etched / neutralized surface in different treatment modalities.

MATERIAL AND METHODS:

Between 1999 and 2003, 273 XiVE® implants were placed (224 in the mandible and 49 in the maxilla) and immediately loaded. The placement torque was at least 35 Ncm. The immediate restoration was performed with the following immediately loaded prostheses:

- Bar – 152 implants, interforaminal region of the mandible
- Bridge – 20 implants, interforaminal region of the mandible

The other 101 implants mainly in the esthetic area of the maxilla and mandible were immediately restored but without functional loading (out of occlusion), for single tooth or bridge restoration.

RESULT:

After a follow-up of 12 to 60 months (average 36.3 months) 3 implants failed in the edentulous mandible during the first 2 months of loading. All other implants are still in

function with acceptable peri-implant parameters. Bone loss > 3mm was observed in six implants placed in the edentulous mandible and in one implant in the maxilla. The 101 non-functionally loaded implants osseointegrated and were restored with a functionally loaded ceramic crown or screw-retained bridge 3 to 4 months after implant placement. Peri-implant probing depth and bone loss showed no significant difference between functional and non-functional implant loading.

DISCUSSION:

The data and the experience described in this 5-year analysis indicate that immediate loading beyond the proven and documented standard of splinting four implants in the anterior mandible can be a predictable technique for shortening treatment time with a high level of satisfaction for patients. This assumes that the implants could be inserted with high primary stability. The specific surface roughness on the endosseous section of the implant seems to enhance the regeneration potential at the interface, thus improving clinical implant osseointegration, allowing accelerate implant protocols.

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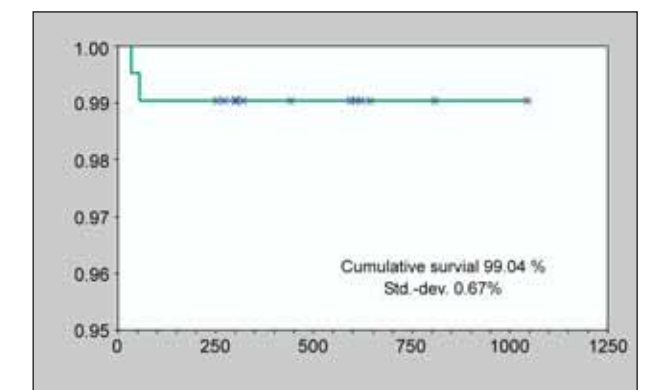


Fig. P15-1: The cumulative survival rate of the implants.

New tissue adapted surface design on implants with taper connection.

Ender M, Jansen R, Eisenmann E, Conserva E: [P265] New tissue adapted surface design on implants with taper connection. *Scientific Poster, 15th Annual Scientific Meeting of the European Association of Osseointegration, 5 – 7 October 2006.*

INTRODUCTION:

Long-term function and stability of the peri-implant hard and soft tissue are the major goals in modern implantological treatment. According to the experience with a new implant surface, the design of the FRIADENT ANKYLOS® implant was changed in order to enhance the possibility of a long-term treatment success by subcrestal implant placement. The smoothed collar replaces the microroughened surface and now extends to the implant shoulder. This modification appears to have a positive effect on the implant-to-bone contact and bone quality. 14 clinics are involved into this interdisciplinary, prospective multicenter investigation to verify the performance of the new implant design with the FRIADENT® plus surface.

OBJECTIVE:

The aim of this poster was to evaluate the modified implant design.

MATERIALS AND METHODS:

The current data are based on 109 ANKYLOS® plus implants that were placed in 70 patients. There were 24 male and 46 female patients involved in the investigation. Their age ranged from 17 to 77 years. Immediate, delayed and late loading were performed with particular case, indication and planned prosthetics.

RESULTS:

No implant failure occurred through to the time of data compilation. There was no measurable bone loss at the time of reentry, apart from one case of bone loss less than 1 mm. No differences in the outcome due to diverse regions of the jaws could be noted. The data indicate a high success rate for the new implant design in different clinical indications. Further results with more patients have to be compared with the present findings.

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Fig. P16-1: X-ray pre-OP.



Fig. P16-2: ANKYLOS® plus implant.



Fig. P16-3: X-ray before reentry.

Clinical outcome of 802 immediately loaded and 2-stage submerged implants with a new grit-blasted and acid-etched surface: 12-month follow-up.

Degidi M, Piattelli A, Gehrke P, Carinci F: Clinical outcome of 802 immediately loaded 2-stage submerged implants with a new grit-blasted and acid-etched surface: 12-month follow-up. *Int J Oral Maxillofac Implants; 2006; 21 (5): 763 – 768.*

OBJECTIVE:

The aim of this study was to evaluate the clinical outcome of delayed or immediately loaded implants of three different implant macro-designs (XiVE® plus, XiVE® TG and FRIALIT®). The hypothesis is that no significant differences in implant success would be observed between immediately and delayed loaded implants.

MATERIALS AND METHODS:

Between July 2003 and December 2003, 321 patients were consecutively enrolled in this study. Immediate loading took place in cases where the implant stability quotient (ISQ) values were > 60 (as determined by resonance frequency analysis) and implant insertion torque was > 25 Ncm. In the case of delayed loading, a submerged technique (2-stage) or a single-stage procedure was used. The following variables were statistically analyzed with logistic regression: implant length, implant diameter,

implant type, implant site, insertion torque, ISQ, and type of loading (immediate or delayed).

RESULTS:

802 implants were placed of which 423 implants were immediately loaded and 379 implants loaded after a delay. All implants were followed up for a minimum of 12 months after prosthetic loading. There was an overall success rate of 99.6% and only three implants were lost. No statistically significant differences were found for any variables between the failures in the two groups (immediate loading protocol versus delayed loading). Implants with a crestal bone loss greater than 0.2 mm during the first year of observation (69 cases) were evaluated as a group; within this subset, only ISQ value ($P < .004$), implant length ($P < .002$), and implant type ($P < .049$) had a statistically significant effect on crestal bone resorption.

CONCLUSION:

Based upon this study of 802 implants, no significant differences in implant success were observed between the two groups.

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Preliminary results of a prospective clinical study on the FRIADENT® plus surface: A two year follow-up.

Gehrke P, Jansen R, Eisenmann E, Dhom G, Neugebauer J: Preliminary results of a prospective clinical study on the FRIADENT® plus surface: A two-year follow-up. *EDI; 2005; 1 (4): 52 – 56.*

BACKGROUND:

The structure of an implant surface is widely recognized as being an essential factor in achieving long-term implant success. It has been suggested that implants with micro-roughened surfaces produce a more rapid bone response and more bone-to-implant contact.

OBJECTIVE:

The aim of the present study was an evaluation of the clinical outcome of implants with the new grit-blasted and high-temperature acid-etched FRIADENT® plus surface.

MATERIALS AND METHODS:

In the period between July 2003 and July 2005, 77 patients (36 men, 41 women, between the ages of 17.3 to 78.7) were enrolled in this study at 10 private and university centers. Patients were accepted into the study according to the following criteria: controlled oral hygiene, the absence of any lesion in the oral cavity, and sufficient residual bone volume to receive implants of at least 3.8 mm in diameter and 10 mm in length. Immediate loading was performed when implant insertion torque values were above 30 Ncm (26 implants). All other 129 implants were placed with a conventional two-stage surgical protocol with 3 to 6-month healing time. In cases of insufficient bone volume, augmentation procedure were performed prior to

(19 cases), and/or at the same time of implant placement (39 cases). Exclusion criteria were as follows: A high degree of bruxism or parafunction, smoking (more than 20 cigarettes/day), excessive consumption of alcohol, localized radiation therapy of the oral cavity, anti-tumor chemotherapy, liver diseases, kidney diseases, blood diseases. Patients with immunosuppressive therapy, corticosteroid treatment, pregnancy, inflammatory and autoimmune diseases of the oral cavity, poor oral hygiene were also excluded.

RESULTS:

Of the 155 implants placed, a total of 152 implants were osseointegrated. Three implants failed. One implant failed after 35 days, prior to loading, and was categorized as early implant failure. One implant failed at 4 months, and one at 8 months post loading. An implant success rate of 97.37% was achieved for a period of 24 months post placement. The mean crestal bone loss after one year was 0.99 mm, and 1.16 mm after two years.

CONCLUSION:

These interim results indicate that FRIADENT® plus implants achieve a high rate of integration that remains stable during the course of implant function. In addition, the plus surface has provided a high level of prosthetic predictability. With an implant success rate of 97.37% and a mean marginal bone loss of 1.16 mm, the investigated implants demonstrated a predictable clinical outcome of treatment concepts for the rehabilitation of partially and fully edentulous patients.

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Histologic analysis of an immediately loaded implant retrieved after 2 months.

Degidi M, Scarano A, Iezzi G, Piattelli A: Histologic analysis of an immediately loaded implant retrieved after 2 months. *J Oral Implantol 2005; 31 (5): 247 – 254.*

INTRODUCTION:

Human biopsy of immediately loaded implants is the most important way to determine the occurrence of osseointegration. Implants inserted in sites with poor bone quality have often been associated with lower success rates.

OBJECTIVE:

The aim of this histologic study is to document the early healing processes in an immediately loaded implant.

MATERIALS AND METHODS:

An implant was inserted in the mandible (bone class D IV) of a 32-year-old male patient and was loaded into a non-functional loading mode. The fixed provisional prosthesis was placed the same day as the implant surgery. After 2 months, because the patient had difficulty accepting the implant, the implant was retrieved with a 5-mm trephine drill.

RESULTS:

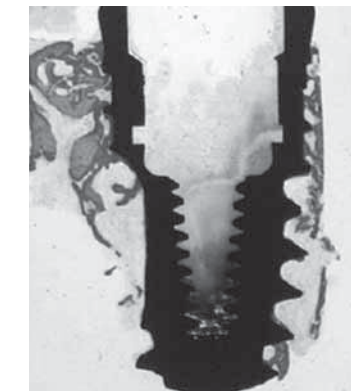
The clinical findings showed an osseointegrated implant. No mobility was ascertained. The implant was surrounded by newly formed bone lamellae with a width of 200 to 400 µm. In many areas it was possible to observe osteoblasts producing osteoid matrix directly on the implant surface. Bone-to-implant contact percentage was 71% +/- 3.2%.

CONCLUSION:

Even in a poor bone site and after a healing period of only 2 months there was a high bone-to-implant contact percentage. The histological investigation confirms that

immediately loaded implants placed in soft spongy bone after a 2-month healing period can present mineralized tissue at the interface.

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The implant (XIVE® plus) was surrounded by lamellar and woven bone. The bone was in close contact with the implant surface. At the coronal level, no infrabony pocket, Howship lacunae, or osteoclasts were present (magnification x 12).

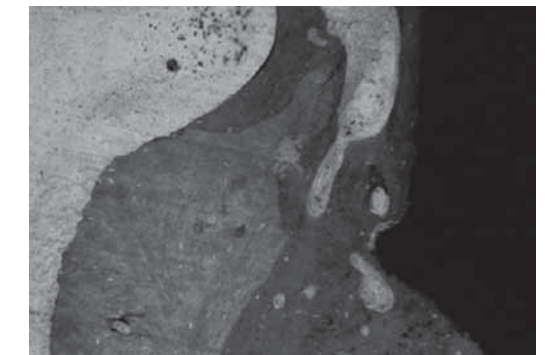


Fig. P19-2: Lamellar and woven bone were observed in direct contact with the implant surface. No gaps or connective tissue were present at the bone-implant interface. No apical epithelial migration was found. No inflammatory infiltrate was present around the implant (original magnification x 100).

Bone response to submerged, unloaded implants inserted in poor bone sites: A histological and histomorphometrical study of 8 titanium implants retrieved from man.

Iezzi G, Degidi M, Scarano A, Perrotti V, Piattelli A: Bone response to submerged, unloaded implants inserted in poor bone sites: a histological and histomorphometrical study of 8 titanium implants retrieved from man. *J Oral Implantol* 2005; 31 (5): 225 – 233.

INTRODUCTION:

An important parameter that influences the long-term success of oral implants is the bone quality of the implant bed. The insertion of implants in the posterior region has long been avoided due to its poor bone quality, higher chewing forces, and presumed higher implant failure rates. This region of soft bone was classified as a high potential risk. The inferior success rates in the posterior maxilla were attributed to low bone density and the resulting low implant-bone contact (BIC).

OBJECTIVE:

The aim of this study was a histological and histomorphometrical analysis of the bone response to submerged implants inserted in posterior areas of the maxilla and mandible.

MATERIALS AND METHODS:

Eight submerged, healed and unloaded implants were evaluated in this study. For varying reasons, these patients had to have the implants removed after healing for six

weeks to twelve months. All implants were removed with a trephine drill (Ø 5 mm) and were prepared histologically.

RESULTS:

Three implants were removed due to inadequate patient adaptation. Two implants no longer met the changed prosthetic requirements. One implant was incorrectly positioned for esthetic and hygiene reasons. Two implants were removed due to pain and dysesthesia. All the implants were retrieved with a 5 mm-trephine bur. Newly formed peri-implant bone was found in all implants even after shorter healing periods. The bone-to-implant contact percentage varied from 30 % to 96 %.

CONCLUSION:

The eight human histological preparations lead to the conclusion that some surfaces have an improved characteristic of contact osteogenesis in soft bone. This assumes that the implant surface is covered with a bone layer as a base for intensive bone formation and remodeling. Also in the case of implants whose healing time is less than two months, there is osseointegration of implants with a rough surface both in the mandible and in the maxilla. From these results, it may be concluded that these implants may be carefully loaded after 2 months of healing, even when inserted in soft bone.

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| Retrieval time | Site | Type of Implant | BIC (in %) |
|----------------|----------|-------------------|------------|
| 6 wk | Mandible | XiVE® plus | 96 |
| 7 wk | Mandible | XiVE® plus | 55 |
| 8 wk | Maxilla | XiVE® plus | 68 |
| 6 mo | Mandible | FRIALIT® Synchro | 70 |
| 6 mo | Mandible | XiVE® DPS surface | 51 |
| 12 mo | Maxilla | XiVE® DPS surface | 30 |

Table P20-1: Retrieval times, sites, types of implants, and bone-to-implant contact (BIC).

Bone formation around one-stage implants with a modified sandblasted and acid-etched surface: Human histologic results at 4 weeks.

Degidi M, Piattelli A, Shibli JA, Perrotti V, Iezzi G: Bone formation around one-stage implants with a modified sandblasted and acid-etched surface. Human histologic results at 4 weeks. *Int J Periodontics Restorative Dent*; 2009; 29 (6): in press.

INTRODUCTION:

To the present day, knowledge is limited of the healing process at the interface between implant and bone and of the adaptation of the mineral tissue surrounding an implant. The sequences in the early phase of the peri-implant tissue healing are still not fully understood. It is therefore of major importance to identify the biological sequences in the early healing phase.

OBJECTIVE:

The aim of this histological and histomorphological study was to study peri-implant bone formation around a surface-modified implant after a healing time of four weeks.

MATERIAL AND METHODS:

Three patients with a partially edentulous dental arch participated in the study approved by the ethics commission. The lower posterior region was restored with implant-supported bridges. An additional implant (2 x ANKYLOS®, 1 x Straumann) was inserted distal of this in each patient. After four weeks these additional implants were removed with a trephine drill (Ø 5 mm). All implants were clinically osseointegrated and immobile. The histological preparation and the histomorphological evaluation followed a standard protocol.

RESULTS:

The FRIADENT® plus surface and the SLActive surface show a high load bearing capacity and thus good cell adhesion. The bone-implant contact (BIC) varied between 42 % and 61 % (Tab. P21-1). All implants were surrounded by

spongy previously existing bone (Fig. P21-1 to P21-4). At higher resolution, osteoblasts may be identified on the metal surface that already formed new bone (Fig. P21-4). There were no signs of inflammation.

CONCLUSION:

The high percentage of bone contact (BIC) in the early healing phase is probably due to the microporosity and the hydrophilic implant surface.

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Fig. P21-1: Implant A (ANKYLOS®) is surrounded by previously existing bone supplemented by newly formed bone in the peri-implant region.

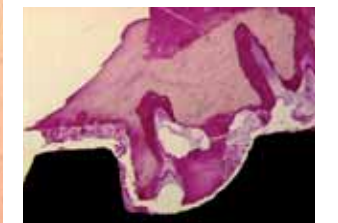


Fig. P21-2: The existing and newly formed bone at 40 x magnification.



Fig. P21-3: The 100 x magnification shows that the newly formed bone lies on the implant surface.

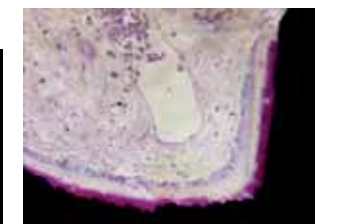


Fig. P21-4: In the case of implant B (ANKYLOS®) a thin layer of newly formed bone may be identified at 100x magnification. Osteoblasts form osteoid matrix (OM).

| Implant | Bone quality | ISQ (insertion) | Insertion torque | BIC |
|-----------|--------------|-----------------|------------------|--------------|
| ANKYLOS® | D2 and D3 | 80 | 45.0 Ncm | 52.0% ± 2.5% |
| ANKYLOS® | D1 and D2 | 72 | 45.0 Ncm | 61.0% ± 2.9% |
| Straumann | D2 | 83 | 26.6 Ncm | 42.0% ± 6.9% |

Table P21-1

P22

Bone formation around immediately loaded and submerged dental implants with a modified sandblasted and acid-etched surface after 4 and 8 weeks: A histologic and histomorphometric analysis.

Degidi M, Piattelli A, Shibli JA, Perrotti V, Iezzi G: Bone formation around immediately loaded and submerged dental implants with a modified sandblasted and acid-etched surface after 4 and 8 weeks: A histologic and histomorphometric analysis. *Int J Oral Maxillofac Implants; 2009; 24 (5): in press.*

OBJECTIVE:

The biological mechanisms of immediate loading are still not fully understood. The aim of this histological and histomorphological analysis was to analyse the bone-titanium interface with immediate loading and submerged healing implants after 4 and 8 weeks healing time.

MATERIAL AND METHODS:

Four patients with a partially edentulous dental arch participated in the study approved by the ethics commission. The lower posterior region was restored with implant-supported bridges. An additional implant (4 x ANKYLOS®) was inserted distal of this in each patient. Two implants were loaded on the day of insertion by a temporary metal ceramic crown outside occlusion. These crowns were connected with the temporary bridge. The additional implants healed submerged in the other two patients. An immediately loaded and unloaded implant were removed after four and eight weeks respectively. The histological preparation and the histomorphological evaluation followed a standard protocol.

RESULTS:

All implants were clinically and radiologically osseointegrated and immobile before they were removed. Parts of mineralised tissue were found around the implants. There were no signs of foreign body or inflammatory reactions. Newly formed bone was observed around all implants. The immediately loaded implants showed a high proportion of mineralised tissue at the interface after both four and eight weeks (Tab. P22-1; Fig. P22-1 and P22-2). The volume of

newly formed bone was lower for the submerged healed implants (Fig. P22-3 and P22-4).

CONCLUSION:

Even after four to eight weeks a high bone-implant contact is apparent for unloaded and immediately loaded implants. In the latter case there was even a large amount of bone. Immediate loading does not impede bone formation in the early period of healing. This investigation on human preparations supports the concept of immediate loading of implants.

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Fig. P22-1a: An immediately loaded implant (ANKYLOS®) after eight weeks healing time (8 x magnification).

Fig. P22-1b: A relatively thick layer of newly formed bone is apparent on the implant surface at high resolution (100 x).

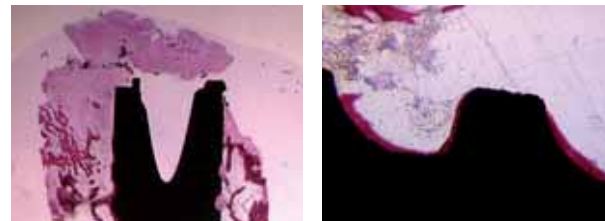


Fig. P22-2a: A submerged healed implant (ANKYLOS®) after eight weeks waiting time (8 x magnification).

Fig. P22-2b: A relatively thin layer of newly formed bone is apparent on the implant surface at high resolution (100 x).

| ANKYLOS® | 4 weeks | | 8 weeks | |
|----------|-------------------|--------------|-------------------|--------------|
| | Immediate loading | Unloaded | Immediate loading | Unloaded |
| BIC | 65.6% ± 3.9% | 54.7% ± 4.2% | 76.2% ± 3.9% | 62.3% ± 4.9% |

Table P22-1

The influence of the surface on different clinical parameters is presented in the following articles. Publications marked with * also document the FRIADENT® plus surface.

* Junker R, Dimakis A, Thoneick M, Jansen JA: Effects of implant surface coatings and composition on bone integration: a systematic review. *Clin Oral Implants Res; 2009; 20 Suppl 4 185 – 206.*

* Lang NP, Jepsen S: Implant surfaces and design (Working Group 4). *Clin Oral Implants Res; 2009; 20 Suppl 4 228 – 231.*

Wennerberg A, Albrektsson T: Effects of titanium surface topography on bone integration: a systematic review. *Clin Oral Implants Res; 2009; 20 Suppl 4 172 – 184.*

Conclusions

Reviewing progress in the osseointegration of implants, especially over the last decade, it is clear that this is not only attributable to changes in protocols, but essentially to the micromorphology and the properties of the implant surfaces. The FRIADENT® plus surface is one of the leading implant surfaces. It excels by virtue of high wettability and very rapid formation of bone on the implant surface. The combination of a blasting process with a specific etching procedure on the titanium surface under high-temperature conditions in the case of the FRIADENT® plus surface results in earlier osseointegration and outstanding implant-bone contact. These excellent properties are documented in numerous in-vitro and in-vivo studies a small selection of which is compiled in this brochure.