



Current scientific status

Study overview

Ceramic-implantology | Interference fields of the oral cavity | Vitamins relevant for dentistry

CERAMIC IMPLANTOLOGY

- 1.1 Own Studies/Dissertations
- 1.2 General Studies

1. CERAMIC IMPLANTOLOGY

1.1 Own Studies/Dissertations

1.1.1 Finished Studies/Dissertations

DISSERTATION UNIVERSITY ULM 2006.

Klinische Nachuntersuchung von Zirkondioxidkeramik-Implantaten - Funktion als Kalzium-Kathode.

First long term results - A clinical report of zirkondioxide-implants.

Schlömer G, Volz KU, Sidharta J, Haase S

ABSTRACT

The study should give more information to the question if dental implants built of zircon dioxide (producer: Z-Systems, Konstanz, GER) will show the same success rates as titanium implants have shown over the years. Present studies raise the question if titanium may cause harm to the human immune system, therefore it is necessary to find a material which can replace titanium implants. In the study 92 zircon dioxide-implants were examined which were placed in 34 patients. 66 Z1/Z2-implants were placed with a mean incorporating time of 3.5 years. 26 implants were Z3-implants which were first placed in 2003. They were incorporated with a mean time of 1.8 years. 6 implants were placed in the anterior region, 86 implants in the posterior region. Nearly all implants were single tooth restorations (85), 7 implants were restored in short span bridges.

Success of the implants were measured by the means of sulcus depth measurements, attachment levels, radiographic analysis of bone density around the implants, acoustic tests of osseointegration, API, SBI and by asking patient opinions to assess the implant success. The overall implant success rate was 96.7 % which is comparable to success rates with titanium implants.

In the radiographic density analysis of the implant surrounding bone, 98 % of all zircon dioxide-implants showed a significant increase of bone matrix in the compacta zone compared to time of placement. Obviously the ceramic implants lead to a gain in marginal bone strength which is according to literature not that often seen with titanium implants. This may be observed due to an optimal physiological loading of the marginal bone through the one-piece-implants, or a biological influence of the zircon dioxide may lead to a strengthened bone around these implants.

No implant showed a sulcus depth of more than 3 mm. 89 of 92 implants sounded perfectly while tapped with a metal instrument which is a manual test of osseointegration. Plaque accumulation tests showed a similar results compared to other testings of ceramic materials in the literature: the plaque accumulation on zircon dioxide-implants is very low, 12 of 34 patients had less plaque accumulation on the implants than on the natural teeth. The implants showed no recessions or changes in attachment levels concerning the soft tissues.

The study underlines the capacity of zircon dioxide-implants (Z-Systems) to be a substitute of titanium based implants. The success rates show similar results, the observation of a strengthened marginal bone is encouraging for the long term results.

Zirconia implants of the first generation. Late implants without application of the Swiss Biohealth Concept.

DISSERTATION UNIVERSITY HAMBURG 2017.

Erfolg von dentalen Keramik-Implantaten und Patientenzufriedenheit nach Sofortimplantation.

Success of dental ceramic implants and patient satisfaction after immediate implant placement.

Henningsen A, Neuhöffer L, Stolzer C, Volz KU, Gosau M, Smeets R.

ABSTRACT

The aim of this study was the investigation of the outcome of immediate implants of a ceramic implant system (Swiss Dental Solutions) after immediate and conventional loading in the upper and lower jaw and their osseointegration. The success rate with regard to peri-implant bone height and soft tissue behavior of this procedure were determined with regard to patient-related and prosthetic factors. Additionally patient satisfaction was determined by a questionnaire (OHIP). The study included patients treated from June 2013 to June 2015 in the dental practices of Dr. Scholz (former Dr. Volz and Dr. Scholz), Konstanz, Dr. Steinbach & colleagues, Stuttgart and Paracelsus Klinik Lustmühle, CH-Teufen with immediate and late implants and immediate and conventional loading.

After 783 days of maximum observation time survival rate was 92 % and a success rate 91.3 %. Bone loss over the entire study period was -0.58 mm for immediate implants and -0.73 mm for late implants. A statistically significant influence of type of loading and time point of placement on the implant success and the peri-implant radiological bone loss was not found. The mean pink esthetic score for the immediate implants was 12.14 and 12.3 points, and for the OHIP questionnaire the response rate was $n = 22$ (53.7 %) with an average of 0.54 points.

The survival probability after about 26 months in this study was for immediate implants 90.3 % and for late implants 97.3 %. Depending on the type of loading, a survival probability of 93.5 % for implants with immediate loading after approximately 20 months and of 86.5 % for implants without immediate loading after 26 months was found. Taking into account the inclusion criteria dental

zirconia implants are suitable for immediate implantation and immediate loading after a strict indication. Immediate implantations without application of the Swiss Biohealth Concept.

1.1.2 Ongoing Studies/Dissertations

STUDY IN COOPERATION WITH THE CLINIC DENTAL COSMETICS COSTA RICA, SAN JOSÉ.

BISS - Bilateral Implant Stabilization System - Eine klinische Studie.

BISS - Bilateral Implant Stabilization System - A clinical study.

Fernández A, Hueber R.

BACKGROUND:

With pronounced bone resorption, immediate implantation with primary stable implant integration is not always possible. A new development by Dr. med. dent. Karl Ulrich Volz, SWISS DENTAL SOLUTIONS, which will offer new opportunities in this area, is the new Bilateral Implant Stabilization System (BISS).

METHODS:

The Bilateral Implant Stabilization System is incorporated in patients with severe bone loss, where a primary stability of an implant is not possible. A stabilization of the augmented bone is achieved by the flexible osteosynthesis plate of the BISS, which simultaneously forms a firm screw connection with the interface of the SDS-implants. On the one hand, it acts as a parasol that keeps the periosteum at a distance, while at the same time allowing for immediate osseointegration of the stabilized implants with lamellar bone.

DISSERTATION UNIVERSITY HAMBURG.

Untersuchung des Implantationszeitpunktes auf das krestale Knochenniveau bei einteiligen Keramik-Implantaten.

Crestal bone level changes in immediate vs. delayed placed zirconia implants (one-piece zirconia implants).

Stolzer C¹, Smeets R¹, Alkhouri S.

AUTHOR INFORMATION:

1 Dptm. Of Oral and Maxillofacial Surgery, University Medical Center Hamburg-Eppendorf, Division of Orofacial Reconstruction.

MATERIAL:

A retrospective study, evaluation of 300 implants: 150 immediate implants / 150 late implants.

FUNDING PROGRAM:

SDS

MULTICENTER STUDY:

Dental office Dr. Witthöft, dental office Dr. Vajen, dental office Dr. Nischwitz.

METHODS:

Evaluation of the data: crestal bone level, oral hygiene indices, prosthetic success and evaluation of all X-ray images.

CURRENT STATUS:

Recording the parameters of treatment documentation.

With application of the Swiss Biohealth Concept.

DISSERTATION UNIVERSITY HAMBURG.

Untersuchung des Implantationszeitpunktes auf das krestale Knochenniveau bei zweiteiligen Keramik-Implantaten.

Crestal bone level changes in immediate vs. delayed placed zirconia implants (two-piece zirconia implants).

Stolzer C¹, Smeets R¹, Arnim L.

AUTHOR INFORMATION:

1 Dptm. Of Oral and Maxillofacial Surgery, University Medical Center Hamburg-Eppendorf, Division of Orofacial Reconstruction.

MATERIAL:

A retrospective study, evaluation of 300 implants: 150 immediate implants / 150 late implants.

FUNDING PROGRAM:

SDS

SINGLECENTER STUDY:

Dental office Dr. NischwitzZ

METHODS:

Evaluation of the data: crestal bone level, oral hygiene indices, prosthetic success and evaluation of all X-ray images post-operative and 12 months and/or 24 months after prosthetics.

With application of the Swiss Biohealth Concept

DISSERTATION UNIVERSITY HAMBURG.

Korrelation des Vitamin D3-Spiegels im Blut in Bezug auf die Verlustrate von Keramik-Implantaten – in vivo Humanstudie.

Correlation of blood vitamin D3 levels in relation to the loss rate of zirconia implants - in vivo human study.

Stolzer C¹, Smeets R¹, Eberhard L.

AUTHOR INFORMATION:

1 Dptm. Of Oral and Maxillofacial Surgery, University Medical Center Hamburg-Eppendorf, Division of Orofacial Reconstruction

AIM:

The aim of this study is to evaluate the clinical significance of vitamin D blood levels in relation to the loss rate of dental zirconia and titanium implants.

MATERIAL:

A case-control study on 200 zirconia implants.

METHODS:

Evaluation of the following data: `Percussion test` (manual and Ostell-/Periotest measurement -> Opt. stability: 0-8), insertion test (insertion torque 15 N/cm), blood test and loss rates.

CURRENT STATUS:

Votum of ethic committee, data collection, further parameters where required: Osteocalcin, Betacrossleps, PIMP, AP and if indicated bone AP, K2, DPD and cross-links in urine.

DISSERTATION UNIVERSITY HAMBURG.

Simultaneous sinuslift and implantation using Bone growing Zirconiumoxide implants and advanced plateletrich fibrin (A-PRF) as sole grafting material.

Stolzer C¹, Smeets R¹, Hutfilz S²

AUTHOR INFORMATION:

1 Dptm. Of Oral and Maxillofacial Surgery, University Medical Center Hamburg-Eppendorf, Division of Orofacial Reconstruction.

2 SHBZ Dptm. of Oralsurgery and Biological Dentistry Chemnitz.

PURPOSE:

To assess the relevance of simultaneous sinuslift with a modified zirconoxid implant and implantation with advanced - and platelet-rich fibrin (A-PRF, Choukroun's technique) as sole subsinus filling material.

MATERIALS:

A modified zirconoxide implant from the company SDS SWISS DENTAL SOLUTIONS is used. At its apical end, this has a discus-shaped plateau to support the Schneiderian membrane on a large area and at the same time minimising the risk of perforations of the Schneiderian membrane. The creation of a large peri-implant cavity creates a "bioactive container" by initiating predictable bone formation by supporting and using the APRF as a sole grafting material. Clinical and radiographic follow-up will be performed just after implant placement and after six months.

DISSERTATION UNIVERSITY HAMBURG.

Blutlaborparameter in Bezug auf ihre klinische Aussagekraft bezüglich der Prädiktierbarkeit des Erfolges auf Implantationen zu prüfen (Titan).

Blood laboratory parameters in relation to their clinical significance in regard to the predictability of success on implantations (titanium).

Stolzer C1, Smeets R1, Wegener A.

AUTHOR INFORMATION:

1 Dptm. Of Oral and Maxillofacial Surgery, University Medical Center Hamburg-Eppendorf, Division of Orofacial Reconstruction

MATERIAL:

300 CaseS

SINGLECENTER STUDY:

SWISS BIOHEALTH CLINIC, Kreuzlingen

METHODS:

Laboratory chemical analysis.

CURRENT STATUS:

Determination of the parameters in cooperation with the Institute of Osteology at the UKE. Several parameters are important (Barvencic) Osteocalcin, Betacrossleps, PIMP, AP and if indicated bone AP, K2, DPD and cross-links in urine.

DISSERTATION UNIVERSITY BONN.

Auswirkungen der biologischen Zahnmedizin auf den allgemeinen Gesundheitszustand des Patienten

The effects of biological dentistry on the health status of patients.

Wittmann M, Kneer M, Spalek M.

MATERIAL:
100-300 Patients

SINGLECENTER STUDY:
SWISS BIOHEALTH CLINIC, Kreuzlingen

METHODS:
Longitudinal study, use of the Medical Symptoms Questionnaire (MSQ) as a data ascertainment: comparison of MSQ results before and after surgery. Statistical evaluation of the data. The results are tested for significance using a T-test. The Levene test is used to calculate the variance of the variables. At $p > 0.05$, equality of variances is assumed. The frequency distribution of the variables is checked with the chi-square test.

CURRENT STATUS:
The study is in preparation for submission to the Ethics Committee.

DISSERTATION UNIVERSITY MARBURG.

Untersuchung der Erfolgsquote von keramischen Sofortimplantaten im Oberkiefer-Seitenzahnbereich mit und ohne simultanen internen Sinuslift

Evaluation of the success rate of immediate zirconia implants placed in the maxillary posterior region with and without simultaneous internal sinus lift

Sättele D, Ziebart T, SWISS BIOHEALTH ACADEMY.

DESIGN:
Retrospective study

MATERIAL:
All immediate zirconia implants (SDS) in the maxillary posterior region (regions 14-17 and 24-27) which have been inserted and prosthetically restored at the SWISS BIOHEALTH CLINIC, Kreuzlingen/Switzerland, from 01.01.2017 to 31.12.2019 are included. The treatments were carried out by applying THE SWISS BIOHEALTH CONCEPT.

METHODS:
The present study is divided into four groups: Immediate implantation without internal sinus lift in inconspicuous extraction sockets, immediate implantation without internal sinus lift in extraction sockets with periapical pathologies, immediate implantation with internal sinus lift in inconspicuous extraction sockets, immediate implantation with internal sinus lift in extraction sockets with periapical pathologies.

Determination of the frequency and extent of periapical pathologies and evaluation of the sinus floor profile (sinus floor inclination angle) by evaluation of the DVT (preoperative). The following parameters are determined on the orthopantomogram: Implant length and marginal bone level.

For immediate implants with simultaneous internal sinus lift further parameters are determined: residual bone height, apical bone deficit, apical bone gain.

CURRENT STATUS:
Recording the parameters in February 2020.

1.1.3 Planned Studies/Dissertations

DISSERTATION UNI XXX.

Drehmoment bei Sofortimplantation: Welches Drehmoment kann durch das scharfe Gewinde erreicht werden?

The insertion torque and immediate implant placement: Which torque can be achieved with the sharp thread?

SWISS BIOHEALTH ACADEMY, Kreuzlingen, Switzerland

DESIGN:
Prospective study

MATERIAL:
100 zirconia implants, anterior and posterior region will be examined separately.

METHODS:
Application of countersinks which correspond to the outer diameter (insertion torque 0 in the cortical bone). Determination which insertion torques can be achieved with the implant thread (up to a maximum of 80 N/cm). Evaluation of the data, survival rate after six months with provisional restoration and marginal bone loss.

DISSERTATION UNI XXX.

Einheilung von Keramik-Implantaten in den ersten drei Monate in Bezug auf den Vitamin D3- und LDL-Wert.

Osseointegration of zirconia implants in the first three months in relation to vitamin D3 and LDL levels.

SWISS BIOHEALTH ACADEMY, Kreuzlingen, Switzerland

DESIGN:
Prospective study

MATERIAL:
100 zirconia implants

METHODS:
Measuring of the patient's vitamin D3 and LDL-levels at the time of registration at the SWISS BIOHEALTH CLINIC, on the day of dental surgery and six months post-operative at the time of final prosthetic restoration. Evaluation of the data: survival rate and subjective parameters of each patient with a questionnaire.

DISSERTATION UNI XXX.

Einfluss des Implantatwinkels auf die Erfolgsrate von Sofort-implantaten bezogen auf den Limbus alveolaris.

Influence of the implant angle on the success rate of immediate implants in relation to the alveolar limb.

SWISS BIOHEALTH ACADEMY, Kreuzlingen, Switzerland

DESIGN:
Prospective study

MATERIAL:
100 zirconia implants (50 posterior maxilla – 50 posterior mandible)

METHODS:
Evaluation of the data: survival rate, bone loss and determination of each implant angle by using a DVT post-operative (Sidexis software).

DISSERTATION UNI XXX.

Knochenaufbau durch Keramik-Implantate?
Eine prospektive Studie zur Ermittlung der periimplantären Knochenanlagerung.

Bone growth around zirconia implants? A prospective study to determine peri-implant bone growth.

SWISS BIOHEALTH ACADEMY, Kreuzlingen, Switzerland

DESIGN:
Prospective study

MATERIAL:
100 zirconia implants (25 anterior maxilla – 25 anterior mandible – 25 posterior maxilla – 25 posterior mandible).

METHODS:
Measurement of bone density using the Sidexis software at three different positions of the implant: 1. position in the middle of fine thread 2. at the transition of fine thread to coarse thread 3. at the apical end of the implant. Evaluation of the data: measurement of marginal bone loss and determination of the survival rate.

DISSERTATION UNI XXX.

Der Einfluss des Nahrungsergänzungsmittels Basic Immune auf Gingivitis und Parodontitis.

The influence of the supplement Basic Immune on gingivitis and periodontitis.

SWISS BIOHEALTH ACADEMY, Kreuzlingen, Switzerland

DESIGN:

A randomized, blinded study

MATERIAL:

100 patients (50 patients with Basic Immune- and 50 patients with placebo-supplementation).

METHODS:

One subject group and one control group receive Basic Immune or a placebo for four weeks. The influence on gingivitis and periodontitis as well as on other medical parameters (LDL, HRV, stress) should be investigated and evaluated.

DISSERTATION UNI XXX.

Bone Growth um SDS Keramik-Implantate nach einem Jahr bei Anwendung des THE SWISS BIOHEALTH CONCEPTES.

Bone growth around SDS zirconia implants after one year by applying THE SWISS BIOHEALTH CONCEPT.

SWISS BIOHEALTH ACADEMY, Kreuzlingen, Switzerland

DESIGN:

Retrospective study

MATERIAL:

50-200 zirconia implants (SDS)

FUNDING PROGRAM:

SDS

METHODS:

Determination of vertical bone growth (measurement from implant body apical end to crest of bone) and bone density. Detection of vertical bone growth (measurement from implant tip to end of bone) and bone density. X-ray analysis 1. on the day of surgery, 2. three to five months post-operatively at the day of prosthetic restoration and 3. after one year. Measurement of bone gain and soft tissue behavior (soft tissue growth and Esthetic Score) around the implants. Accompanying determination and evaluation of the following data: D3, LDL, if necessary further parameters relating to bone metabolism, state of the patient's health (diagnosis) and intraoperative findings.

DISSERTATION UNI XXX.

Bestimmung der Knochen
Klassen in Relation zu
Drehmoment und Stabilität
(Periotest) von Keramik-
Implantaten. Einfluss auf die
Erfolgsquote und spätere
prothetische Versorgung.

Classification of bone in relation
to insertion torque and stability
(Periotest) of zirconia implants.
Influence on the success rate and
the final prosthetic restoration.

SWISS BIOHEALTH ACADEMY, Kreuzlingen, Switzerland

DESIGN:

Retrospective study

MATERIAL:

100 zirconia implants (SDS)

METHODS:

Evaluation of the data: Implant type and length, Hounsfield measurement, insertion torque and Periotest measurement, classification of bone, marginal bone loss, determination of survival rate, photo documentation of all inserted implants at the SWISS BIOHEALTH CLINIC on the day of surgery and on the day of prosthetics.

1. CERAMIC IMPLANTOLOGY

1.2 General Studies

1.2.1 Material Properties

CLIN ORAL IMPLANTS RES. 2006
OCT;17(5):565-71.

Zirconia-implant-supported all-ceramic crowns withstand long-term load: a pilot investigation.

Kohal RJ, Klaus G, Strub JR.

OBJECTIVES:

The purpose of this pilot investigation was to test whether zirconia implants restored with different all-ceramic crowns would fulfill the biomechanical requirements for clinical use. Therefore, all-ceramic Empress-1 and Procera crowns were cemented on zirconia implants and exposed to the artificial mouth. Afterwards, the fracture strength of the all-ceramic implant-crown systems was evaluated. Conventional titanium implants restored with porcelain-fused-to-metal (PFM) crowns served as controls.

MATERIAL AND METHODS:

Sixteen titanium implants with 16 PFM crowns and 32 zirconia implants with 16 Empress-1 crowns and 16 Procera crowns each--i.e., three implant-crown groups--were used in this investigation. The titanium implants were fabricated using the ReImplant system and the zirconia implants using the Celay system. The upper left central incisor served as a model for the fabrication of the implants and the crowns. Eight samples of each group were submitted to a long-term load test in the artificial mouth (1.2 million chewing cycles). Subsequently, a fracture strength test was performed with seven of the eight crowns. The remaining eight samples of each group were not submitted to the long-term load in the artificial mouth but were fracture-tested immediately. One loaded and one unloaded sample of each group were evaluated regarding the marginal fit of the crowns.

RESULTS:

All test samples survived the exposure to the artificial mouth. Three Empress-1 crowns showed cracks in the area of the loading steatite ball. The values for the fracture load in the titanium implant-PFM crown group without artificial loading ranged between 420 and 610 N (mean: 531.4 N), between 460 and 570 N (mean: 512.9 N) in the Empress-1 crown group, and in the Procera crown group the values were between 475 and 700 N (mean: 575.7 N) when not loaded artificially. The results when the specimens were loaded artificially with 1.2 million cycles were

as follows: the titanium implant-PFM crowns fractured between 440 and 950 N (mean: 668.6 N), the Empress-1 crowns between 290 and 550 N (mean: 410.7 N), and the

Procera crowns between 450 and 725 N (mean: 555.5 N). No statistically significant differences could be found among the groups without artificial load. The fracture values for the PFM and the Procera crowns after artificial loading were statistically significantly higher than that for the loaded Empress-1 crowns. There was no significant difference between the PFM crown group and the Procera group.

CONCLUSIONS:

Within the limits of this pilot investigation, it seems that zirconia implants restored with the Procera crowns possibly fulfill the biomechanical requirements for anterior teeth. However, further investigations with larger sample sizes have to confirm these preliminary results. As three Empress-1 crowns showed crack development in the loading area of the steatite balls in the artificial mouth, their clinical use on zirconia implants has to be questioned.

Survival rate and fracture resistance of zirconium dioxide implants after exposure to the artificial mouth: An in-vitro study

Kohal RJ, Strub JR, Andreiotelli M, Peters C, Auschill T.

ABSTRACT

The aim of the present study was to evaluate the survival rate and the fracture strength of zirconium dioxide implants, imitating anterior tooth replacement, and to compare the results with those of titanium implants before and after exposure to the artificial mouth.

A total of 120 ceramic and titanium implants were used for the experiment. The Ti-implants were divided into two control groups A (two-piece implants) and B (one-piece implants) including sixteen titanium implants each. The ceramic implants (one-piece implants) were divided into five groups C (Y-TZP BIO-HIP® implants), D (Y-TZP-A BIO-HIP® implants), E (Y-TZP-A BIO- HIP® implants with special surface topography), F (Y-TZP-A BIO-HIP® implants with special surface topography + preparation of the implant heads) and G (Y-TZP-A BIO-HIP® implants with special surface topography + restoration with ZrO₂ crowns, different width of the preparation in each subgroup), using sixteen samples of each, with the exception of group D, which included twenty-four samples. The test and the control groups were divided into 15 subgroups of 8 samples each. One subgroup from groups A (A2), B (B2), C (C2), E (E2) and F (F2), two subgroups from group D (D2, D3) and both subgroups from group G (G1, G2) were exposed to 1.2 million thermomechanical loading cycles in the artificial mouth in order to simulate 5 years of clinical service. Fracture of the implants was considered as failure. Then, all test specimens (exposed and not exposed to the artificial mouth) were loaded until fracture occurred in a universal testing machine. After exposure to the artificial mouth the survival rates reported were as follows: A2 87.5 %, C2 50 %, D3 (no thermocycling) 87.5 % and E2 87.5 %. All the other subgroups demonstrated a survival rate of 100 %.

The observed mean fracture strength values of the subgroups that were not exposed to the artificial mouth were: A1 825 N, B1 5717 N, C1 1337 N, D1 940 N, E1 850 N and F1 578 N. For the samples that were exposed to the artificial mouth the mean fracture strength values were the follo-

wing: A2 715 N, B2 2749 N, C2 855 N, D2 879 N, D3 980 N, E2 725 N, F2 607 N, G1 542 N and G2 539 N. Among the different groups no statistically significant differences were found, with the exception of subgroup C1 when compared to subgroup E1 and of subgroup E1 when compared to subgroup F1 ($p < 0.05$). The results in the present study showed that the preparation of the abutments had a negative influence in the fracture strength values of the implant.

All mean values obtained were within the limits of clinical acceptance, indicating the use of one- piece zirconia implants may be clinically acceptable. However, long-term clinical data are necessary before one-piece zirconia implants can be recommended for daily practice.

Biomechanical and histomorphometric comparison between zirconia implants with varying surface textures and a titanium implant in the maxilla of miniature pigs.

Gahlert M, Gudehus T, Eichhorn S, Steinhauser E, Kniha H, Erhardt W.

ABSTRACT

BACKGROUND:

Mechanical properties and biocompatibility make zirconia ceramics suitable implant material. The characteristics of tooth-color like, the ability to be machined and the low plaque affinity make zirconia especially suitable as a dental implant material. The influence of surface modification on the osseointegration of this material has not been extensively investigated.

PURPOSE:

Long-term investigations with titanium implants have shown superior biomechanical results with the sandblasted acid-etched (SLA) surface, demonstrating a high bone-implant interaction. The objective of this study was to compare two different zirconia surface topographies biomechanically and histologically with the well-documented titanium SLA surface

MATERIAL AND METHODS:

Zirconia implants with either a machined (ZrO₂m) or a sandblasted (rough, ZrO₂r) surface were manufactured with the exact same cylindrical shape with a standard ITI thread configuration as the SLA titanium implants. The incisors 2 and 3 were removed from both sides of the maxillae of 13 adult miniature pigs and the tissues left to heal for 6 months. After this time period the animals received a total of 78 implants using a randomized scheme, with the titanium SLA implant used as an only individual reference. After healing periods of 4, 8, and 12 weeks 20, 24, and 25 implants, respectively, were subjected to removal torque tests (RTQ) as the main biomechanical analysis of the study. A fewer number was resected on bloc, embedded in methylmethacrylat and analyzed for their direct bone apposition under a light microscope.

RESULTS:

Surface analysis revealed the highest surface roughness for the SLA-implant, followed by ZrO₂r and ZrO₂m. The turned ZrO₂m implants showed statistically significant lower RTQ values than the other two implants types after 8 and 12 weeks, while the SLA implant showed significantly higher RTQs values than ZrO₂r surface after 8 weeks. Differences in the bone apposition were observed in the histomorphometric analysis using light microscopy for all surfaces at any time point.

CONCLUSION:

The findings suggest that ZrO₂r implants can achieve a higher stability in bone than ZrO₂m implants. Roughening the turned zirconia implants enhances bone apposition and has a beneficial effect on the interfacial shear strength.

MATERIALI IN TEHNOLOGIJE 2007
SEPT;41(5):237-241.

The fracture and fatigue of surface-treated tetragonal zirconia (Y-TZP) dental ceramics

Kosmač T, Oblak C, Jevnikar P.

ABSTRACT

The effects of dental grinding and sandblasting on the biaxial flexural strength of Y-TZP ceramics containing the mass fraction of 3 % yttria were evaluated. Dental grinding at high rotation speed lowers the mean strength under static loading and the survival rate under cyclic loading. Sandblasting, in contrast, may provide a powerful tool for surface strengthening also resulting in a substantially higher survival rate under cyclic loading. Fractographic examination of ground specimens revealed that failure originated from radial cracks extending up to 50 μm from the grinding groves into the bulk of the material. However, no evidence of grinding-induced surface cracks could be obtained by SEM analysis of the ground samples, prepared by a standard bonded-interface technique. Sandblasting, in contrast, introduces lateral cracks, which are not detrimental to the strength of Y-TZP ceramics. The "medical-grade" Y-TZP ceramics also containing 0.25 % of dispersed alumina used in this work exhibited full stability under hydrothermal conditions.

CLIN IMPLANT DENT RELAT RES. 2009
JUN;11(2):158-66.

Fracture strength of zirconia implants after artificial aging.

Andreiotelli M, Kohal RJ.

ABSTRACT

BACKGROUND:

Zirconia (ZrO_2) might be an alternative material to titanium (Ti) for dental implant fabrication. However, no data are available on the fracture strength of one-piece ZrO_2 oral implants.

PURPOSE:

The objective of this study was to evaluate the fracture strength of ZrO_2 implants after exposure to the artificial mouth.

MATERIALS AND METHODS:

One hundred twenty ZrO_2 and Ti implants were used. The Ti implants were divided into two control groups (A and B). ZrO_2 implants manufactured from yttria-stabilized tetragonal ZrO_2 polycrystal (Y-TZP) in group C, from Y-TZP dotted with alumina (Y-TZP-A) in group D, and from Y-TZP-A with a modified surface in groups E and F were used. In group F, the implant heads were prepared, and in group G, the implants were restored with ZrO_2 crowns. Each group included 16 samples with the exception of group D, which included 24 samples. A subgroup of each implant type (eight implants) was subjected to thermomechanical cycling in a chewing simulator prior to fracture testing. Test specimens were then loaded until a fracture occurred.

RESULTS:

Seven of the 120 samples failed in the chewing simulator. ZrO_2 implant fracture occurred at 725 to 850 N when the implants were not prepared, and at 539 to 607 N when prepared. The samples in group A fractured at the level of the abutment screw. All ZrO_2 implants fractured at the level of the Technovit resin (Heraeus Kulzer GmbH & Co., Wehrheim, Germany). No fracture of the ZrO_2 crowns in group G was observed.

CONCLUSION:

Mean fracture strength values obtained were all within the limits of clinical acceptance. However, implant preparation had a statistically significant negative influence on the implant fracture strength. Long-term clinical data are necessary before one-piece ZrO_2 implants can be recommended for daily practice.

CLIN IMPLANT DENT RELAT RES. 2009
DEC;11(4):323-9. DOI:
10.1111/J.1708-8208.2008.00116.X. EPUB 2008
SEP 9.

Stability of prototype two-piece zirconia and titanium implants after artificial aging: an in vitro pilot study.

Kohal RJ, Finke HC, Klaus G.

ABSTRACT

BACKGROUND:

Zirconia oral implants are a new topic in implant dentistry. So far, no data are available on the biomechanical behavior of two-piece zirconia implants. Therefore, the purpose of this pilot investigation was to test in vitro the fracture strength of two-piece cylindrical zirconia implants after aging in a chewing simulator.

MATERIALS AND METHODS:

This laboratory in vitro investigation comprised three different treatment groups. Each group consisted of 16 specimens. In group 1, two-piece zirconia implants were restored with zirconia crowns (zirconia copings veneered with Triceram; Esprident, Ispringen, Germany), and in group 2 zirconia implants received Empress 2 single crowns (Ivoclar Vivadent AG, Schaan, Liechtenstein). The implants, including the abutments, in the two zirconia groups were identical. In group 3, similar titanium implants were reconstructed with porcelain-fused-to-metal crowns. Eight samples of each group were submitted to artificial aging with a long-term load test in the artificial mouth (chewing simulator). Subsequently, all not artificially aged samples and all artificially aged samples that survived the long-term loading of each group were submitted to a fracture strength test in a universal testing machine. For the pairwise comparisons in the different test groups with or without artificial loading and between the different groups at a given artificial loading condition, the Wilcoxon rank-sum test for independent samples was used. The significance level was set at 5 %.

RESULTS:

One sample of group 1 (veneer fracture), none of group 2, and six samples of group 3 (implant abutment screw fractures) failed while exposed to the artificial mouth. The values for the fracture strength after artificial loading with 1.2 million cycles for group 1 were between 45 and 377 N (mean: 275.7 N), in group 2 between 240 and 314 N (mean:

280.7 N), and in the titanium group between 45 and 582 N (mean: 165.7 N). The fracture strength results without artificial load for group 1 amounted to between 270 and 393 N (mean: 325.1 N), for group 2 between 235 and 321 N (mean: 281.8 N), and between 474 and 765 N (mean: 595.2 N) for the titanium group. The failure mode during the fracture testing in the zirconia implant groups was a fracture of the implant head and a bending/fracture of the abutment screw in the titanium group.

CONCLUSIONS:

Within the limits of this pilot investigation, the biomechanical stability of all tested prototype implant groups seems to be - compared with the possibly exerted occlusal forces - borderline for clinical use. A high number of failures occurred already during the artificial loading in the titanium group at the abutment screw level. The zirconia implant groups showed irreparable implant head fractures at relatively low fracture loads. Therefore, the clinical use of the presented prototype implants has to be questioned.

Evaluation of stresses occurring on three different zirconia dental implants: three-dimensional finite element analysis.

Caglar A, Bal BT, Aydin C, Yilmaz H, Ozkan S.

ABSTRACT

PURPOSE:

The aim of this study was to evaluate the von Mises, compressive, and tensile stresses occurring on three different zirconia dental implants and surrounding bone with three-dimensional finite element analysis.

MATERIALS AND METHODS:

Three different zirconia implants (Z-Systems, Ziterion, and White-Sky), 10 mm in length and 4 mm in diameter, and anterior maxillary bone were modeled using three-dimensional finite element analyses. Zirconia implants were placed into the maxillary left central incisor region. Loading was applied in horizontal and oblique axes (at angles of 90 and 30 degrees with respect to the implant long axes). Oblique loading was 178 N and horizontal loading was 25.5 N.

RESULTS:

Under oblique loading, von Mises stresses for all implants were similar, and under horizontal loading conditions, the highest von Mises stress was found at the buccal and palatal neck region of the Ziterion implant (46.57 MPa). In cortical bone, the highest von Mises stresses were observed at the buccal region of the Z-Systems implant under oblique and horizontal loading conditions (26.65 MPa and 10.74 MPa, respectively). The highest compressive stresses were observed at the implant buccal neck region and cortical bone interface of the Z-Systems implant under oblique and horizontal loading conditions. For both loading conditions, the highest tensile stress values were observed at the implant palatal region and cortical bone interface of the Z-Systems implant.

CONCLUSION:

The von Mises, compressive, and tensile stresses that occurred in cortical bone were higher than those observed in trabecular bone. Generally, the stresses in the Z-Systems implant were higher than in the other zirconia implants. The differences between the stress values occurring on the zirconia implants may be related to the different body and thread designs of these implants.

Raue Y-TZP Biokeramikoberflächen für die dentale Implantologie.

Rough Y-TZP bioceramic surfaces for dental implantology

Hildebrand G, Strickstroch M, Grohmann S, Rechtenbach A, Moje H-J, Moje J, Zylla I-M, Liefelth K.

ABSTRACT

Compared with conventional bioceramic systems yttrium stabilized tetragonal zirconia (Y-TZP) ceramics possess some superior mechanical properties, ensuring a broad application in dentistry. Based on enhancing bond strength, sandblasting is a popular method used to achieve this purpose by increasing surface roughness and providing undercuts. In this context Moje Keramikimplantate GmbH & Co. KG has a long experience concerning the modification of surface topography of yttrium stabilized tetragonal zirconia (Y-TZP) ceramics containing traces of alumina for applications in dental implant surgery. This sophisticated approach for generating micro structured surfaces of high quality and reproducibility include a special ceramic process technology followed by different abrasive sand blasting regimes. The resulting bioceramic surface displays a mean surface roughness (Ra) ranging from rather smooth surface (0.6 µm) to a microtopography widely accepted as the common golden standard (SLA titanium, Ra: 1.7 µm) in dental implantology. Additionally, even rougher surfaces can be achieved with a mean surface roughness (Ra) of approximately 3 µm. Cell biological analysis with the osteosarcoma cell line MC3T3-E1 (subclone 4) reveal that the introduced microstructure does not result in any cytotoxic effects imposed on the cells. All materials and topographies investigated promote both adhesion and proliferation of osteoblastic cells. Interestingly, the highest cell count was observed on the Y-TZP sample with a mean surface roughness of Ra 3.0 µm indicating that rougher topographies are favoured by the osteoblasts. Furthermore, cells spread well on all sample surfaces with more spindle shaped phenotypes on the roughened titanium reference.

Material testing further comprised bending strength analysis performed on Y-TZP discs according to current standards. The bending strength of different rough Y-TZP bioceramics varied between 720 and 850 MPa and satisfies the common requirements for dental prosthesis. Since manufacturing and the technology for microstructuring bioceramic surfaces still offers some degrees of freedom to adjust the resulting microtexture and phase distribution the biomechanical properties may be further improved in the future. Certainly, Y-TZP bioceramics with good osteo-inductive properties and an enhanced product safety may be generated in the near future.

BIOMED TECH 2010; 55 (SUPPL. 1) 2010 BY WALTER DE GRUYTER.

Topografische, zellbiologische und biomechanische Analyse von Y-TZP Keramiken für die dentale Implantologie.

Topographic, cell biological and biomechanical analysis of Y-TZP ceramics in dental implantology.

Liefeith K, Strickstock M, Zylla IM, Hildebrand G, Grohmann S, Rost J, Moje HJ.

ABSTRACT

Bioceramic surfaces with a similar roughness to the SLA Titanium surface were manufactured and analyzed topographically and cell-biologically. As expected, all rough Y-TZP ceramic surfaces examined here as well as the SLA Titanium surface do not show any cytotoxic influences on the used osteoblasts. In particular the rough Y-TZP ceramic sample with a Ra-value of approx. 3 µm shows the best results in proliferation due to a higher surface area. A FE-analysis performed to estimate the influence of the load on the surrounding bone tissue was accomplished at different ceramic implant geometries.

J BIOMED MATER RES A. 2011 SEP 15;98(4):604-13. DOI: 10.1002/JBM.A.33145. EPUB 2011 JUN 30.

In vivo comparative biokinetics and biocompatibility of titanium and zirconium microparticles.

Olmedo DG, Tasat DR, Evelson P, Rebagliatti R, Guglielmotti MB, Cabrini RL.

ABSTRACT

Titanium and zirconium are biomaterials that present a layer of titanium dioxide (TiO₂) or zirconium dioxide (ZrO₂). As a result of corrosion, microparticles can be released into the bioenvironment, and their effect on tissues is seemingly associated with differences in the physicochemical properties of these metals. The aim of this study was to perform a long-term evaluation of the distribution, destination, and potential risk of TiO₂ and ZrO₂ microparticles that might result from the corrosion process. Wistar rats were i.p. injected with an equal dose of either TiO₂ or ZrO₂ suspension. The following endpoints were evaluated at 3, 6, and 18 months: (a) the presence of particles in blood cells and liver and lung tissue, (b) Ti and Zr deposit quantitation, (c) oxidant-antioxidant balance in tissues, and (d) O₂(⁻) generation in alveolar macrophages. Ti and Zr particles were detected in blood mononuclear cells and in organ parenchyma. At equal doses and times postadministration, Ti content in organs was consistently higher than Zr content. Ti elicited a significant increase in O₂(⁻) generation in the lung compared to Zr. The consumption of antioxidant enzymes was greater in the Ti than in the Zr group. The present study shows that the biokinetics of TiO₂ and ZrO₂ depends on particle size, shape, and/or crystal structure.

CONFERENCE PAPER 2014 JUNE.

Effect of the Design on the Strength of Ceramic Implants.

Just BA, Schöne A, Fischer J.

ABSTRACT

OBJECTIVE:

Implants are mechanically stressed during insertion and subsequent functional loading. The aim of this investigation was to evaluate the effect of abutment design and implant diameter of one piece ceramic implants on torsional and bending strength.

METHOD:

Three experimental one piece ceramic implants with different abutment designs (A, B, C) and different diameters (d: 4.0, 4.5, 5.0 mm) went under investigation. To evaluate the torsional strength, implants (n = 9) were inserted into a pig jaw. Static fracture load was measured according to ISO 14801 (n = 15) and fracture patterns were correlated with the results of finite element analyses.

RESULT:

During implant placement abutment A failed. Abutment B showed sufficient stability against torsional forces while abutment C revealed superior properties regarding force distribution and clinical handling. Loading according to ISO 14801 always resulted in fracture of the endosseous implant portion. Fracture load was correlated to d³. No fractures occurred within the abutments. Finite element analysis reliably predicted fracture pattern.

CONCLUSION:

The abutment design has a strong impact regarding torsional strength during implant placement. During functional loading the implant diameter seems to be more important in respect to fracture resistance.

DENT MATER. 2015 DEC;31(12):E279-88.

Loading capacity of zirconia implant supported hybrid ceramic crowns.

Rohr N, Coldea A, Zitzmann NU, Fischer J.

ABSTRACT

OBJECTIVE:

Recently a polymer infiltrated hybrid ceramic was developed, which is characterized by a low elastic modulus and therefore may be considered as potential material for implant supported single crowns. The purpose of the study was to evaluate the loading capacity of hybrid ceramic single crowns on one-piece zirconia implants with respect to the cement type.

METHODS:

Fracture load tests were performed on standardized molar crowns milled from hybrid ceramic or feldspar ceramic, cemented to zirconia implants with either machined or etched intaglio surface using four different resin composite cements. Flexure strength, elastic modulus, indirect tensile strength and compressive strength of the cements were measured. Statistical analysis was performed using two-way ANOVA (p=0.05).

RESULTS:

The hybrid ceramic exhibited statistically significant higher fracture load values than the feldspar ceramic. Fracture load values and compressive strength values of the respective cements were correlated. Highest fracture load values were achieved with an adhesive cement (1253±148N). Etching of the intaglio surface did not improve the fracture load.

SIGNIFICANCE:

Loading capacity of hybrid ceramic single crowns on one-piece zirconia implants is superior to that of feldspar ceramic. To achieve maximal loading capacity for permanent cementation of full-ceramic restorations on zirconia implants, self-adhesive or adhesive cements with a high compressive strength should be used.

CLIN ORAL IMPLANTS RES. 2016
FEB;27(2):162-6.

Surface micro-structuring of zirconia dental implants.

Fischer J, Schott A, Märtin S.

ABSTRACT

OBJECTIVE:

Sandblasting with subsequent acid etching is a potential procedure to generate microstructured surfaces on zirconia implants. The aim of the study was to systematically analyze the effect of these process steps on surface morphology and mechanical strength of the implants.

MATERIALS AND METHODS:

Zirconia implant blanks (ceramic implant, VITA) were sandblasted (105- μm alumina, 6 bar), subsequently HF-etched, and finally heat-treated at 1250 °C. Surface topographies were documented by SEM. Surface roughness Ra (n = 4), monoclinic volume fraction in the surface layer (n = 1), and static fracture load (n = 4) were measured.

RESULTS:

Surface roughness Ra reached a maximum of 1.2 μm after 4 x sandblasting. Scratches and sharp edges dominated the surface aspect. Fracture load increased with the number of sandblasting cycles with a gain of 30 % after 20 cycles. HF etching did not change the Ra values, but sharp edges were rounded and small pits created. A minor decrease in fracture load with increasing etching time was observed. Heat treatment of 1 h reduced the fracture load by 1/3. Longer heat treatment had no further effect. The roughness Ra was not modified by heat treatment. Fracture load was strongly correlated with the monoclinic fraction except for the results obtained directly after acid etching, where a constant monoclinic fraction was observed.

CONCLUSIONS:

Sandblasting with 105- μm alumina followed by 1 h HF etching at room temperature and 1 h heat treatment at 1250 °C is a reliable and tolerant process to create a surface roughness of about Ra = 1.2 μm on zirconia implants.

CLIN IMPLANT DENT RELAT RES. 2017
APR;19(2):245-252.

The Impact of In Vitro Accelerated Aging, Approximating 30 and 60 Years In Vivo, on Commercially Available Zirconia Dental Implants.

Monzavi M, Noubissi S, Nowzari H.

ABSTRACT

BACKGROUND:

Despite increased popularity of Zirconia dental implants, concerns have been raised regarding low temperature degradation (LTD) and its effect on micro-structural integrity.

PURPOSE:

This study evaluated the effect of LTD on four types of Zirconia dental implants at 0, 30, and 60 years of artificial aging. The impact of aging on t-m transformation and micro crack formation was measured.

MATERIALS AND METHODS:

Accelerated aging at 15 and 30 hours, approximating 30 and 60 years in vivo, aged 36 Zirconia dental implants: Z systems® (A), Straumann® (B), Ceraroot® (C), and Zeramex® (D). Focused ion beam-scanning electron microscopic analysis determined the micro structural features, phase transformation, and the formation of micro cracks.

RESULTS:

At 15 hours, type A implant presented with micro cracks and t-m transformation of 0.9 μm and 3.1 μm , respectively. At 30 hours, micro cracks remained shallow (1 μm). At 15 hours, type B implant presented micro cracks (0.7 μm) and grain transformation (1.2 μm). At 30 hours, these features remained superficial at 0.6 and 1.5 μm , respectively. Type C implant presented surface micro cracks of 0.3 μm at 15 hours. The depth of t-m transformation slightly increased to 1.4 μm . At 30 hours, number of micro cracks increased at the surface to an average depth of 1.5 μm . Depth of t-m transformation increased to an average of 2.5 μm . At 15 hours, micro cracks remained superficial (0.8 μm) for type D implant and depth of t-m transformation increased to 2.3 μm . At 30 hours, the depth of micro cracks increased to an average of 1.3 μm followed by increased t-m transformation to a depth of 4.1 μm .

CONCLUSION:

Depth of grain transformation remained within 1-4 μm from the surface. The effect of aging was minimal for all Zirconia implants.

J PROSTHODONT RES. 2018 APR;
62(2):258-263.

Ultimate force and stiffness of 2-piece zirconium dioxide implants with screw-retained monolithic lithium-disilicate reconstructions.

Joda T, Voumard B, Zysset PK, Brägger U, Ferrari M.

ABSTRACT

PURPOSE:

The aims were to analyze stiffness, ultimate force, and failure modes of a 2-piece zirconium dioxide (ZrO₂) implant system.

METHODS:

Eleven 2-piece ZrO₂ implants, each mounted with ZrO₂ abutments plus bonded monolithic lithium disilicate (LS2) restorations, were grouped for 3.3 mm (A) and 4.1 mm (B) diameter samples. Quasi-static load was monotonically applied under a standardized test set-up (loading configuration according to DIN ISO 14801). The ultimate force was defined as the maximum force that implants are able to carry out until fracture; stiffness was measured as the maximum slope during loading. An unpaired t-test was performed between group A and B for ultimate force and stiffness ($p < 0.05$).

RESULTS:

Force-displacement curves revealed statistically homogeneous inner-group results for all samples. Failure modes showed characteristic fractures at the neck configuration of the implants independent of the diameter. Mean stiffness was 1099 N/mm (± 192) for group A, and significantly lower compared to group B with 1630 N/mm (± 274) ($p < 0.01$); whereas mean ultimate force was 348 N (± 53) for group A, and significantly increased for group B with 684 N (± 29) ($p < 0.0001$).

CONCLUSIONS:

The examined 2-piece ZrO₂ implant system mounted to LS2-restorations seems to be a stable unit under in-vitro conditions with mechanical properties compared to loading capacity of physiological force. The metal-free implant reconstructions demonstrated high stiffness and ultimate force under quasi-static load for single tooth replacement under consideration of the dental indication of narrow and standard diameter implants.

DENT MATER J. 2018 MAR 30;37(2):222-228.

Correlations between fracture load of zirconia implant supported single crowns and mechanical properties of restorative material and cement.

Rohr N, Märtin S, Fischer J.

ABSTRACT

Zirconia implants that were restored with veneered zirconia displayed severe chipping rates of the restorations in clinical studies. Purpose of this study was to evaluate the fracture load of different zirconia implant supported monolithic crown materials (zirconia, alumina, lithium disilicate, feldspar ceramic and polymer-infiltrated ceramic) cemented with various cements (Harvard LuteCem SE, Harvard Implant Semi-permanent, Multilink Automix, VITA Adiva F-Cem). Flexural strength and fracture toughness of crown materials and compressive strength of the cements were measured. Fracture load values of crowns fabricated from lithium disilicate, feldspar ceramic and polymer-infiltrated ceramic were increased when cement with high compressive strength was used. Fracture loads for zirconia and alumina crowns were not influenced by the cement. Flexural strength and fracture toughness of the ceramics correlated linearly with the respective fracture load when using adhesive cement with high compressive strength. To achieve sufficient fracture load values, cementation with adhesive cement is essential for feldspar and polymer-infiltrated ceramic.

Influence of cement type and ceramic primer on retention of polymer-infiltrated ceramic crowns to a one-piece zirconia implant.

Rohr N, Brunner S, Märtin S, Fischer J.

ABSTRACT

STATEMENT OF PROBLEM:

The best procedure for cementing a restoration to zirconia implants has not yet been established.

PURPOSE:

The purpose of this in vitro study was to measure the retention of polymer-infiltrated ceramic crowns to zirconia 1-piece implants using a wide range of cements. The effect of ceramic primer treatment on the retention force was also recorded. The retention results were correlated with the shear bond strength of the cement to zirconia and the indirect tensile strength of the cements to better understand the retention mechanism.

MATERIAL AND METHODS:

The retention test was performed using 100 polymer-infiltrated ceramic crowns (Vita Enamic) and zirconia implants (ceramic implant CI). The crowns were cemented with either interim cement (Harvard Implant semipermanent, Temp Bond), glass-ionomer cement (Ketac Cem), self-adhesive cement (Perma Cem 2.0, RelyX Unicem Automix 2, Panavia SA), or adhesive cement (Multilink Implant, Multilink Automix, Vita Adiva F-Cem, RelyX Ultimate, Panavia F 2.0, Panavia V5 or Panavia 21) (n=5). Additionally ceramic primer was applied on the intaglio crown surface and implant abutment before cementation for all adhesive cements (Multilink Implant, Multilink Automix: Monobond plus; RelyX Ultimate Scotchbond Universal; Vita Adiva F-Cem: Vita Adiva Zr-Prime; Panavia F2.0, Panavia V5: Clearfil Ceramic Primer) and 1 self-adhesive cement containing 10-methacryloyloxydecyl dihydrogen phosphate (MDP) (Panavia SA: Clearfil Ceramic Primer). Crown debond fracture patterns were recorded. Shear bond strength was determined for the respective cement groups to polished zirconia (n=6). The diametral tensile strength of the cements was measured (n=10). Statistical analysis was performed using 1-way or 2-way analysis of variance followed by the Fisher LSD test ($\alpha=0.05$) within each test parameter.

RESULTS:

Adhesive and self-adhesive resin cements had shear bond strength values of 0.0 to 5.3 MPa and revealed similar retention forces. Cements containing MDP demonstrated shear bond strength values above 5.3 MPa and displayed increased retention. The highest retention values were recorded for Panavia F 2.0 (318 ± 28 N) and Panavia 21 (605 attained retention values between 222 ± 16 N (Multilink Automix) and 270 ± 26 N (Panavia SA), which were significantly higher ($P < .05$) than glass-ionomer (Ketac Cem: 196 ± 34 N) or interim cement (Harvard Implant semipermanent: 43 ± 6 N, Temp Bond: 127 ± 13 N). Application of manufacturer-specific ceramic primer increased crown retention significantly only for Panavia SA.

CONCLUSIONS:

Products containing MDP provided a high chemical bond to zirconia. Self-adhesive and adhesive resin cements with low chemical bonding capabilities to zirconia provided retention force values within a small range (220 to 290 N).

1.2.2 Soft tissue Behavior and Microflora

J PROSTHET DENT. 1992 AUG;68(2):322-6.

Tissue compatibility and stability of a new zirconia ceramic in vivo.

Ichikawa Y, Akagawa Y, Nikai H, Tsuru H.

ABSTRACT

Tissue reaction and stability of partially stabilized zirconia ceramic in vivo was evaluated with the use of the subcutaneous implantation test. During the experimental period, zirconia ceramic was completely encapsulated by a thin fibrous connective tissue with less than 80 microns thickness. No changes of weight and 3-point bending strength were detected after 12 months of implantation. The result suggests that zirconia ceramic is biocompatible and no degradation of zirconia ceramic occurred.

INT J ORAL MAXILLOFAC IMPLANTS. 2002 NOVDEC; 17(6): 793-8.

Bacterial colonization of zirconia ceramic surfaces: an in vitro and in vivo study.

Rimondini L, Cerroni L, Carrassi A, Torricelli P.

ABSTRACT

PURPOSE:

The microbial colonization of new ceramic materials developed for abutment manufacturing was assessed.

MATERIALS AND METHODS:

The materials used in these experiments were disks of 'as-fired' and 'rectified' ceramic material made of tetragonal zirconia polycrystals stabilized with yttrium (Y-TZP) and commercially pure grade 2 titanium (Ti) with corresponding eluates. They were tested in vitro with the following bacteria: *Streptococcus mutans*, *S. sanguis*, *Actinomyces viscosus*, *A. naeslundii*, and *Porphyromonas gingivalis*. Proliferation was evaluated on plates by inhibitory halos around pits, previously inoculated with eluates obtained from the materials. Bacterial adhesion on materials was quantified by spectrophotometric evaluation of the slime production by the same bacteria. Moreover, early bacterial adhesion was evaluated in human volunteers and observed with SEM.

RESULTS:

No inhibition of bacterial proliferation using eluates was observed. In vitro as-fired and rectified Y-TZP showed significantly more adherent *S. mutans* than did Ti disks, while *S. sanguis* seemed to adhere easily to Ti specimens. No differences were noted for *Actinomyces* spp and *P. gingivalis*. In vivo Y-TZP accumulated fewer bacteria than Ti in terms of the total number of bacteria and presence of potential putative pathogens such as rods. No differences were observed between rectified and as-fired Y-TZP.

DISCUSSION:

Overall, Y-TZP accumulates fewer bacteria than Ti.

CONCLUSION:

Y-TZP may be considered as a promising material for abutment manufacturing..

Qualität des periimplantären
Weichgewebeattachments von
Zirkondioxid-Implantaten
(Abutments). Vergleich der
Ergebnisse einer Literaturre-
cherche mit den Erfahrungen
aus der eigenen Praxis.

Quality of the periimplant soft
tissue attachment of
zirconia implants (-abutments).
Comparison of the results of a
literature review with the expe-
riences of dental practioners.

Mellinghoff J.

ABSTRACT

PURPOSE:

In the present work, zirconia implants are discussed solely with respect to their suitability as stock for peri- implant soft tissue. The aim of the study was to compare the results of a literature review with the results of five years of clinical use in our dental practice.

MATERIAL AND METHODS:

A systematic literature research was conducted in the internet database PUBMED using the key- words 'zircon*'; 'implant', 'soft tissue', 'bacterial adhesion', 'mucosa', 'attachment', 'connective tissue', and 'plaque'. In the clinical part of the work, 65 zirconia implants type Z-Lock-III were inserted in 34 patients according to a surgical protocol, cared for during the healing process using protec- tive measures and examined in annual follow-ups after the placement of the prosthetic superstructure. The mean expo- sure time was approximately 22 month (min. 1.3 months/max. 59 months).

RESULTS:

In the literature review, 72 hits were generated, with a total of 16 publications that were relevant for our topic. The studies evaluated soft tissue attachment that was histologi- cally examined, plaque adhesion, bacterial colon- ization with germs associated with periodontal diseases, in- flammation factors of the soft tissue, as well as the influence on the color of the periimplant soft tissue. Compared with TiO₂, the implants and abutments of zirconia achieved com- parable or better results in all studies. At all times in the in- vestigation, the evaluation of the clinical findings showed average probing depths between 2 and 3 mm. Plaque and bleeding results were described as exception- ally good. In ad- dition, esthetically pleasing results could be achieved even with soft tissue in problematic condition.

CONCLUSIONS:

Zirconia implants and abutments provide a very good periimplant soft tissue interface that achieves an irrita- tion-free attachment. From an esthetic point of view, there are notable advantages for using Zirconia as com- pared to TiO₂ when dealing with a very thin gingiva Typ II and a high smile line.

J PERIODONTOL. 2004 FEB;75(2):292-6.

Bacterial adhesion on commercially pure titanium and zirconium oxide disks: an in vivo human study.

Scarano A, Piattelli M, Caputi S, Favero GA, Piattelli A.

ABSTRACT

BACKGROUND:

Little is known about the mechanisms of bacterial interaction with implant materials in the oral cavity. A correlation between plaque accumulation and progressive bone loss around implants has been reported. Bacterial adhesion shows a direct positive correlation with surface roughness. Other surface characteristics also seem to be extremely important with regard to plaque formation. Different adhesion affinities of bacteria have been reported for different materials. The aim of this study was to characterize the percentage of surface covered by bacteria on commercially pure titanium and zirconium oxide disks.

METHODS:

Ten patients participated in this study. A removable acrylic device was adapted to the molar-premolar region, and commercially pure titanium (control) and zirconium oxide (test) disks were glued to the buccal aspect of each device. The surface roughness of titanium and test specimens was similar. After 24 hours, all disks were removed and processed for scanning electron microscopy, for the evaluation of the portion of surface covered by bacteria.

RESULTS:

In control specimens, the area covered by bacteria was 19.3 % +/- 2.9; in test specimens, the area was 12.1 % +/- 1.96. The disk surface covered by bacteria on test specimens was significantly lower than that of control specimens ($P = 0.0001$).

CONCLUSION:

Our results demonstrate that zirconium oxide may be a suitable material for manufacturing implant abutments with a low colonization potential.

J DENT. 2012 FEB;40(2):146-53. DOI: 10.1016/J.JDENT.2011.12.006. EPUB 2011 DEC 9.

Surface properties of titanium and zirconia dental implant materials and their effect on bacterial adhesion.

Al-Radha AS, Dymock D, Younes C, O'Sullivan D.

ABSTRACT

OBJECTIVES:

Zirconia ceramic material has been widely used in implant dentistry. In this in vitro study the physiochemical properties of titanium and zirconia materials were investigated and the affinity of different bacteria to different materials was compared.

METHODS:

Disc samples with different surface states were used: polished partially stabilized zirconia (PZ), titanium blasted with zirconia (TBZ), titanium blasted with zirconia then acid etched (TBZA), and polished titanium (PT) as a control. Surface topography was examined using scanning electron microscopy and profilometry. Contact angle, surface free energy (SFE), surface microhardness and chemical composition were determined. Disc samples were separately incubated with *Streptococcus mitis* and *Prevotella nigrescens*, either with or without pre-coating with human saliva, for 6h and the surface area covered by bacteria was calculated from fluorescence microscope images.

RESULTS:

PZ and TBZ exhibited lower surface free energy and lesser surface wettability than PT. Also, PZ and TBZ surfaces showed lower percentage of bacterial adhesion compared with control PT surface.

CONCLUSIONS:

The zirconia material and titanium blasted with zirconia surface (TBZ surface) showed superior effect to titanium material in reducing the adhesion of the experimented bacteria especially after coating with saliva pellicle. Modifying titanium with zirconia lead to have the same surface properties of pure zirconia material in reducing bacterial adhesion. SFE appears to be the most important factors that determine initial bacterial adhesion to smooth surface.

IMPLANTOLOGIE 2014 MARCH 22 (1):65-70.

Zirconia and peri-implant soft tissue – A clinical case observation.

Weng D.

ABSTRACT

In previous years, zirconia implants have predominantly been investigated as to their osseointegrative capacity and their fracture resistance. Recently the focus has shifted toward the interaction between zirconia and peri-implant soft tissues or plaque as well as towards the prosthetic connection between a zirconia implant and its superstructure. This update of a previously published clinical case shows that the affinity between peri-implant soft tissues and zirconia might be improved compared with titanium, which might be beneficial regarding the long-term stability of the peri-implant soft tissue.

IMPLANT DENT. 2015 FEB;24(1):37-41.
DOI: 10.1097/ID.0000000000000167.

Soft tissue biological response to zirconia and metal implant abutments compared with natural tooth: microcirculation monitoring as a novel bioindicator.

Kajiwara N, Masaki C, Mukaibo T, Kondo Y, Nakamoto T, Hosokawa R.

ABSTRACT

INTRODUCTION:

Zirconia is often used for implant abutments for esthetics. The aim of this clinical study was to compare the effects of zirconia and metal abutments on periimplant soft tissue.

MATERIALS AND METHODS:

Ten maxillary anterior implant patients, 5 with metal abutments and 5 with zirconia abutments, were enrolled in this trial. The soft tissue around the implant abutments was evaluated by 2-dimensional laser speckle imaging and thermography. The blood flow in soft tissue around natural teeth was also measured to correct for differences among the subjects.

RESULTS:

Significantly greater blood flow was detected in the zirconia abutment group (95.64 ± 5.17 %) relative to the metal abutment group (82.25 ± 8.92 %) in free gingiva ($P = 0.0317$). Reduced blood flow (by almost 18 %) was detected in the tissue surrounding metal abutments compared with the tissue surrounding natural teeth. The surface temperature showed no significant difference for all measurements.

CONCLUSIONS:

These results suggest that blood flow in tissue surrounding zirconia abutments is similar to that in soft tissue around natural teeth. Moreover, zirconia abutments could be advantageous for the maintenance of immune function by improving blood circulation.

In vitro biofilm formation on commercially available machined and micro-roughened titanium and zirconia implant surfaces.

Roehling S, Astasov-Frauenhoffer M, Hauser-Gerspach I, Braissant O, Engelhardt H, Waltimo T, Gahlert M.

ABSTRACT

BACKGROUND:

It has been shown that biofilm formation and subsequent plaque accumulation on implant surfaces can induce peri-implant infections and that besides surface roughness and surface free energy, the type of biomaterial can also influence the bacterial adhesion and colonization on implant surfaces. In recent years, zirconia has become an alternative to titanium for the fabrication of dental implants and it has been hypothesized that zirconia might have a reduced bacterial adhesion compared to titanium; however, results from experimental studies are rather controversial.

AIM/HYPOTHESIS:

The aim of the present experimental study was to investigate and compare biofilm formation on commercially available machined and micro-roughened zirconia and titanium implant surfaces using an in vitro 3-species biofilm and human plaque samples.

MATERIAL AND METHODS:

Experimental disks made of titanium (Ti-M, Ti-SLA) or zirconia (ZrO₂-M, ZrO₂-ZLA) with a machined or a sand-blasted and acid-etched surface topography, respectively, were produced. Initially, disks were coated with an in vitro 3-species biofilm, consisting of *Streptococcus sanguinis*, *Porphyromonas gingivalis* and *Fusobacterium nucleatum*, or with human plaque samples that were collected from 4 patients within the course of a regular oral hygiene recall. Following to that, the disks were incubated in an anaerobic flow chamber. Finally, after 72 h of incubation, structure, amount, thickness and metabolism of the formed biofilms were evaluated by using scanning electron microscopy (SEM), safranin staining, 4',6 - diamidin-2phenylindol (DAPI) staining combined with confocal laser scanning microscopy (CLSM) and isothermal microcalorimetry (IMC). Each microbiological experiment was conducted 3 times (n = 3) on each type of titanium and zirconia disks.

RESULTS:

The 3-species biofilm evaluation showed structured and organized biofilms only on Ti-SLA, whereas ZrO₂-ZLA, ZrO₂-M and Ti-M showed single aggregates of bacteria. Additionally, zirconia showed statistically significantly reduced 3-species biofilm thickness compared to titanium (ZrO₂-M: 8.41 μ m; ZrO₂-ZLA: 17.47 μ m; Ti-M: 13.12 μ m; Ti-SLA: 21.97 μ m); however, no differences were found with regard to 3-species-biofilm mass and metabolism. Human plaque analysis showed optical density values of 0.06 and 0.08 for ZrO₂-M and ZrO₂-ZLA, and values of 0.1 and 0.13 for Ti-M and Ti-SLA, respectively, indicating statistically significantly reduced human biofilm mass on zirconia compared to titanium. Additionally, zirconia revealed statistically significantly reduced human plaque thickness (ZrO₂-M: 9.04 μ m; ZrO₂-ZLA: 13.83 μ m; Ti-M: 13.42 μ m; Ti-SLA: 21.3 μ m) but a similar human plaque metabolism compared to titanium.

CONCLUSIONS AND CLINICAL IMPLICATIONS:

After 72 h of incubation, 3-species biofilm evaluation only showed statistically significant differences between zirconia and titanium with regard to biofilm thickness. However, two out of three quantitative microbiological techniques showed statistically significantly reduced human plaque biofilm formation on zirconia compared to titanium implant surfaces. Thus, it might be suggested that zirconia surfaces might have a reduced disposition for peri-implant plaque formation.

J CLIN PERIODONTOL. 2015 OCT;42(10):
967-75.

Histological analysis of loaded zirconia and titanium dental implants: an experimental study in the dog mandible.

Thoma DS, Benic GI, Muñoz F, Kohal R, Sanz Martin I, Cantalapiedra AG2, Hämmerle CH, Jung RE.

ABSTRACT

OBJECTIVE:

To assess whether or not peri-implant soft tissue dimensions and hard tissue integration of loaded zirconia implants are similar to those of a titanium implant.

MATERIALS AND METHODS:

In six dogs, two one-piece zirconia implants (VC, ZD), a two-piece zirconia implant (BPI) and a control one-piece titanium implant (STM) were randomly placed. CAD/CAM crowns were cemented at 6 months. Six months later, animals were killed and histomorphometric analyses were performed, including: the level of the mucosal margin, the extent of the peri-implant mucosa, the marginal bone loss and the bone-to-implant contact (BIC). Means of outcomes variables were calculated together with their corresponding 95 % confidence intervals.

RESULTS:

In general, the mucosal margin was located coronally to the implant shoulder. The buccal peri-implant mucosa ranged between 2.64 ± 0.70 mm (VC) and 3.03 ± 1.71 mm (ZD) (for all median comparisons $p > 0.05$). The relative marginal bone loss ranged between 0.65 ± 0.61 mm (BPI) and 1.73 ± 1.68 mm (ZD) (buccal side), and between 0.55 ± 0.37 mm (VC) and 1.69 ± 1.56 mm (ZD) (lingual side) ($p > 0.05$). The mean BIC ranged between $78.6 \% \pm 17.3 \%$ (ZD) and $87.9 \% \pm 13.6 \%$ (STM) without statistically significant differences between the groups ($p > 0.05$).

CONCLUSIONS:

One- and two-piece zirconia rendered similar peri-implant soft tissue dimensions and osseointegration compared to titanium implants that were placed at 6 months of loading. Zirconia implants, however, exhibited a relatively high fracture rate.

J MED MICROBIOL. 2016 JUL;65(7):596-604.
DOI: 10.1099/JMM.0.000267. EPUB 2016
APR 19.

Bacterial adhesion and biofilm formation on yttria-stabilized, tetragonal zirconia and titanium oral implant materials with low surface roughness - an in situ study.

Al-Ahmad A, Karygianni L, Schulze Wartenhorst M, Bächle M, Hellwig E, Follo M, Vach K, Han JS.

ABSTRACT

Bacterially-driven mucosal inflammation and the development of periimplantitis can lead to oral implant failure. In this study, initial bacterial adhesion after 2 h, and biofilm formation after 1 day and 3 days, were analysed in situ on novel 3 mol % yttria-stabilized tetragonal zirconia polycrystal samples, as well as on alumina and niobium co-doped yttria-stabilized tetragonal zirconia samples. Pure titanium implant material and bovine enamel slabs served as controls. The initially adherent oral bacteria were determined by 4',6-diamidino-2-phenylindole-staining. Biofilm thickness, surface covering grade and content of oral streptococci within the biofilm were measured by fluorescence in situ hybridization. No significant differences between the ceramic and titanium surfaces were detectable for either initial bacterial adhesion or the oral streptococci content of the in situ biofilm. The oral biofilm thickness on the implant surfaces were almost doubled after three days compared to the first day of oral exposure. Nevertheless, the biofilm thickness values among the different implant surfaces and controls did not differ significantly for any time point of measurement after 1 day or 3 days of biofilm formation. Significant differences in the covering grade were only detected between day 1 and day 3 for each tested implant material group. The content of oral streptococci increased significantly in parallel with the increase in biofilm age from day 1 to day 3. In conclusion, oral implant zirconia surfaces with low surface roughness are comparable to titanium surfaces with respect to initial bacterial adhesion and biofilm formation.

Analysis of *P. gingivalis*, *T. forsythia* and *S. aureus* levels in edentulous mouths prior to and 6 months after placement of one-piece zirconia and titanium implants.

Siddiqi A, Milne T, Cullinan MP, Seymour GJ.

ABSTRACT

BACKGROUND:

It has been suggested that completely edentulous patients harbour fewer periodontopathic bacteria compared with dentate patients, due to the removal of the subgingival periodontal environment. However, reappearance of certain microbes has been reported after the placement of implants in these patients.

AIM:

The aim of this study was to determine whether the periodontopathic bacteria *Porphyromonas gingivalis* and *Tannerella forsythia*, as well as the non-periodontopathic bacterium, *Staphylococcus aureus*, emerged in edentulous patients 6 months after placement of one-piece zirconia and titanium implants.

MATERIALS AND METHODS:

Twenty-six patients were included in the study (titanium = 13, zirconia = 13). Microbial samples were collected from the tongue prior to implant placement and 6 months after implant placement from both the tongue and from around the implants. A qRT-PCR assay using SYBR green/ROX chemistry was used for the detection and quantification of *rgp*, *nuc* and *karilysin* single-copy gene of *P. gingivalis*, *T. forsythia* and *S. aureus*, respectively. Positive controls used in the study were pure bacterial gDNA purified from cultures of *P. gingivalis* and *S. aureus*, a cloned sequence of the *karilysin* gene for *T. forsythia*, a plaque sample positive for *P. gingivalis* and *T. forsythia*, and nasal gDNA for *S. aureus*.

RESULTS:

The results show that prior to implant placement, all three bacterial species were below the lower limit of quantification in all edentulous patients. The samples collected from the tongue and around the implants remained below the lower limit of quantification for each of the three species. However, all positive controls used in the study were

detectable in the samples. qPCR standard curves showed correlation coefficients > 0.97 and efficiencies >94.5 % (slope range -3.19 to -3.46) for each of the SYBR green PCR assays.

CONCLUSION:

The results of this study indicate that the tested organisms did not emerge 6 months after implant placement irrespective of the nature of the implant biomaterial. A further follow-up of at least 2 years post-implantation of these patients is suggested to determine whether there are any changes in the oral microbiota and whether such changes are associated with the development of peri-implant disease.

INT J ORAL MAXILLOFAC SURG. 2017
AUG;46(8):1039-1044.

Papilla and alveolar crest levels in immediate versus delayed single-tooth zirconia implants.

Kniha K, Kniha H, Möhlhenrich SC, Milz S, Hölzle F,
Modabber A.

ABSTRACT

The aim of this study was to determine the correlation between the papilla deficit and the distance between the bone crest at the neighbouring tooth and the contact point of the clinical crown (distance 4) for immediate and delayed zirconia implants. This prospective observational study included 78 patients with 82 implants investigated at the 1-year follow-up. Patients received single-unit zirconia implants (Straumann PURE Ceramic Implant with ZLA surface) that were placed using either the delayed (group A) or immediate (group B) protocol after tooth extraction. The distance of the alveolar crest of the neighbouring tooth to the height of the interdental papilla and the absence of the papilla were also assessed. There was a strong correlation between the papilla deficit and distance 4 in group A (Spearman's $\rho=0.64$). However, in group B, only a weak correlation between the two distances was found (Spearman's $\rho=0.28$). A full soft tissue margin was generated when distance 4 was 7-8 mm or less. Delayed implant placement showed a critical distance between the alveolar crest at the neighbouring tooth and the contact point of the crown risking a visible papilla deficit of between 7 mm and 8 mm.

J PERIODONTOL. 2017 MAR;88(3):298-307.
DOI: 10.1902/JOP.2016.160245. EPUB 2016
OCT 7.

In Vitro Biofilm Formation on Titanium and Zirconia Implant Surfaces.

Roehling S, Astasov-Frauenhoffer M, Hauser-Gerspach I,
Braissant O, Woelfler H, Waltimo T, Kniha H, Gahlert M.

ABSTRACT

BACKGROUND:

It has been hypothesized that zirconia might have a reduced bacterial adhesion compared with titanium; however, results from experimental studies are rather controversial. The aim of the present study is to compare biofilm formation on zirconia and titanium implant surfaces using an in vitro three-species biofilm and human plaque samples.

METHODS:

Experimental disks made of titanium (Ti) or zirconia (ZrO₂) with a machined (M) or a sandblasted (SLA) and acid-etched (ZLA) surface topography were produced. An in vitro three-species biofilm or human plaque samples were applied for bacterial adhesion to each type of disk, which after 72 hours of incubation was assessed using an anaerobic flow chamber model.

RESULTS:

Zirconia showed a statistically significant reduction in three-species biofilm thickness compared with titanium (ZrO₂-M: 8.41 μm ; ZrO₂-ZLA: 17.47 μm ; Ti-M: 13.12 μm ; Ti-SLA: 21.97 μm); however, no differences were found regarding three-species-biofilm mass and metabolism. Human plaque analysis showed optical density values of 0.06 and 0.08 for ZrO₂-M and ZrO₂-ZLA, and values of 0.1 and 0.13 for Ti-M and Ti-SLA, respectively; indicating a statistically significant reduction in human biofilm mass on zirconia compared with titanium. Additionally, zirconia revealed a statistically significant reduction in human plaque thickness (ZrO₂-M: 9.04 μm ; ZrO₂-ZLA: 13.83 μm ; Ti-M: 13.42 μm ; Ti-SLA: 21.3 μm) but a similar human plaque metabolism compared with titanium.

CONCLUSION:

Zirconia implant surfaces showed a statistically significant reduction in human plaque biofilm formation after 72 hours of incubation in an experimental anaerobic flow chamber model compared with titanium implant surfaces.

Effect of Different Crown Materials on the InterLeukin-One Beta Content of Gingival Crevicular Fluid in Endodontically Treated Molars: An Original Research.

Saravanakumar P, Thallam Veeravalli P, Kumar V A, Mohamed K, Mani U, Grover M, Thirumalai Thangarajan S.

ABSTRACT

INTRODUCTION:

Crown materials used in fixed prosthodontics come into close and prolonged contact with the gingiva.

OBJECTIVE:

The purpose of this study was to evaluate the effect of different crown materials on the interleukin-one beta (IL-1 μ m) content of the gingival crevicular fluid and to study which crown material causes the highest inflammation on the marginal gingiva on a biochemical basis.

MATERIALS AND METHODS:

Twenty patients with single endodontically treated tooth were examined. Contralateral teeth were taken as controls. The crown materials in contact with the marginal gingiva were divided into three groups: Group 1- metal, Group 2- ceramic, Group 3-zirconia. The collected data were analyzed with International Bibliography of the Social Sciences (IBSS). Statistical Package for the Social Sciences (SPSS) Statistics software 23.0 (IBM Corp, Armonk, New York). All assay procedures were carried out and the results of the collected samples were calculated using the ELISA-AIDTM technique.

RESULTS:

Multiple comparisons using one-way analysis of variance (ANOVA) between the materials on day zero, 45 th and 90 th day was highly significant with $p=0.0005$. Pairwise comparison using Tukey's honest significant difference (HSD) posthoc test was also highly statistically significant with $p=0.0005$ except for ceramic & zirconia which were significant at $p=0.04$ on the 90 th day. Multiple comparison using repeated measure of ANOVA with Bonferroni correction between day zero, 45 th and 90 th day was found to be statistically significant only for zirconia ($p=0.002$).

CONCLUSION:

This study was conducted to evaluate the effect of different crown materials on the amount of marginal gingival inflammation by measuring the IL-1 μ m content in gingival crevicular fluid (GCF). At the end of the three-month analysis, it was seen that the zirconia crowns exhibited the least marginal gingival inflammation.

CLIN ORAL INVESTIG. 2018 JUL;22(6):
2335-2343.

Oral bacterial colonization on dental implants restored with titanium or zirconia abutments: 6-month follow-up.

de Freitas AR, Silva TSO, Ribeiro RF, de Albuquerque Junior RF, Pedrazzi V, do Nascimento C.

ABSTRACT

OBJECTIVE:

This investigation aimed to characterize in a 6-month follow-up the microbial profile of implants restored with either titanium or zirconia abutments at the genus or higher taxonomic levels.

METHODS:

Twenty healthy individuals indicative for implant-retained single restorations were investigated. Half of participants were restored with titanium and half with zirconia abutments. Biofilm was collected from the implant-related sites after 1, 3, and 6 months of loading. The 16S rDNA genes were amplified and sequenced with Roche/454 platform.

RESULTS:

A total of 596 species were identified in 360 samples and grouped in 18 phyla and 104 genera. Titanium- or zirconia-related sites as well as teeth showed similar total numbers of operational taxonomic units (OTUs) colonizing surfaces over time. Firmicutes, Proteobacteria, Fusobacteria, Bacteroidetes, and Actinobacteria were the most prevalent phyla with significant differences between different surfaces and time point. Unclassified genera were found in lower levels (1.71 % up to 9.57 %) on titanium and zirconia samples when compared with teeth, with no significant differences.

CONCLUSION:

Titanium- and zirconia-related surfaces are promptly colonized by a bacterial community similar to those found in the remaining adjacent teeth. Results suggest a selective adhesion of different bacterial genotypes for either titanium or zirconia surfaces. Data also indicate a significant interaction between the relative effects taxa, time point, and sampling site.

CLINICAL RELEVANCE:

The present study disclosed a wider spectrum of microorganisms colonizing either titanium- or zirconia-related microbiomes in very early stage of implant colonization, revealing differences and suggesting a probably specific mechanism for selective bacterial adhesion.

CLIN ORAL IMPLANTS RES. 2019
JUL;30(7):660-669. DOI: 10.1111/CLR.13451.
EPUB 2019 MAY 12.

Tissue integration of zirconia and titanium implants with and without buccal dehiscence defects-A histologic and radiographic preclinical study.

Thoma DS, Lim HC, Paeng KW, Jung UW, Hämmerle CHF, Jung RE.

ABSTRACT

OBJECTIVE:

To histologically and radiographically evaluate soft (primary outcome) and hard tissue integration of two-piece titanium and zirconia dental implants with/without buccal dehiscence defects.

MATERIALS AND METHODS:

In six dogs, five implants were randomly placed on both sides of the mandible: (a) Z1: a zirconia implant (modified surface) within the bony housing, (b) Z2: a zirconia implant (standard surface) within the bony housing, (c) T: a titanium implant within the bony housing, (d) Z1_D: a Z1 implant placed with a buccal bone dehiscence (3 mm in height, identical width to implant body), and (e) T_D: a titanium implant placed with a buccal bone dehiscence. Two weeks of healing and 6 months of loading were applied on each hemi-mandible, respectively.

RESULTS:

The median level of the margo mucosae shifted more apically over time in all groups (borderline statistical significance in groups Z1_D: -0.52 mm and T_D: -1.26 mm). The median height of the peri-implant mucosa in groups Z1_D and T_D was greatest at 2 weeks and 6 months, but the linear change in the peri-implant mucosa was statistically significant only for group T_D over time (-1.45 mm). Z1 demonstrated a higher bone-to-implant contact compared to Z2 and T. Minimal change of radiographic marginal bone levels in all groups was observed (<1 mm).

CONCLUSION:

When buccal dehiscence was presented, titanium implants presented significant loss of peri-implant mucosal height compared to zirconia implants with a modified surface, due to greater apical shift of the margo mucosae. A modified zirconia surface enhanced osseointegration.

1.2.3 Osseointegration

J PROSTHET DENT. 1993 JUN;69(6):599-604.
DOI: 10.1016/0022-3913(93)90289-Z.

Interface histology of unloaded and early loaded partially stabilized zirconia endosseous implant in initial bone healing.

Akagawa Y, Ichikawa Y, Nikai H, Tsuru H.

ABSTRACT

Clinical and histologic evaluations of partially stabilized zirconia endosseous implants under unloaded and early loaded conditions in four beagle dogs were performed to examine the possibility of osseointegration of a newly developed one-stage zirconia implant during initial bone healing. No clear difference in clinical features was observed. Direct bone apposition to the implant was generally seen in both implants. However, loss of crestal bone height was quite evident around the loaded implants. These findings suggest that the initial unloaded condition is preferable to achieve osseointegration of one-stage zirconia implants.

J PROSTHET DENT. 1998 NOV;80(5):551-8.
DOI:10.1016/S0022-3913(98)70031-9.

Comparison between freestanding and tooth-connected partially stabilized zirconia implants after two years' function in monkeys: a clinical and histologic study.

Akagawa Y, Hosokawa R, Sato Y, Kamayama K.

ABSTRACT

STATEMENT OF PROBLEM:

Partially stabilized zirconia implants placed by a 1-stage procedure have been previously shown to obtain initial osseointegration under clinically unloaded condition. However, it is unknown whether freestanding and tooth-connected partially stabilized zirconia implants can maintain a long-term direct bone-implant interface.

PURPOSE:

This study examined the possibility of the long-term stability of osseointegration around partially stabilized zirconia implants with a 1-stage procedure with different loading designs.

MATERIAL AND METHODS:

Thirty-two partially stabilized zirconia implants were placed into the mandibles of 8 monkeys. Three months after implant placement, 3 types of superstructure were provided in each animal to obtain different concepts of support as (1) single freestanding implant support, (2) connected freestanding implant support, and (3) a combination of implant and tooth support. At 12 and 24 months after loading, clinical, histologic, and histomorphometric evaluations of peri-implant tissues were performed on 28 implants.

RESULTS:

No clear difference in clinical features was observed among the different types of support. Direct bone apposition to the implant was generally seen in all groups. Histometrically, bone contact ratio ranged between 66 % and 81 %, and bone area ratio varied between 49 % and 78 % at 24 months after loading. These values showed almost no difference among single freestanding, connected freestanding, and implant-tooth supports of partially stabilized zirconia implants.

CONCLUSION:

In a primate model, partially stabilized zirconia implants placed with a 1-stage procedure achieve long-term stability of osseointegration with the use of single freestanding, connected freestanding, and implant-tooth supports.

DEUTSCHER ÄRZTE-VERLAG KÖLN ZAHN-
ÄRZTL IMPL 2003;19(2).

Zirkonoxid-Implantate unter Belastung. Eine vergleichende histologische, tierexperimentelle Untersuchung.

Zirconia implants under occlusal load. A histological animal experiment.

Kohal RJ, Weng D, Bächle M, Klaus G.

ABSTRACT

The aim of this project was to investigate the histological behavior (osseointegration) of loaded ZrO₂-implants in an animal model. Five months after extractions of the upper anterior teeth twelve custom-made titanium implants (control group) and twelve custom-made zirconia (PSZ=partially stabilized zirconia) implants (test group) were inserted in the regions of teeth 12, 11, 21, and 22 in six monkeys (*Macaca fascicularis*). Six months after implant insertion abutment connection was performed (titanium- and zirconia-abutments) and impressions were taken for single crowns. Further three months later, the crowns were inserted. Five months after insertion of the crowns the implants with the surrounding hard and soft tissues were histologically prepared and evaluated under the light microscope regarding the mineralized bone-to-implant contact. All implants showed primary stability during insertion. No implant was lost during the investigational period. The mean mineralized bone-to-implant contact after five months of loading and 14 months of healing amounted to 67.4 % (SD: 17 %) for the zirconia implants. The osseointegration values in the different animals were in the range of 42.4 % to 87.7 %. There was no statistically significant difference to the titanium control group ($p = 0.29$).

Within the limits of this animal experiment it can be concluded that the utilized custom-made ZrO₂ -implants do osseointegrate to the same extent as custom-made titanium control implants.

J PERIODONTOL. 2004 SEP;75(9):1262-8.

Loaded custom-made zirconia and titanium implants show similar osseointegration: an animal experiment.

Kohal RJ, Weng D, Bächle M, Strub JR.

ABSTRACT

BACKGROUND:

Zirconia might be an alternative material to titanium for dental implant fabrication. The aim of the present study was to investigate the histological behavior (osseointegration) of loaded zirconia implants in an animal model and to compare it with the behavior of titanium implants.

METHODS:

Five months after extraction of the upper anterior teeth, 12 custom-made titanium implants (control group) and 12 custom-made zirconia implants (test group) were inserted in the extraction sites in six monkeys. Before insertion, the titanium implant surfaces were sandblasted with Al₂O₃ and subsequently acid-etched. The zirconia implants were only sandblasted. Six months following implant insertion, impressions were taken for the fabrication of single crowns. A further 3 months later, nonprecious metal crowns were inserted. Five months after insertion of the crowns, the implants with the surrounding hard and soft tissues were harvested, histologically prepared, and evaluated under the light microscope regarding the peri-implant soft tissue dimensions and mineralized bone-to-implant contact.

RESULTS:

No implant was lost during the investigational period. The mean height of the soft peri-implant tissue cuff was 5 mm around the titanium implants and 4.5 mm around the zirconia implants. No statistically significant differences were found in the extent of the different soft tissue compartments. The mean mineralized bone-to-implant contact after 9 months of healing and 5 months of loading amounted to 72.9 % (SD: 14 %) for the titanium implants and to 67.4 % (SD: 17 %) for the zirconia implants. There was no statistically significant difference between the different implant materials.

CONCLUSION:

Within the limits of this animal experiment, it can be concluded that the custom-made zirconia implants osseointegrated to the same extent as custom-made titanium control implants and show the same peri-implant soft tissue dimensions.

Bone tissue responses to surface-modified zirconia implants: A histomorphometric and removal torque study in the rabbit.

Sennerby L, Dasmah A, Larsson B, Iverhed M.

ABSTRACT

BACKGROUND:

Zirconia ceramics are biocompatible and have mechanical properties that make them suitable as materials for dental implants. Little is known about how surface modification influences the stability and bone tissue response to zirconia implants.

PURPOSE:

The objective of the investigation was to histologically and biomechanically evaluate the bone tissue response to zirconia implants with two different surface modifications in comparison with machined, nonmodified zirconia implants and oxidized titanium implants.

MATERIALS AND METHODS:

Threaded zirconia implants with a diameter of 3.75 mm with either a machined surface (Zr-Ctr) or one of two surface modifications (Zr-A and Zr-B) were manufactured. Oxidized titanium (Ti-Ox) implants 3.75 mm in diameter were also used. The implants were characterized with regard to surface topography using an interferometer. Twelve rabbits received 96 implants using a rotational scheme, two in each tibia and two in each femur. The implants in six rabbits were subjected to removal torque (RTQ) tests after a healing period of 6 weeks. The implants in the remaining six animals were removed en bloc for light microscopic analysis. Back-scatter scanning electron microscopic (BS-SEM) analyses were used to evaluate the state of the bone-implant interface at the modified zirconia implants after RTQ testing.

RESULTS:

The Ti-Ox and Zr-A implants showed the highest surface roughness, followed by the Zr-B implants and, finally, the Zr-Ctr implants. The nonmodified ZrO₂ implants showed statistically significant lower RTQs than all other implants. No significant differences in bone-implant contact or bone area filling the threads were observed. BS-SEM showed intact surface layers of the surface-modified implants

after RTQ testing and revealed fracture of the interface bone rather than a separation.

CONCLUSION:

The present study showed a strong bone tissue response to surface-modified zirconia implants after 6 weeks of healing in rabbit bone. The modified zirconia implants showed a resistance to torque forces similar to that of oxidized implants and a four- to fivefold increase compared with machined zirconia implants. The findings suggest that surface-modified zirconia implants can reach firm stability in bone.

DISSERTATION UNIVERSITY MUNICH 2006.

“Untersuchung des Einwachs- verhaltens von Zirkoniumdioxid- Implantaten in die Kieferknochenstruktur – Eine experimentelle Studie am Miniaturschwein“.

Biomechanical and histomor- phometric comparison between zirconia implants with varying surface textures and the titanium SLA implant in the maxilla of miniature pigs.

Gahlert M, Erhardt W, Gudehus H, Schmahl W,
Märtlbauer E, Matis U.

ABSTRACT

In comparison to titanium, ZrO₂ implants offer a variety of advantages for the use as oral implantologic material. As it is well accepted that implant success is dependent on surface roughness it has been proven that the SLA surface achieves a better bone anchorage than all other comparative tested surfaces.

Even though topological treatment of ZrO₂ implants is threatening the stiffness of the endosseous zirconium screws, it has been possible to develop a surface whose average surface roughness amounts to half the one of the SLA surface on titanium screws. The purpose of the present study was to evaluate the bone anchorage to three different screw shaped implants of various materials and surfaces in a well-established animal model on 13 minipigs comparing the modified sandblasted ZrO₂ with the machined ZrO₂ and the well documented titanium SLA implant.

After 4, 8 and 12 weeks of bone healing, removal torque testing was performed to evaluate the interfacial shear strength of each surface type. In addition 13 implants were evaluated histomorphometrically for the apposition of mineralised structures after 4 and 12 weeks of healing. Even though the titanium SLA surface revealed better results after all healing periods the results remain still

positive: The blasted ZrO₂ implants yielded a higher mean removal torque than the machined ZrO₂ implants especially in the 8 and 12 week animal groups without reaching statistical significance. These results are testified by a higher percentage of bone-to-implant contact for the blasted zirconium screws. It is established that the interlock between implant and in-growth bone for the SLA surface is loosened at the 12 weeks time period. This phenomenon could also be seen around the roughened ZrO₂ implants but not around those with machined surfaces and is due to active remodelling processes around an implant surface. If it should succeed to create an analogue surface structure for the ZrO₂ screws as it has been realised for titanium by developing the SLA surface, the interfacial biomechanical properties should be comparable.

Taking into account the outstanding aesthetic aspect this newly biomaterial could totally replace titanium in the cases of viewable dental rehabilitations.

Behavior of CAL72 osteoblast-like cells cultured on zirconia ceramics with different surface topographies.

Bächle M, Butz F, Hübner U, Bakalinis E, Kohal RJ.

ABSTRACT

OBJECTIVES:

Because of its inherent strength, biocompatibility, and tooth-like color, zirconia ceramics have the potential to become an alternative to titanium as dental implant material. This study aimed at investigating the osteoblastic response to yttrium-stabilized tetragonal zirconia polycrystal (Y-TZP) with different surface topographies.

METHODS:

CAL72 osteoblast-like cells were cultured on machined (TZP-m), airborne particle abraded (TZP-s), and airborne particle abraded and acid-etched Y-TZP (TZP-sa) surfaces. Polystyrene and airborne particle abraded with large grit and acid-etched (SLA) titanium served as a reference control. The surface topography was examined by scanning electron microscopy (SEM) and profilometry. At culture days 3, 6, and 12, cell proliferation, at day 12 cell morphology, and cell-covered surface area were determined.

RESULTS:

The surface roughness of Y-TZP was increased by airborne particle abrasion and additionally by acid etching. No statistically significant differences were found between average roughness (R(a)) and maximum peak-to-valley height (R(p-v)) values of airborne particle abraded and acid-etched Y-TZP and SLA titanium. Whereas the cell proliferation assay revealed statistically significant greater values at day 3 for surface-treated Y-TZP and polystyrene cultures as compared with machined Y-TZP, no differences between the Y-TZP groups, SLA titanium, and polystyrene were observed at culture days 6 and 12.

CONCLUSIONS:

Cell morphology and cell-covered surface area were not affected by the type of substrate. The results suggest that roughened Y-TZP is an appropriate substrate for the proliferation and spreading of osteoblastic cells.

Osseointegration of zirconia implants compared with titanium: an in vivo study.

Depprich R1, Zipprich H, Ommerborn M, Naujoks C, Wiesmann HP, Kiattavorncharoen S, Lauer HC, Meyer U, Kübler NR, Handschel J.

AUTHOR INFORMATION

1 Department of Operative and Preventive Dentistry and Endodontics, Heinrich-Heine-University, Düsseldorf, Germany. depprich@med.uni-duesseldorf.de

ABSTRACT

BACKGROUND:

Titanium and titanium alloys are widely used for fabrication of dental implants. Since the material composition and the surface topography of a biomaterial play a fundamental role in osseointegration, various chemical and physical surface modifications have been developed to improve osseous healing. Zirconia-based implants were introduced into dental implantology as an alternative to titanium implants. Zirconia seems to be a suitable implant material because of its tooth-like colour, its mechanical properties and its biocompatibility. As the osseointegration of zirconia implants has not been extensively investigated, the aim of this study was to compare the osseous healing of zirconia implants with titanium implants which have a roughened surface but otherwise similar implant geometries.

METHODS:

Forty-eight zirconia and titanium implants were introduced into the tibia of 12 minipigs. After 1, 4 or 12 weeks, animals were sacrificed and specimens containing the implants were examined in terms of histological and ultrastructural techniques.

RESULTS:

Histological results showed direct bone contact on the zirconia and titanium surfaces. Bone implant contact as measured by histomorphometry was slightly better on titanium than on zirconia surfaces. However, a statistically significant difference between the two groups was not observed.

CONCLUSION:

The results demonstrated that zirconia implants with modified surfaces result in an osseointegration which is comparable with that of titanium implants.

INT J ORAL MAXILLOFAC IMPLANTS. 2008
JUL-AUG;23(4):691-5.

The zirconia implant-bone interface: a preliminary histologic evaluation in rabbits.

Hoffmann O, Angelov N, Gallez F, Jung RE, Weber FE.

ABSTRACT

PURPOSE:

Zirconia ceramics, a biocompatible material with favorable mechanical properties, has been suggested for use in the manufacture of dental implants instead of the commonly used titanium. Not much data exist on the early healing response around zirconia dental implants. The aim of this study was to give a descriptive histologic assessment of the degree of early bone apposition around zirconia dental implants at 2 and 4 weeks after insertion compared to surface-modified titanium implants.

MATERIALS AND METHODS:

Four zirconia and 4 titanium implants were placed in New Zealand white male rabbits. One implant was inserted in the condyle of each distal femur. Specimens were harvested at 2 and 4 weeks and processed with light microscopic analysis. The area of bone-implant contact was evaluated histomorphometrically.

RESULTS:

A high degree of bone apposition could be observed on all implants at both time points. Differences in the percentage of implant surface covered with bone were noted between the 2 time points, with comparable results for the 2 materials.

CONCLUSION:

The results of this limited histologic study demonstrate a similar rate of bone apposition on zirconia and surface-modified titanium implant surfaces during early healing. To confirm these results, further studies need to be conducted, involving larger sample size at more time points.

INT J PROSTHODONT. 2008
JAN-FEB;21(1):27-36.

Osseointegration and clinical success of zirconia dental implants: a systematic review.

Wenz HJ, Bartsch J, Wolfart S, Kern M.

ABSTRACT

PURPOSE:

Various ceramic implant systems made of yttria-stabilized tetragonal zirconia polycrystals (Y-TZP) have become commercially available in recent years. A systematic search of the literature was performed to assess the clinical success of dental Y-TZP implants and whether the osseointegration of Y-TZP is comparable to that of titanium, the standard implant material.

MATERIALS AND METHODS:

The internet database MEDPILOT was searched cumulatively for the keywords zircon* and dent* and implant as well as for zircon* and osseointegration. The last search was conducted on January 31st, 2007. Subsequently, the reference lists of the relevant publications were searched. Furthermore, a letter was sent to the 5 identified manufacturers of zirconia dental implants to ask for peer-reviewed publications.

RESULTS:

Ninety-six articles were found by the search strategy. No controlled clinical studies in humans regarding clinical outcomes or osseointegration could be identified. Clinical data were restricted to case studies and case series. Only 7 animal studies fulfilled the inclusion criteria. Osseointegration was evaluated at 4 weeks to 24 months after placement in different animal models and sites and under different loading conditions. The mean bone-implant contact percentage was above 60% in almost all experimental groups. In studies that used titanium implants as a control, Y-TZP implants were comparable to or even better than titanium implants. Surface modifications may further improve initial bone healing and resistance to removal torque.

CONCLUSIONS:

Y-TZP implants may have the potential to become an alternative to titanium implants but cannot currently be recommended for routine clinical use, as no long-term clinical data are available.

CLIN ORAL IMPLANTS RES. 2009
APR;20(4):333-9.

Biomechanical and histological behavior of zirconia implants: an experiment in the rat.

Kohal RJ, Wolkewitz M, Hinze M, Han JS, Bächle M, Butz F.

ABSTRACT

OBJECTIVE:

This study aimed at evaluating the integration of zirconia implants in a rat femur model.

MATERIAL AND METHODS:

Zirconia implants with two distinct surface topographies were compared with titanium implants with similar topographies. Titanium and zirconia implants were placed into the femurs of 42 male Sprague-Dawley rats. Four groups of implants were utilized: machined zirconia implants, zirconia implants with a rough surface, machined titanium implants, and titanium implants with an electrochemically roughened surface. After a healing period of 28 days, the load-bearing capacity between the bone and the implant surface was evaluated by a push-in test. Additionally, after a healing period of 14 and 28 days, respectively, bone tissue specimens containing the implants were processed and histologically analyzed.

RESULTS:

The mean mineralized bone-to-implant contact showed the highest values after 14 and 28 days for the rough surfaces (titanium: 36%/45%; zirconia: 45%/59%). Also, the push-in test showed higher values for the textured implant surfaces, with no statistical significance between titanium (34 N) and zirconia (45.8 N).

CONCLUSIONS:

Within the limits of the animal investigation presented, it was concluded that all tested zirconia and titanium implant surfaces were biocompatible and osseointegrative. The presented surface modification of zirconia implants showed no difference regarding the histological and biomechanical results compared with an established electrochemically modified titanium implant surface.

CLIN ORAL IMPLANTS RES. 2009
AUG;20(8):844-50. DOI:
10.1111/J.1600-0501.2009.01727.X.

Surface-modified zirconia implants: tissue response in rabbits.

Rocchietta I, Fontana F, Addis A, Schupbach P, Simion M.

ABSTRACT

AIM:

To evaluate the bone tissue response to zirconia implants with three different surface modifications in comparison with the oxidized titanium surface with the goal to optimize osseointegration in terms of strength and speed.

MATERIALS AND METHODS:

A total of 18 rabbits with 143 implants were used. One hundred and twenty-three were threaded zirconia ceramic implants with three different surface topographies and 20 modified titanium oxide implants were controls. Each rabbit received eight implants and sacrificed after 3 weeks. The removal torque test (RTQ) and histology were performed.

RESULTS:

Sixteen out of 18 rabbits completed the study with a total of 110 implants. No statistical significance was observed between the chemical modification implants compared with the topographically modified zirconia implant in terms of interfacial shear strength proven by the RTQ applied. No statistical significance was also observed in the bone-to-implant contact between the zirconia implants and the control oxidized implants.

CONCLUSIONS:

The findings suggest that additional specific chemical modifications of the topographically modified zirconia implants do not seem to enhance the bone-to-implant contact and appear not to increase the interfacial shear strength.

Osseointegration of one-piece zirconia implants compared with a titanium implant of identical design: a histomorphometric study in the dog.

Koch FP, Weng D, Krämer S, Biesterfeld S, Jahn-Eimermacher A, Wagner W.

ABSTRACT

OBJECTIVE:

The aim of this study was to evaluate osseointegration of one-piece zirconia vs. titanium implants depending on their insertion depth by histomorphometry.

MATERIAL AND METHODS:

Four one-piece implants of identical geometry were inserted on each side of six mongrel dogs: (1) an uncoated zirconia implant, (2) a zirconia implant coated with a calcium-liberating titanium oxide coating, (3) a titanium implant and (4) an experimental implant made of a synthetic material (polyetheretherketone). In a split-mouth manner they were inserted in submerged and non-submerged gingival healing modes. After 4 months, dissected blocks were stained with toluidine blue in order to histologically assess the bone-to-implant contact (BIC) rates and the bone levels (BL) of the implants.

RESULTS:

All 48 implants were osseointegrated clinically and histologically. Histomorphometrically, BL in the crestal implant part did not differ significantly with regard to material type or healing modality. The submerged coated zirconia implants tended to offer the most stable crestal BL. The histometric results reflected the different healing modes by establishing different BL. The median BIC of the apical implant part of the zirconia and titanium group amounted to 59.2 % for uncoated zirconia, 58.3 % for coated zirconia, 26.8 % for the synthetic material and 41.2 % for titanium implants.

CONCLUSIONS:

Within the limits of this animal study, it is concluded that zirconia implants are capable of establishing close BIC rates similar to what is known from the osseointegration behaviour of titanium implants with the same surface modification and roughness.

Mechanical anchorage and peri-implant bone formation of surface-modified zirconia in minipigs.

Schliephake H¹, Hefti T, Schlottig F, Gédet P, Staedt H.

AUTHOR INFORMATION

¹Department of Oral and Maxillofacial Surgery, George-Augusta-University, Göttingen, Germany.

ABSTRACT

AIM:

To test the hypothesis that peri-implant bone formation and mechanical stability of surface-modified zirconia and titanium implants are equivalent.

MATERIALS AND METHODS:

Twelve minipigs received three types of implants on either side of the mandible 8 weeks after removal of all pre-molar teeth: (i) a zirconia implant with a sandblasted surface; (ii) a zirconia implants with a sandblasted and etched surface; and (iii) a titanium implant with a sandblasted and acid-etched surface that served as a control. Removal torque and peri-implant bone regeneration were evaluated in six animals each after 4 and 13 weeks.

RESULTS:

The titanium surface was significantly rougher than both tested zirconia surfaces. Mean bone to implant contact (BIC) did not differ significantly between the three implant types after 4 weeks but was significantly higher for titanium compared with both zirconia implants after 13 weeks ($p < 0.05$). Bone volume density (BVD) did not differ significantly at any interval. Removal torque was significantly higher for titanium compared with both zirconia surfaces after 4 and 13 weeks ($p < 0.001$). The sandblasted and etched zirconia surface showed a significantly higher removal torque after 4 weeks compared with sandblasted zirconia ($p < 0.05$); this difference levelled out after 13 weeks.

CONCLUSIONS:

It is concluded that all implants achieved osseointegration with similar degrees of BIC and BVD; however, titanium implants showed a higher resistance to removal torque, probably due to higher surface roughness.

Vergleich der Osseointegration dentaler Zirkonoxidimplantate mit verschiedenen Gewindeparametern und Oberflächentopographien.

Comparison of osseointegration of dental zirconoxid implants with different thread designs as well as surface topographies.

Mueller CK, Solcher P, Peisker A, Mtsariashvilli M,
Schlegel KA, Hildebrand G, Rost J, Liefeith K, Chen J,
Schultze-Mosgau S.

ABSTRACT

AIM:

Titanium represents the current standard material in dental implantology. Electrochemical corrosion, sensitization potential as well as esthetic comprise resulted in the testing of zirconiumoxid as an alternative material. Taking this into account it was the aim of the present study to evaluate the osseointegration of different zirconiumoxid implants.

MATERIALS AND METHODS:

A total of 6 different implant designs was evaluated in the study: (1) titanium, zylindric + thread design 1, Ra = 1,7 μm ; (2) zirconiumoxid, cylindric + thread design 1, Ra = 1,7 μm ; (3) zirconiumoxid, cylindric + thread design 2, Ra = 1,7 μm ; (4) zirconiumoxid, conical + thread design 2, Ra = 1,7 μm ; (5) zirconiumoxid, cylindric + thread design 1; Ra = 0,3 μm and (6) zirconiumoxid, cylindric + thread design 1, Ra = 3,0 μm . Six different implants were inserted in the frontal skull in each of 10 minipigs. Biopsies were harvested after 2 and 4 months respectively and subjected to microradiography.

RESULTS:

No significant differences between titanium and zirconoxid were found regarding the microradiographically detected bone-implant-contact. Irrespective of the thread design cylindric zirconoxid implants showed a higher BIC at the 2 month follow up than conic zirconiumdioxid implants. Among zirconoxid implants, those with an intermediate Ra value showed a significantly higher bone-

implant-contact as compared with low (0,3 μm) and high (3 μm) Ra implants 4 months ($p < 0,001$) post op.

CONCLUSION:

It is concluded that all implants achieved osseointegration Regarding the biologic process of osseointegration titanium and zirconoxid showed equal properties in the present study. Cylindric implant design and intermediate surface roughness seemed to enhance osseointegration. However, the mechanical properties of zirconoxid under functional loading should be evaluated in further studies.

Biomechanical evaluation of a microstructured zirconia implant by a removal torque comparison with a standard Ti-SLA implant.

Bormann KH, Gellrich NC, Kniha H, Dard M, Wieland M, Gahlert M.

ABSTRACT

OBJECTIVES:

The purpose of this study was to evaluate the biomechanical bone tissue response to novel microstructured zirconia implants in comparison to sandblasted and acid-etched (SLA) titanium implants through the analysis of removal torque (RTQ) measurements.

MATERIALS AND METHODS:

Ti-SLA implants with a sandblasted, large-grit and acid-etched surface were compared with zirconia implants with an acid-etched surface. All implants had the same shape, a diameter of 4.1 mm and a length of 10 mm. A total of 136 implants were placed in the maxillae of 17 miniature pigs. Six animals were sacrificed after both 4 and 8 weeks and five animals were sacrificed after 12 weeks, thus providing a total of 102 implants for RTQ testing (34 implants were reserved for future histological analysis). The RTQ analysis was successfully performed, using a mixed model regression with P-values calculated using the nonparametric Brunner-Langer method, on 100 of the 102 implants, two were excluded from the analysis.

RESULTS:

The adjusted mean RTQ values for Ti-SLA implants were 131 Ncm (95 % CI: 107-155) at 4 weeks, 128 Ncm (108-148) Ncm at 8 weeks, and 180 Ncm (153-207 Ncm) at 12 weeks of healing, whereas RTQ values for the zirconia implants were 110 Ncm (86-134), 97 Ncm (76-118) and 147 Ncm (121-174) at the corresponding time intervals. A comparison of the implant materials resulted in P-values of $P = 0.114$ at 4 weeks, $P = 0.034$ at 8 weeks and $P = 0.105$ at 12 weeks (significance set at $P < 0.05$).

CONCLUSIONS:

Within the limits of the present study, it could be confirmed that the biomechanical bone-tissue response of the investigated zirconia implants is non-inferior to that of the well-documented, roughened titanium surface, at each time point, within the set tolerance. There were no statistically significant differences between the two materials after a healing period of 4 and 12 weeks. The RTQ values of both implant types increased significantly from the 8-week to the 12-week time point.

In vivo performance of zirconia and titanium implants: a histomorphometric study in mini pig maxillae.

Gahlert M, Roehling S, Sprecher CM, Kniha H, Milz S, Bormann K.

ABSTRACT

OBJECTIVES:

To compare the bone tissue response to surface-modified zirconia (ZrO₂) and titanium implants.

METHODS:

Cylindrical low-pressure injection moulded zirconia (ZrO₂) implants were produced with an acid-etched surface. Titanium implants with identical shape, sandblasted and acid-etched surface (SLA) served as controls. Eighteen adult miniature pigs received both implant types in the maxilla 6 months after extraction of the canines and incisors. The animals were euthanized after 4, 8 and 12 weeks and 16 zirconia and 18 titanium implants with the surrounding tissue were retrieved, embedded in methylmethacrylate and stained with Giemsa-Eosin. The stained sections were digitized and histomorphometrically analysed with regard to peri-implant bone density (bone volume/total volume) and bone-implant contact (BIC) ratio. Statistical analysis was performed using Mann-Whitney' U-test.

RESULTS:

Histomorphometrical analysis showed direct osseous integration for both materials. ZrO₂ implants revealed mean peri-implant bone density values of 60.4 % (SD ± 9.9) at 4 weeks, 65.4 % (SD ± 13.8) at 8 weeks, and 63.3 % (SD ± 21.5) at 12 weeks after implantation, whereas Ti-SLA implants demonstrated mean values of 61.1 % (SD ± 6.2), 63.6 % (SD ± 6.8) and 68.2 % (SD ± 5.8) at corresponding time intervals. Concerning the BIC ratio, the mean values for ZrO₂ ranged between 67.1 % (SD ± 21.1) and 70 % (SD ± 14.5) and for Ti-SLA between 64.7 % (SD ± 9.4) and 83.7 % (SD ± 10.3). For the two parameters investigated, no significant differences between both types of implants could be detected at any time point.

CONCLUSION:

The results indicate that there was no difference in osseointegration between ZrO₂ implants and Ti-SLA controls regarding peri-implant bone density and BIC ratio.

INT J ORAL MAXILLOFAC IMPLANTS. 2012
MAR-APR;27(2):352-8.

Osseointegration of zirconia implants with different surface characteristics: an evaluation in rabbits.

Hoffmann O, Angelov N, Zafiroopoulos GG, Andreana S.

ABSTRACT

PURPOSE:

Zirconia ceramics are a viable alternative to titanium for use as dental implants. However, the smooth surface of zirconia means that longer healing periods are needed to accomplish osseointegration compared to roughened titanium surfaces. Surface modifications can be used to increase the roughness of zirconia. The aim of this study was to assess histologically and compare the degree of early bone apposition around zirconia dental implants with sandblasted, sintered, or laser-modified surfaces to that seen around surface-modified titanium implants. Removal torque was also measured and compared.

MATERIALS AND METHODS:

Ninety-six implants--24 each of four types (sintered zirconia, laser-modified zirconia, sandblasted zirconia, and acid-etched titanium)--were placed in 48 New Zealand White female rabbits. One implant was inserted in each distal femur. Half of the specimens were harvested at 6 or 12 weeks and processed for light microscopic analysis; the area of bone-to-implant contact was measured morphometrically. The other half were evaluated for removal torque at 6 and 12 weeks.

RESULTS:

No statistically significant differences existed in bone apposition between the different surfaces at either time point. Differences in removal torque were significantly different between titanium and sandblasted zirconia and between sintered zirconia and sandblasted zirconia, with the first mentioned demonstrating a higher torque value at 6 weeks. At 12 weeks, the only significant difference in removal torque was between titanium and sandblasted zirconia, with titanium demonstrating the higher value.

CONCLUSION:

Comparable rates of bone apposition in the zirconia and titanium implant surfaces at 6 and 12 weeks of healing were observed. Removal torque values were similar for all implants with a roughened surface.

INT J ORAL MAXILLOFAC SURG. 2012
MAY;41(5):638-45.

A comparison of biocompatibility and osseointegration of ceramic and titanium implants: an in vivo and in vitro study.

Möller B, Terheyden H, Açil Y, Purcz NM, Hertrampf K, Tabakov A, Behrens E, Wiltfang J.

ABSTRACT

This study compared the biocompatibility in vitro and the osseointegration in vivo of zirconium and titanium implants regarding implant surfaces and the bone-implant contacts. The different implant surfaces and the biocompatibility of zirconium versus titanium implants were determined by vitality and cytotoxic tests in vitro. The contact of the osteoblasts to the implant surface was determined by scanning electron microscopy (SEM). The in vivo study for osseointegration was performed in domestic pigs over 4 and 12 weeks. In each animal, 4 zirconium and 4 titanium implants (WhiteSky, BlueSky, Bredent, Germany) were inserted in the os frontale and analysed by histomorphometry. Cytotoxicity and SEM showed good biocompatibility in relation to the investigated implant materials. Histological results showed direct bone-implant contact of the implant surfaces. The zirconium implants showed a slight delay in osseointegration in terms of bone-implant contact as measured by histomorphometry (after 4 weeks, zirconium ($59.3 \pm 4.6\%$) versus titanium ($64.1 \pm 3.9\%$); after 12 weeks, zirconium ($67.1 \pm 2.3\%$) versus titanium ($73.6 \pm 3.2\%$). A statistically significant difference between the two groups was not observed. The results indicated similar biocompatibility and osseointegration for zirconium compared to titanium implants.

DENT MATER. 2013 JUL;29(7):763-76.

Osteoblast and bone tissue response to surface modified zirconia and titanium implant materials.

Kohal RJ, Bächle M, Att W, Chaar S, Altmann B, Renz A, Butz F.

ABSTRACT

OBJECTIVE:

This study examined the in vitro and in vivo response of osteoblasts to a novel, acid-etched and sandblasted zirconia surface.

METHODS:

Osteoblastic hFOB 1.19 cells were cultured either on electrochemically anodized titanium (TiUnite®), machined titanium (Ti-m), sandblasted and acid-etched zirconia (TZP-proc), and machined zirconia (TZP-A-m). The surface topography of the various substrates was analyzed by 3D laserscan measurements and scanning electron microscopy. At culture days 1, 3, 7, 14, 21, and 28, cell proliferation was determined. Gene expression was analyzed using RT-PCR. Histologic analysis and biomechanical testing was performed on miniature implants placed in the rat femur.

RESULTS:

During the first 7 days, a retarded cell proliferation was observed on the TiUnite® surface. After 28 days of cultivation, cell proliferation reached similar levels on all surfaces. An up-regulation of bone and extracellular matrix specific genes could be seen for TZP-proc at day 21. The mean bone-implant contact rate after a healing period of 14 and 28 days, respectively, was higher for TiUnite® than for TZP-proc. At 28 day, the biomechanical test showed significantly higher values for TiUnite® than for all other surfaces.

SIGNIFICANCE:

The novel, rough zirconia surface was accepted by hFOB 1.19 cells and integrates into rat bone tissue. However, osseointegration seemed to proceed more slowly and to a lesser extent compared to a moderately roughened titanium surface.

ORAL SURG ORAL MED ORAL PATHOL
ORAL RADIOLOG. 2013 JUL;116(1):E1-8.

Analysis of the influence of the macro- and microstructure of dental zirconium implants on osseointegration: a minipig study.

Mueller CK, Solcher P, Peisker A, Mtsariashvili M, Schlegel KA, Hildebrand G, Rost J, Liefeth K, Chen J, Schultze-Mosgau S.

ABSTRACT

OBJECTIVES:

It was the aim of this study to analyze the influence of implant design and surface topography on the osseointegration of dental zirconium implants.

STUDY DESIGN:

Six different implant designs were tested in the study. Nine or 10 test implants were inserted in the frontal skull in each of 10 miniature pigs. Biopsies were harvested after 2 and 4 months and subjected to microradiography.

RESULTS:

No significant differences between titanium and zirconium were found regarding the microradiographically detected bone-implant contact (BIC). Cylindric zirconium implants showed a higher BIC at the 2-month follow-up than conic zirconium implants. Among zirconium implants, those with an intermediate Ra value showed a significantly higher BIC compared with low and high Ra implants 4 months after surgery.

CONCLUSIONS:

Regarding osseointegration, titanium and zirconium showed equal properties. Cylindric implant design and intermediate surface roughness seemed to enhance osseointegration.

Microstructured zirconia surfaces modulate osteogenic marker genes in human primary osteoblasts.

Bergemann C, Duske K, Nebe JB, Schöne A, Bulnheim U, Seitz H, Fischer J.

ABSTRACT

In dentistry, zirconia has been used since the early 1990s for endodontic posts, more recently for implant abutments and frameworks for fixed dental prostheses. Zirconia is biocompatible and mechanically strong enough to serve as implant material for oral implants. Although several zirconia implant systems are available, currently the scientific and clinical data for zirconia implants are not sufficient to recommend them for routine clinical use. Here the influence of microstructured yttria-stabilized zirconia (YZ) on human primary osteoblast (HOB) behavior was determined. YZ surfaces were treated by sandblasting (YZ-S), acid etching (YZ-SE) and additionally heat treatment (YZ-SEH). Morphological changes of HOB were determined by scanning electron microscopy. Actin cytoskeleton was investigated by laser scanning microscopy and analyzed by novel actin quantification software. Differentiation of HOB was determined by real time RT-PCR. Improved mechanical interlocking of primary HOB into the porous microstructure of the acid etched and additionally heat treated YZ-surfaces correlates with drastically increased osteocalcin (OCN) gene expression. In particular, OCN was considerably elevated in primary HOB after 3 days on YZ-SE (13-fold) as well as YZ-SEH (12-fold) surfaces. Shorter actin filaments without any favored orientation on YZ-SE and YZ-SEH surfaces are associated with higher roughness (Ra) values. Topographically modified yttria-stabilized zirconia is a likely material for dental implants with cell stimulating properties achieving or actually exceeding those of titanium.

Osseointegration of Zirconia in the Presence of Multinucleated Giant Cells.

Chappuis V, Cavusoglu Y, Gruber R, Kuchler U, Buser D, Bosshardt DD.

ABSTRACT

BACKGROUND:

Current strategies to reduce medical device-associated infections propose zirconia as a potential implant material which may limit bacterial adhesion. Because multinucleated giant cells (MNGCs) have been detected on these implant surfaces, concerns have been raised regarding tissue integration.

PURPOSE:

The present study examined the presence of MNGCs and their subsequent effect upon tissue integration. Surface-modified implants made of yttria-stabilized (TZP) and alumina-toughened zirconia (ATZ) were compared with commercially pure titanium (Ti).

MATERIALS AND METHODS:

Seven miniature pigs received three implants on either side of the maxilla. After healing periods of 4 and 8 weeks, the tissue response at the implant surfaces was characterized according to three specific parameters: bone-to-implant contact (BIC), MNGC-to-implant contact (MIC), and the peri-implant bone density (BD).

RESULTS:

Despite being present on all tested implant surfaces, MNGCs were not associated with an inflammatory cell infiltrate or with fibrous encapsulation. MNGCs were less numerous on the Ti implants (range: 3.9-5.2 %) compared with the ceramic implants (range: 17.6-30.3 %, $p < .0001$). Even though the values of newly formed bone and pristine bone in direct contact with the implant surfaces were high at 4 weeks (tBIC: Ti=82.3 %, TZP=64.3 %, ATZ=70 %), a negative correlation was observed between the presence of MNGCs and newly formed bone at the implant surface ($p < .001$). Interestingly, the newly formed peri-implant bone density, defined as the percentage of new bone area inside the screw threads (nBD), was not diminished by the presence of MNGCs.

CONCLUSIONS:

Differences in the presence of MNGCs and the BIC parameters between Ti and the ceramic implants appear to be a local cellular phenomenon which is restricted to the implant-bone marrow interface and do not affect the peri-implant bone formation. Factors triggering MNGC differentiation and their persistence in response to biomaterial surface need to be investigated in future studies.

IMPLANT DENT. 2016 APR;25(2):193-8. DOI: 10.1097/ID.0000000000000365.

Success Rate of Two-Piece Zirconia Implants: A Retrospective Statistical Analysis.

Jank S, Hochgatterer G.

ABSTRACT

PURPOSE:

About 10 years ago, one-piece zirconia implants were introduced to dentistry. The aim of the study was to evaluate the clinical success of two-piece zirconia implants regarding osseointegration using the manufacturers' warranty data.

MATERIALS AND METHODS:

Over a period of 4 years (2010-2014), the data of warranty replacements of 15,255 sold Zeramex implants were evaluated retrospectively and blinded.

RESULTS:

Three hundred forty-seven (2.2 %) nonosseointegrated implants were sent back. Zeramex T showed an average success rate of 96.7 %, whereas Zeralock implants exhibited an average success rate of 98.5 %. Furthermore, Zeramex Plus implants exhibit an average success rate of 99.4 % within the investigated period. Assuming, that 2 % of the failed implants were unreturned, the above-mentioned values show no changes. Assuming 5 % (10 %) of unreturned nonosseointegrated implants, the average success rate of Zeramex T decreases from 96.7 % to 96.6 % (96.4 %) and of Zeralock from 98.5 % to 98.4 % (98.4 %), respectively. The success rate of Zeramex Plus implants remains unchanged at 99.4 %.

CONCLUSION:

The results of this study imply that two-piece zirconia implants show competitive success rates, improved from >96.7 % to >98.5 % over three product generations.

J BIOMED MATER RES B APPL BIOMATER. 2016 NOV;104(8):1622-1631. DOI: 10.1002/JBM.B.33512. EPUB 2015 AUG 31.

Peri-implant bone response to retrieved human zirconia oral implants after a 4-year loading period: A histologic and histomorphometric evaluation of 22 cases.

Kohal RJ, Schwindling FS, Bächle M, Spies BC.

ABSTRACT

AIM:

To evaluate the bone tissue response to surface modified zirconia oral implants retrieved from humans.

MATERIALS AND METHODS:

Twenty-nine one-piece zirconia implants showed increased marginal bone loss and did not response to the applied peri-implantitis therapy. After their removal using a trephine bur, 22 of the implant-bone biopsies were suitable for an evaluation and immediately immersed in formalin for two weeks. Subsequent, the retrieved specimens were histologically prepared and the regions still showing osseointegration computer-assisted analyzed regarding the bone-to-implant contact (BIC) and bone density using a transmitted-light microscope.

RESULTS:

The removed implants were in situ for a mean time period of 47.7 months. After their removal, compact bone could be depicted at the apical regions. The remaining bone that was attached to the implants contained a regular lamellar structure with osteons and osteocytes. The BIC ranged from 58.1 % to 93.7 % (mean: 76.5 %) and the bone area/density within the implant threads ranged from 57 % to 97.2 % (mean: 84.8 %).

CONCLUSIONS:

The porous zirconia implants showed a sufficient BIC in the areas where bone still was attached. Although the implants had to be removed due to increased bone loss, it seems that the presented zirconia implant surface per se elicited appropriate osseointegration.

Effect of Zirconia Dental Implant Surfaces on Bone Integration: A Systematic Review and Meta-Analysis.

Hafezeqoran A, Koodaryan R.

ABSTRACT

BACKGROUND:

The information available about osseointegration and the bone to implant interaction of zirconia implants with various surface modifications is still far from sufficient.

OBJECTIVE:

The purpose of this systematic review and meta-analysis was to evaluate and compare zirconia dental implants with different surface topographies, with a focus on bone to implant contact and removal torque.

METHODS:

The systematic review of the extracted publications was performed to compare the bone to implant contact (BIC) with removal torque (RT) values of titanium dental implants and machined and surfaced modified zirconia implants.

RESULTS:

A total of fifteen articles on BIC and RT values were included in the quantitative analysis. No significant difference in the BIC values was observed between titanium and machined zirconia implants ($p = 0.373$; 95 % CI: -0.166 to 0.443). However, a significantly better BIC values were observed for acid etched zirconia implants compared with those of titanium implants ($p = 0.032$; 95 % CI: 0.068 to 1.461). Unmodified zirconia implants showed favorable BIC values compared to modified-surface zirconia implants ($p = 0.021$; 95 % CI: -0.973 to -0.080).

CONCLUSION:

Acid etched zirconia implants may serve as a possible substitute for successful osseointegration.

Bone tissue response to experimental zirconia implants.

Mihatovic I, Golubovic V, Becker J, Schwarz F.

ABSTRACT

OBJECTIVES:

This study seeks to assess the bone tissue response at experimental zirconia implants in comparison with titanium implants by means of descriptive histology and histomorphometry in a dog model.

MATERIALS AND METHODS:

Experimental zirconia implants with three different surface roughnesses ($Z1 < Z2 < Z3$) and conventional sand-blasted large grit and acid-etched titanium implants were inserted bilaterally in the lower jaws of nine beagle dogs. Tissue biopsies were obtained after 3 and 14 days and 10 weeks of transmucosal healing. The tissue response was investigated by assessing new, old, and total bone-to-implant contact (nBIC, oBIC, and tBIC).

RESULTS:

After 3 days, histological specimens of all groups showed an intimate contact between the implant threads and pristine bone (tBIC: Ti 42.3 % > Z2 30.1 % > Z3 28.9 % > Z1 25.1 %, $p > 0.05$, unpaired t test, respectively). A provisional matrix was evident at all implant surfaces. At 14 days, percentages of BIC increased in all groups (tBIC: Ti 62.1 % > Z3 69.2 % < Z2 44.4 % > Z1 42.3 %; nBIC: Z3 58.9 % > Ti 52.2 % > Z2 35.1 % > Z1 32.5 %). Two implants, one of group Z1 and one of group Z2, were lost. At 10 weeks, 13 of 18 zirconia implants were lost, equally distributed between all three surface modifications. The remaining implants revealed increased BIC values (tBIC: Z3 69.5 % > Ti 58.5 % > Z1 49.7 % > Z2 37.1 %; nBIC: Z3 57.2 % > Ti 46.5 % > Z1 32.3 % > Z2 29.3 %). Histomorphometrical analysis showed comparable mean BIC values in all groups at all healing periods without showing statistical differences ($p > 0.05$, unpaired t test, respectively).

CONCLUSION:

The bone tissue response throughout the healing periods was characterized by a constant bone remodeling accompanied by resorption of old bone in favor of new bone formation at both titanium and zirconia implants. Surface roughness had a positive effect on BIC, although not showing statistical significance. Due to the poor survival rate, the experimental zirconia implants investigated may not be suitable for clinical use.

Thirty Years of Translational Research in Zirconia Dental Implants: A Systematic Review of the Literature.

Siddiqi A, Khan AS, Zafar S.

ABSTRACT

Thirty years of translational research in zirconia (Zr) ceramics has led to significant improvements in the biomedical field, especially in dental implantology. Oral implants made of yttria-tetragonal zirconia polycrystals (Y-TZP) because of their excellent mechanical properties, good biocompatibility, and esthetically acceptable color have emerged as an attractive metal-free alternative to titanium (Ti) implants. The aim of the review was to highlight the translational research in Zr dental implants that has been conducted over the past 3 decades using preclinical animal models. A computer search of electronic databases, primarily PubMed, was performed with the following key words: "zirconia ceramics AND animal trials," "ceramic implants AND animal trials," "zirconia AND animal trials," "zirconia AND in vivo animal trials," without any language restriction. However, the search was limited to animal trials discussing percentage bone-implant contact (% BIC) around zirconia implants/discs. This search resulted in 132 articles (reviews, in vivo studies, and animal studies) of potential interest. We restricted our search terms to "zirconia/ceramic," "bone-implant-contact," and "animal trials" and found 29 relevant publications, which were then selected for full-text reading. Reasons for exclusion included the article's not being an animal study, being a review article, and not discussing % BIC around Zr implants/discs. Most of the studies investigated BIC around Zr in rabbits (30 %), pigs (approximately 20 %), dogs, sheep, and rats. This review of the literature shows that preclinical animal models can be successfully used to investigate osseointegration around Zr ceramics. Results of the reviewed studies demonstrated excellent % BIC around Zr implants. It should be noted that most of the studies investigated % BIC/removal torque under nonloading conditions, and results would have been somewhat different in functional loading situations because of inherent limitations of Zr ceramics. Further trials are needed to evaluate the performance of Zr ceramics in clinical conditions using implants designed and manufactured via novel techniques that enhance their biomechanical properties.

Bone response to functionally loaded, two-piece zirconia implants: A preclinical histometric study.

Janner SFM, Gahlert M, Bosshardt DD, Roehling S, Milz S, Higginbottom F, Buser D, Cochran DL.

ABSTRACT

OBJECTIVE:

To evaluate the bone response to a two-piece zirconia implant in comparison with a control titanium implant in the canine mandible 4 and 16 weeks after restoration.

MATERIAL AND METHODS:

Zirconia and titanium implants were alternately placed bilaterally in healed mandibular molar and premolar sites of five canines. Full-ceramic single-tooth restorations were cemented after 6 weeks of transmucosal healing, allowing for full functional loading of the implants. Histologic and histometric analyses were performed on orofacial and mesiodistal undecalcified sections of the specimens obtained upon sacrifice after 4 and 16 weeks of functional loading. Bone-to-implant contact (BIC), multinucleated giant cells-to-implant contact (MIC), crestal bone level, and peri-implant bone density were histometrically assessed.

RESULTS:

All 60 implants and 60 restorations were still in function after 4 and 16 weeks of loading in both test and control groups. No implant loss, no implant or abutment fracture, and no chipping of the restorations could be detected. Histometric analysis showed no statistically significant differences between zirconia and titanium implants in BIC, crestal bone level, and peri-implant bone density at both time points. Between 4 and 16 weeks, the crestal bone level around zirconia implants showed a small but statistically significant increase in its distance from the implant shoulder. MIC was very low on both implant types and both time points and decreased statistically significantly overtime.

CONCLUSION:

The present two-piece zirconia implant showed a similar bone integration compared to the titanium implant with similar surface morphology after 4 and 16 weeks of loading.

INT J ORAL MAXILLOFAC IMPLANTS. 2018 JANUARY/ FEBRUARY;33(1):217-222.

Peri-implant Crestal Bone Changes Around Zirconia Implants in Periodontally Healthy and Compromised Patients.

Kniha K, Milz S, Kniha H, Ayoub N, Hölzle F, Modabber A.

ABSTRACT

PURPOSE:

No consensus regarding the efficacy of zirconia implants in maintaining peri-implant hard and soft tissue health has yet been obtained. The aim of this retrospective follow-up study was to gain knowledge about peri-implant bone behavior and about implant survival and success after treatment with zirconia dental implants in patients with normal and compromised soft and hard tissue conditions.

MATERIALS AND METHODS:

This follow-up study involved 86 patients with 123 zirconia implants (Straumann PURE Ceramic Implant) that were radiographically investigated directly after implant placement (day 0), 3 months after placement, and 1 year after the definitive implant crown placement. The clinical assessment was done at the 1-year postloading appointment and also included the modified Plaque Index, modified Sulcus Bleeding Index, and sulcus pocket depths. Eighteen patients with periodontally compromised conditions were compared to 68 patients with healthy periodontal conditions.

RESULTS:

The survival rate was 100 % and success rate was 94.5 %, with no differences between the two groups. The alveolar crest around the ceramic implants showed no significant difference between day 0 and 1 year postloading for both groups ($P > .05$). There was also no significant difference at 1 year postloading between the groups in the distance from the implant shoulder to the peri-implant bone crest ($P = .67$) or in pocket depth ($P = .07$).

CONCLUSION:

No significant peri-implant bone loss was observed in the first year. The survival and success rates showed no differences between the periodontally healthy and periodontally compromised groups; however, only a limited number of patients with periodontally compromised conditions were included in this study.

DENT MATER. 2018 FEB;34(2):171-182.

Osseointegration of zirconia dental implants in animal investigations: A systematic review and meta-analysis.

Pieralli S, Kohal RJ, Lopez Hernandez E, Doerken S, Spies BC.

ABSTRACT

OBJECTIVE:

To determine the osseointegration rate of zirconium dioxide (ZrO_2) dental implants in preclinical investigations.

DATA:

Data on the osseointegration rate was extracted considering the bone to implant contact (BIC), removal torque analysis (RTQ) and push-in tests. Meta analyses were conducted using multilevel multivariable mixed-effects linear regression models. The Šidák method was used in case of multiple testing.

SOURCES:

An electronic screening of the literature (MEDLINE/Pubmed, Cochrane Library and Embase) and a supplementary manual search were performed. Animal investigations with a minimum sample size of 3 units evaluating implants made of zirconia (ZrO_2) or its composites ($ZrO_2 > 50\text{vol. } \%$) were included.

STUDY SELECTION:

The search provided 4577 articles, and finally 54 investigations were included and analyzed. Fifty-two studies included implants made from zirconia, 4 zirconia composite implants and 37 titanium implants. In total, 3435 implants were installed in 954 animals.

CONCLUSIONS:

No significant influence of the evaluated bulk materials on the outcomes of interest could be detected. When comparing different animal models, significant differences for the evaluated variables could be found. These results might be of interest for the design of further animal investigations.

INT J ORAL MAXILLOFAC IMPLANTS. 2019
MARCH/APRIL;34(2):357-365.

Ligature-Induced Peri-implant Bone Loss Around Loaded Zirconia and Titanium Implants.

Roehling S, Gahlert M, Janner S, Meng B, Woelfler H,
Cochran DL.

ABSTRACT

PURPOSE:

To radiographically investigate ligature-induced peri-implant bone loss around loaded titanium (Ti-SLA) and zirconia (ZrO₂-ZLA) implants using a canine model.

MATERIALS AND METHODS:

Forty sandblasted and acid-etched titanium and zirconia implants were alternately placed in the mandibles of five canines (20 Ti-SLA, 20 ZrO₂-ZLA). Implants were restored after 6 weeks of unloaded healing. After 4 weeks of functional loading, oral hygiene procedures were stopped and experimental peri-implant bone loss was initiated by placing cotton ligatures. After 8 weeks of active progression, ligatures were removed and plaque was allowed to accumulate for another 16 weeks of spontaneous progression (without ligatures). Standardized radiographs were taken at implant placement, at functional loading, and every 2 weeks during active and spontaneous progression of bone loss.

RESULTS:

Before ligature placement, all implants were successfully osseointegrated and no clinical or radiographic signs of peri-implant infections were detectable. Two weeks after ligature removal, one titanium implant was lost; however, no zirconia implant failures were observed during the study. Radiographically, zirconia implants revealed statistically significantly less crestal peri-implant bone loss compared to titanium implants at the end of the active progression period (Ti-SLA: 3.92 mm; ZrO₂-ZLA: 2.65 mm; $P < .01$); however, no significant differences occurred after the spontaneous progression period ($P = .6$). Combining the active and spontaneous progression periods together, zirconia implants demonstrated significantly reduced peri-implant bone loss compared to titanium implants (Ti-SLA: 3.76 mm; ZrO₂-ZLA: 2.42 mm; $P < .01$).

CONCLUSION:

These results demonstrate a significantly reduced ligature-induced inflammation and bone loss for ZrO₂-ZLA implants compared to Ti-SLA implants in the canine model.

1.2.4 Clinically case Series and Studies

INT J ORAL MAXILLOFAC IMPLANTS. 2007 MAY-JUN;22(3):430-5.

One-year follow-up of first consecutive 100 zirconia dental implants in humans: a comparison of 2 different rough surfaces.

Oliva J, Oliva X, Oliva JD.

ABSTRACT

PURPOSE:

The aim of this study was to evaluate the success rate of 100 consecutive zirconia dental implants with 2 different rough surfaces after 1 year of follow-up.

MATERIALS AND METHODS:

One-piece zirconia dental implants (CeraRoot, Barcelona, Spain) with 1 of 2 different roughened surfaces were designed and manufactured for this study. Five different implant designs were manufactured. Standard or flapless surgical procedures were used for implant placement. Simultaneous bone augmentation or sinus elevation were performed in the cases where bone height or width was insufficient. Implants in the anterior region (canine to canine) were immediately restored with provisional prostheses. Implants placed using less than 35 N torque were splinted with composite resin using an etched and bonded approach to the neighboring teeth or implants to minimize implant mobility and failure. Definitive all-ceramic restorations were placed 4 months after implant placement (8 months for implants where bone augmentation or sinus elevation was performed).

RESULTS:

The study included 36 patients with a mean age of 50 years. The overall implant success rate after 1 year of follow-up was 98 % in both the coated and noncoated groups.

CONCLUSIONS:

From the preliminary results of this investigation, it can be concluded that zirconia dental implants with roughened surfaces might be a viable alternative for tooth replacement. Further follow-up is needed to evaluate the long-term success rates of the implant surfaces studied.

MINERVA STOMATOL. 2010 JUL-AUG;59(7-8):381-92.

Edentulous jaws rehabilitation with yttrium-stabilized zirconium dioxide implants: two years follow-up experience.

Borgonovo AE, Arnaboldi O, Censi R, Dolci M, Santoro G.

ABSTRACT

AIM:

The aim of this study was to present authors' two-year clinical experience with Yttrium-stabilized zirconium dioxide implants placed in native bone or regenerated bone.

METHODS:

Yttrium-stabilized zirconium dioxide implants made of brezirkon (whiteSKY, Bredent medical, Senden, Germany) were used for the treatment of edentulous ridge rehabilitation in the Dental Clinic of the University of Milan (Head of the Department, Prof. F. Santoro). Zirconium dioxide is a highly resistant ceramic material obtained by cleaning zirconium dioxide and zirconium silicate. The implant used in the clinical study featured a conical one piece implant with double cylindrical thread with a sandblasted rough surface. The prosthetic section was smooth.

RESULTS:

Forty-six implants have been inserted in 18 patients from January 2007 to January 2009, the follow-up period was comprised between 6 and 24 months. The overall success rate was 89 %; the success rate in native bone was 97 % and 74 % in augmented bone. It can be stated that the success rate is comparable to titanium fixtures.

CONCLUSION:

It would be logical to use a ceramic material for the esthetic regions; zirconium dioxide is particularly suitable since it features tissue friendliness and resistance comparable to titanium. The good mechanical properties, possibility of easy fabrication of the prosthetic restoration and the good integration into the tissue and the esthetics provide perfect preconditions for yttrium-stabilized zirconium dioxide to become the most commonly used material in implant dentistry.

EUR J ORAL IMPLANTOL. 2010
SUMER;3(2):111-20.

Immediate occlusal versus non-occlusal loading of single zirconia implants. A multicentre pragmatic randomised clinical trial.

Cannizzaro G, Torchio C, Felice P, Leone M, Esposito M.

ABSTRACT

PURPOSE:

To evaluate whether immediate non-occlusal loading of single zirconia implants could reduce early failures when compared to immediate occlusal loading.

MATERIALS AND METHODS:

Forty partially edentulous patients who received one single zirconia implant (Z-Systems) at least 10 mm long and 3.25 mm wide inserted with a torque of at least 35 Ncm were randomised to immediate occlusal or non-occlusal loading groups. All patients received provisional acrylic crowns the same day of implant placement. Provisional crowns were replaced after 4 to 5 months by definitive full ceramic crowns. Outcome measures were implant success, any complications and peri-implant marginal bone levels.

RESULTS:

One year after loading, no patients had dropped out. Five implants (12.5 %) failed early: three occlusally loaded and two non-occlusally loaded. Three complications occurred, all after delivery of the definitive crowns: one crown fractured (occlusal loading), one had to be remade after debridement because of hyperplastic tissues (occlusal loading), and one crown decemented (nonocclusal loading). These differences were not statistically significant. Both groups gradually lost periimplant bone in a highly statistically significant way. One year after loading, patients subjected to non-occlusal loading lost an average of 0.7 mm of peri-implant bone versus 0.9 mm in the occlusal group. This difference in bone loss between groups was not statistically significant. There was an association between immediate post-extractive implants and implant failures ($P=0.01$). Four of the 10 immediate post-extractive implants (40 %) failed versus one out of 30 delayed implants (3 %).

CONCLUSIONS:

The results of this study do not provide a conclusive answer to whether immediate non-occlusal loading may decrease implant failures. Immediately loaded zirconia implants placed in post-extractive sites had high failure rates.

INT J ORAL MAXILLOFAC IMPLANTS. 2010
MAR-APR;25(2):336-44.

Five-year success rate of 831 consecutively placed Zirconia dental implants in humans: a comparison of three different rough surfaces.

Oliva J, Oliva X, Oliva JD.

ABSTRACT

PURPOSE:

The aim of this study was to evaluate the 5-year success rate of zirconia (ZrO_2) implants with three different kinds of surfaces.

MATERIALS AND METHODS:

One-piece zirconia dental implants (CeraRoot) with three different roughened surfaces were designed and manufactured for this study: coated, uncoated, and acid-etched. Five different implant designs were manufactured. Standard or flapless surgical procedures were used for implant placement. Simultaneous bone augmentation or sinus elevation was performed when bone height or width was insufficient. Definitive all-ceramic restorations were placed 4 months after implant placement (8 months or more for implants when bone augmentation or sinus elevation was performed). The implants were followed up to 5 years (mean, 3.40 +/- 0.21).

RESULTS:

In all, 831 implants were placed in 378 patients with a mean age of 48 years. The overall implant success rate after 5 years of follow-up was 95 % (92.77 % for uncoated implants, 93.57 % for coated implants, and 97.60 % for acid-etched implants). The success rate of the acid-etched surface group was significantly better than that of the other two.

CONCLUSION:

From this midterm investigation, it can be concluded that zirconia dental implants with roughened surfaces might be a viable alternative for tooth replacement. Further follow-up is needed to evaluate the long-term success rates of the implant surfaces studied.

MINERVA STOMATOL. 2011 MAY;60(5):229-41.

Use of endosseous one-piece yttrium-stabilized zirconia dental implants in premolar region: a two-year clinical preliminary report.

Borgonovo A, Censi R, Dolci M, Vavassori V, Bianchi A, Maiorana C.

ABSTRACT

OBJECTIVE:

The aim of this work was to clinically and radiographically evaluate survival and success rate of zirconia dental implants positioned in premolar area during a follow-up period of at least 12 months up to 24 months.

METHODS:

Sixteen patients were treated with 26 zirconia implants. All implants received immediate temporary restorations and 6 months after surgery were definitively restored. Twelve to 14 months after implant insertion, a clinical-radiographical evaluation was performed in order to estimate peri-implant tissues health and peri-implant marginal bone loss.

RESULTS:

The survival rate was 96.16 %. The success rate was 91.6 %.

CONCLUSION:

significant even if results are encouraging. Further scientific information regarding clinical use of zirconia dental implants are needed, as well as prospective long-term clinical studies in order to understand if zirconia implants may represent a valid alternative to titanium implants.

CLIN ORAL IMPLANTS RES. 2013

MAY;24(5):569-75. DOI:

10.1111/J.1600-0501.2012.02425.X. EPUB 2012 FEB 15.

Immediate provisional restoration of single-piece zirconia implants: a prospective case series - results after 24 months of clinical function.

Payer M, Arnetzl V, Kirmeier R, Koller M, Arnetzl G, Jakse N.

ABSTRACT

OBJECTIVE:

Aim of this prospective case series was to evaluate the outcome of immediately provisionalized single-piece zirconia implants.

MATERIAL AND METHODS:

A total of 20 zirconia implants were inserted in single-tooth gaps in the maxilla (11) and mandible (9) of 20 patients. Implants were restored with all-ceramic CAD/CAM provisionals without occlusal contacts immediately after placement. Permanent all-ceramic restoration was performed 4 months after surgery. Plaque index (PI), bleeding on probing (BOP), Periotest® (PV), pink aesthetic score (PES), mean radiographic marginal bone levels (MBL), implant survival and success were evaluated up to 24 months.

RESULTS:

Assessment of PI at baseline and follow-ups after 6, 12, 18 and 24 months revealed 27 % (± 5.3), 24 % (± 6), 23 % (± 6.1), 23 % (± 5.3) and 22 % (± 6.4), respectively. Evaluation of BOP revealed 25 % (± 5.6), 21 % (± 6), 21 % (± 7.2), 18 % (± 5.9) and 15 % (± 5.5), respectively. Implants presented stable at follow-ups (PV). PES improved, but not statistically significant from 8.13 (± 1.5) at baseline to 10 (± 2) 24 months after implantation. Measurements of MBL showed a significant bone loss of 1.01 mm within the first year after placement ($P < 0.001$) and 1.29 mm 24 months post-implant insertion, not reaching further statistically significant levels ($P > 0.05$). One implant was lost 4 months after placement, resulting in a survival and success rate of 95 %.

CONCLUSION:

Clinical and radiographic parameters demonstrated a 95 % integration of immediately loaded zirconia single-piece implants. A long-term randomized-controlled clinical trial was initiated to confirm evidence of this protocol.

Prosthodontic maintenance of overdentures on zirconia implants: 1-year results of a randomized controlled trial.

Osman RB, Ma S.

ABSTRACT

PURPOSE:

The purpose of this study was to determine the prosthodontic outcomes of one-piece zirconia implants and their attachment systems in edentulous participants with maxillary and mandibular overdentures after 1 year of a randomized controlled trial.

MATERIALS AND METHODS:

Random allocation of 24 edentulous participants (age range: 45 to 86 years) into titanium (control) or zirconia (test) groups using one-piece implants and a planned unsplinted prosthodontic design was performed. Four maxillary implants (one midpalatal; three anterior crestal) and three mandibular implants (one midsymphyseal; two bilateral distal) were conventionally loaded with the overdentures. Similar attachment systems were used throughout: ball abutment-type matrices (diameter: 2.25 to 3.1 mm as part of the one-piece implants) and custommade plastic matrices (with or without metal housings depending on the matrix size). Prosthodontic outcomes were documented during the first year of the clinical trial.

RESULTS:

Following three deaths and two dropouts, there were 19 participants who were available at the 1-year recall. Of these participants, 3 had early maxillary implant failure and had to be converted to conventional maxillary complete dentures opposing mandibular implant overdentures. There were 79 maintenance events, 34 in the titanium (control) group and 45 in the zirconia (test) group. Matrix loss occurred as a result of three zirconia implant fractures (one mandibular and two crestal maxillary implants). Maintenance events were principally the replacement of matrices and overdenture fracture. Although relines and replacement overdentures also occurred, overall there were no significant differences in prosthodontic maintenance between the control and test groups. A six-field prosthodontic-success analysis table showed no statistically significant difference between the two groups; however, 50 % of participants in each group were allocated to the retreatment (repair) field, which produced a low prosthodontic success rate.

CONCLUSIONS:

Removable overdentures can be used on both one-piece titanium and zirconia implants with these attachment systems, due to no difference in prosthodontic maintenance and success. Before recommending routine use of a "metal-free" overdenture treatment option in clinical practice, consideration must be given to the success of the implants themselves.

CLIN ORAL IMPLANTS RES. 2014
DEC;25(12):1366-77.

Ceramic implants (Y-TZP): are they a viable alternative to titanium implants for the support of overdentures? A randomized clinical trial.

Osman RB, Swain MV, Atieh M, Ma S, Duncan W.

ABSTRACT

OBJECTIVE:

The objective of this study was to assess 1-year clinical success of one-piece zirconia implants compared with similar-design titanium implants, in the context of a novel protocol for implant distribution.

MATERIALS AND METHODS:

Twenty-four edentulous participants were randomly allocated to one-piece titanium or zirconia implant group. Each participant received four implants in the maxilla (mid-palatal and three anterior crestal implants) and three implants in the mandible (mid-symphyseal and two bilateral distal implants). Conventional loading protocol was followed. Marginal bone remodeling and clinical success of implants were evaluated. The data were statistically analyzed, and risk predictors for implant failures were evaluated.

RESULTS:

There was no significant difference in the survival rate between the two groups. In the mandible, the survival rate of titanium implants was 95.8 % vs. 90.9 % for the zirconia implants. The corresponding values in the maxilla were 71.9 % and 55 %, respectively. Three implants in the zirconia group fractured. Statistically significant less marginal bone loss was observed around titanium implants (0.18 mm) compared with the zirconia group (0.42 mm). The prediction model revealed a higher risk for implant failures in the maxilla ($P < 0.0001$).

CONCLUSION:

The outcome of this study indicates caution before recommendation can be made for the use of single-piece zirconia implants for overdenture support. Their use should be limited to cases with proven allergy to titanium. This is mainly due to the increased bone loss and higher fracture rate observed for zirconia implants. Future biomaterial research should focus on producing surface characteristics on zirconia implants with outcomes similar to those established for the optimum osseointegration of titanium implants.

CLIN ORAL IMPLANTS RES. 2015
APR;26(4):413-418. DOI: 10.1111/CLR.12370.
EPUB 2014 MAR 26.

Two-piece zirconia implants supporting all-ceramic crowns: a prospective clinical study.

Cionca N, Müller N, Mombelli A.

ABSTRACT

OBJECTIVES:

The aim of this prospective clinical study is to evaluate the safety and efficacy of a new all-ceramic implant system to replace missing teeth in partially edentulous patients.

MATERIAL AND METHODS:

Thirty-two partially edentulous, systemically healthy patients were treated with 49 two-piece zirconia implants (ZERAMEX[®]) T Implant System). Zirconia abutments were connected with adhesive resin cement. Single-unit full-ceramic crowns were cemented. The cases have been followed for 588 ± 174 days after loading (range 369-889 days). All patients have been re-evaluated 1 year after loading.

RESULTS:

The cumulative survival rate 1 year after loading was 87 % implants. All failures were the result of aseptic loosening, and no implants were lost after the first year. The results of the other cases were good, and the patients were very satisfied. The cumulative soft tissue complication rate was 0 %, the cumulative technical complication rate was 4 % implants, the cumulative complication rate for bone loss >2 mm was 0 %, and the cumulative esthetic complication rate was 0 %. Including the data from 20 patients treated with an earlier version of the system, an over-all 2-year cumulative survival rate of 86 % was calculated for a total of 76 two-piece zirconia implants supporting all-ceramic crowns in 52 patients.

CONCLUSIONS:

Replacement of single teeth in the posterior area was possible with this new full-ceramic implant system. Failures were due to aseptic loosening.

CLIN ORAL IMPLANTS RES. 2015
APR;26(4):371-376.

All-ceramic restoration of zirconia two-piece implants-a randomized controlled clinical trial.

Payer M, Heschl A, Koller M, Arnetzl G, Lorenzoni M, Jakse N.

ABSTRACT

OBJECTIVES:

Aim of this controlled prospective randomized study was to evaluate the outcome of two-piece zirconia implants compared to titanium implants over a period of up to 24 months.

MATERIAL AND METHODS:

A total of 31 implants (16 zirconia/Ziterion vario Z(®) + 15 titanium/Ziterion vario T(®)) were inserted primary stable (>30 Ncm) in the maxilla (7) and mandible (24) of 22 patients (13 male, nine female) requiring neither bone nor soft tissue augmentation. After a healing period of 6 months in the maxilla and 4 months in the mandible, ceramic abutments were luted adhesively to the zirconia implants and definitive all-ceramic restoration was performed with high-density ceramics. Radiographic bone levels, condition of the peri-implant mucosa, aesthetic outcome, implant survival and success were recorded for up to 24 months.

RESULTS:

Measurements of mean marginal bone levels 24 months after surgery showed a significant bone loss ($P < 0.001$) in both groups (Ti: 1.43 (SD \pm 0.67) vs. Zir 1.48 (SD \pm 1.05)). One zirconia implant was lost 8 months after restoration. No further complications were recorded, giving an overall survival and success rate of 93.3 % for zirconia and 100 % for titanium implants after a period of up to 24 months.

CONCLUSIONS:

After 24 months, success rates of the two-piece ceramic implants showed no significant difference compared to control two-piece titanium implants. The bonded zirconia implant abutment connection appears to be capable with clinical application over the observed period. However, further control measurements need to confirm the presented data.

CLIN IMPLANT DENT RELAT RES. 2015
JUN;17(3):483-96.

Soft and Hard Tissue Response to Zirconia versus Titanium One-Piece Implants Placed in Alveolar and Palatal Sites: A Randomized Control Trial.

Siddiqi A, Kieser JA, De Silva RK, Thomson WM, Duncan WJ.

ABSTRACT

BACKGROUND:

Titanium (Ti) implants have been used in the last four decades to replace missing teeth. Alternatives to Ti such as zirconia (Zr) may offer aesthetic advantages and be more acceptable to patients and clinicians concerned about Ti allergy but must show equivalent biological acceptability to Ti.

PURPOSE:

The research aimed to investigate soft and hard tissue response to Ti and Zr implants in edentulous patients.

MATERIALS AND METHODS:

The research included 24 participants (Ti=12, Zr=12) restored with one-piece ball-abutment implants to support overdentures. Participants received four maxillary implants (two in the premolar alveolus, one off center in the alveolar midline, and one wide-diameter implant in the anterior median palate) and three mandibular implants (one in the midline and bilateral posterior implants).

RESULTS:

Success rates for both Ti and Zr implants were low, 67.9 % for all alveolar implants and a survival rate of 50.0 % for the palatal implants. Only 11 (52.4 %) of 21 palatal implants survived the follow-up period. Peri-implant health was equivalent for Ti and Zr implants and showed no statistically significant changes from loading to the 1-year follow-up. Statistically significant differences were noted in radiographic bone level between Ti and Zr implants ($p = .02$), with Zr showing greater bone loss.

CONCLUSIONS:

Although the failure rates with the one-piece Zr implants were higher than with the Ti ones, suggesting that the former's clinical usage as in this study cannot be recommended, it should be borne in mind that the fault may also lie with the novel prosthodontic design which was used.

CLIN ORAL IMPLANTS RES. 2016 JUL;27(7):751-61. DOI: 10.1111/CLR.12670. EPUB 2015 JUL 27.

Evaluation of a one-piece ceramic implant used for single-tooth replacement and three-unit fixed partial dentures: a prospective cohort clinical trial.

Jung RE, Grohmann P, Sailer I, Steinhart YN, Fehér A, Hämmerle C, Strub JR, Kohal R.

ABSTRACT

AIM:

The aim of this clinical trial was to evaluate the safety and efficiency of a one-piece zirconia oral implant after 1 year of function.

MATERIALS AND METHODS:

Two centers included 60 subjects in need of implant-supported single-tooth restorations or three-unit bridges. A total of 71 zirconia one-piece implants were placed and immediately restored with a temporary reconstruction for at least 2 months. The final veneered zirconia restorations were then cemented and followed for 6 months and 1 year after insertion of the restorations. At each visit, a clinical evaluation was performed to analyze biological parameters of the implants and the neighboring teeth. A standardized periapical radiograph was taken at implant insertion, at the placement of the restorations and at the 1-year follow-up.

RESULTS:

Sixty patients with 71 implants (48 in the mandible, 23 in the maxilla) were included in this study and provided with 11 bridges and 49 crowns. Two patients with three implants (one bridge and one single crown) could not be evaluated. One patient lost his implant 5 weeks after implant insertion. Based on 58 patients, the mean survival rate was 98.3 % after one year when the implants of the two patients that did not show up were not counted as lost. The mean marginal bone loss from implant insertion to the 1-year follow-up after the final prosthetic restoration was 0.78 mm with a standard deviation of 0.79 mm. The probing depth around the implants increased from 2.7 mm at insertion of the prosthetic reconstruction to 3.5 mm one year after insertion. The probing depth around the adjacent teeth remained stable at 2.5 mm. At the 1-year recall, the difference was significant. The clinical attachment levels at implants and teeth were not different at the 1-year follow-up with 3.1 mm at tooth and implant sites.

CONCLUSIONS:

The presently tested one-piece ceramic implant was successful in replacing single tooth and three-unit gaps after one year of function. Further long-term data are necessary to verify these initial findings.

CLIN IMPLANT DENT RELAT RES. 2015 JUN;17(3):483-96.

A Retrospective Clinical Study with Regard to Survival and Success Rates of Zirconia Implants up to and after 7 Years of Loading.

Roehling S, Woelfler H, Hicklin S, Kniha H, Gahlert M.

ABSTRACT

PURPOSE:

The study aims to retrospectively investigate the clinical performance of first-generation zirconia implants with a sandblasted surface up to and after 7 years of loading.

MATERIALS AND METHODS:

Clinical records of patients treated with zirconia implants between 2004 and 2009 were screened. Consequently, adequate patients were invited to a clinical and radiographic investigation to classify each implant according to strict success criteria.

RESULTS:

Seventy-one patients receiving 161 implants were available for the evaluation. Overall, 36 implants (22.4 %) were lost due to early ($n=14$) and late failures ($n=4$) or fractures ($n=18$). All surviving 125 implants fulfilled the success criteria. None of the investigated implants had a history of peri-implant infections. Mean values with regard to gingival index, plaque index, modified sulcus bleeding index, and probing depth were 0.03, 0.23, 0.59, and 2.80 mm, respectively. The radiographically evaluated mean crestal bone loss was 0.97 ± 0.07 mm. Diameter-reduced implants (3.25 mm) showed lower survival (58.5 %) compared with implants with a diameter of 4.0 mm (88.9 %) and 5.0 mm (78.6 %). The overall longitudinal survival rate was 77.3 %.

CONCLUSIONS:

First-generation zirconia implants showed low overall survival and success rates. The evaluated clinical and radiographic parameters were consistent with healthy peri-implant tissues. Additionally, nonfractured failures were not associated with peri-implant infections.

CLIN ORAL IMPLANTS RES. 2016
OCT;27(10):1265-1273.

Bi-layered zirconia/fluor-apatite bridges supported by ceramic dental implants: a prospective case series after thirty months of observation.

Spies BC, Witkowski S, Butz F, Vach K, Kohal RJ.

ABSTRACT

OBJECTIVE:

The aim of this study was to determine the success and survival rate of all-ceramic bi-layered implant-supported three-unit fixed dental prostheses (IS-FDPs) 3 years after implant placement.

MATERIAL AND METHODS:

Thirteen patients (seven males, six females; age: 41-78 years) received two one-piece ceramic implants (alumina-toughened zirconia) each in the region of the premolars or the first molar and were finally restored with adhesively cemented bi-layered zirconia-based IS-FDPs (3 in the maxilla, 10 in the mandible) composed of CAD/CAM-fabricated zirconia frameworks pressed-over with fluor-apatite glass-ceramic ingots. At prosthetic delivery and the follow-ups after 1, 2 and 3 years, the restorations were evaluated using modified United States Public Health Service (USPHS) criteria. Restorations with minor veneer chippings, a small-area occlusal roughness, slightly soundable restoration margins, minimal contour deficiencies and tolerable color deviations were regarded as success. In case of more distinct defects that could, however, be repaired to a clinically acceptable level, IS-FDPs were regarded as surviving. Kaplan-Meier plots were used for the success/survival analyses. To verify an impact on subjective patients' perceptions, satisfaction was evaluated by visual analog scales (VAS).

RESULTS:

All patients were seen 3 years after implant installation. No IS-FDP had to be replaced, resulting in 100 % survival after a mean observation period of 29.5 months (median: 30.7). At the 3-year follow-up, 7/13 IS-FDPs showed a veneer chipping, 13/13 an occlusal roughness and 12/13 minimal deficiencies of contour/color. Since six restorations showed a major chipping and/or a major occlusal roughness, the Kaplan-Meier success rate was 53.8 %. However, patients' significantly improved perceptions of function, esthetics, sense, and speech at prosthetic delivery remained stable over time.

CONCLUSION:

Bi-layered zirconia/fluor-apatite IS-FDPs entirely survived the observation period but showed a high frequency of technical complications. Nevertheless, the treatment highly satisfied patients' expectations.

CLIN ORAL IMPLANTS RES. 2017 JAN;28(1):
29-35.

Clinical performance of two-piece zirconia implants in the posterior mandible and maxilla: a prospective cohort study over 2 years.

Becker J, John G, Becker K, Mainusch S, Diedrichs G, Schwarz F.

ABSTRACT

OBJECTIVES:

To assess the clinical performance of two-piece zirconium implants over a period of up to 2 years.

MATERIAL AND METHODS:

A total of 52 patients with single-tooth gaps in the posterior mandible or maxilla received the same type of a two-piece zirconium implant system with customized heights of the transmucosal aspect. Fibreglass abutments were cemented and restored with fixed all-ceramic single crowns using a conventional loading protocol. The cumulative survival rate (primary outcome) was calculated according to the life table method, and Kaplan-Meier survival curves were used to estimate the survival function. Covariates (gender, implant position, implant diameter/length, oral surgeon) were tested using log-rank tests.

RESULTS:

A total of two target implants in 2 patients were lost after a functioning time of 8 months. The cumulative survival rate was 95.8 %, and the mean survival time amounted to 32.9 months. Log-rank tests revealed a significant association for the covariate "oral surgeon" (P = 0.047). The Kaplan-Meier estimates of mechanical/technical and biological complications amounted to 2.1 % and 37.5 %, respectively. All implant sites revealed a marked increase of the vestibular mucosal level and gain of keratinized tissue at 24 months.

CONCLUSION:

Within the limitations of a prospective cohort study, it was concluded that this two-piece zirconium implant/fibreglass abutment system can be successfully used in the clinical indication investigated.

All-ceramic, bi-layered crowns supported by zirconia implants: Three-year results of a prospective multicenter study.

Spies BC, Balmer M, Jung RE, Sailer I, Vach K, Kohal RJ.

ABSTRACT

OBJECTIVES:

To determine the clinical and patient-reported outcomes of bi-layered, all-ceramic posterior single crowns (SCs) supported by zirconia implants in an uncontrolled, prospective, multicenter study.

METHODS:

In two centers, 60 patients received 71 one-piece zirconia oral implants to be restored with either SCs (n=49) or three-unit fixed dental prostheses (n=11). Of these patients, 45 implants were restored with all-ceramic, zirconia-based posterior SCs (one per patient). Survival rates of implants and reconstructions were assessed, and technical success was evaluated according to modified U.S. Public Health Service (USPHS) criteria. Furthermore, patient-reported outcome measures (PROMs) were assessed by applying visual analog scales (VAS). Kaplan-Meier (KM) plots and log-rank tests were used for success/survival analyses. The Wilcoxon matched-pairs signed-rank test was used to evaluate time effects on response variables (PROMs, USPHS criteria).

RESULTS:

Forty patients with 40 SCs could be evaluated after 36.7±1.2 months. No SC was replaced, resulting in 100 % survival. The KM success estimate was 87.5 % (two chippings, one restoration margin, and one contour were rated Charlie). In general, the incidence of chipping (p=.0005) and occlusal roughness (p=.0003) was frequent. Compared with the pre-treatment patient surveys (67-93 %), all surveys at prosthetic delivery except for speech (p=.139) showed significantly improved VAS scores (81-94 %; p<.0001). Thereafter, no decrease in satisfaction could be observed over time until the 3-year follow-up (86-93 %; p≥.390).

CONCLUSIONS:

Veneered, zirconia-based SCs supported by zirconia implants satisfied patients' needs highly. However, significant incidence of chipping and roughness of the veneering ceramic may compromise the clinical long-term outcome for this indication.

CLINICAL SIGNIFICANCE:

Posterior, zirconia-based SCs supported by zirconia oral implants entirely survived the follow-up period of 3 years, but two major chippings, one a significant marginal opening and one pronounced over-contouring, resulted in a reduced KM success estimate of 87.5 % after 36 months of observation.

Zirconia implants as abutments for single crowns and fixed dental prostheses - 5 years results of a prospective cohort investigation.

Balmer M, Spies BC, Kohal R, Hämmerle C, Vach K, Jung R.

ABSTRACT

BACKGROUND:

Zirconia implants have been added to the portfolio of an increasing number of implant companies as an alternative to titanium. Their application is generally justified only by patient's request for metal-free reconstructions and promising results from preclinical or short-term human clinical studies. Presently, the long-term scientific evidence is very limited. Prior to their wider use, zirconia implants have to prove their clinical effectiveness in terms of long-term safety and success.

AIM/HYPOTHESIS:

To evaluate the clinical and radiological outcomes of one-piece zirconia implants as abutments for single crowns or fixed dental prostheses over an observation period of 5 years in function.

MATERIAL AND METHODS:

In a prospective clinical study with two investigational centers, 60 patients were included and 71 one-piece zirconia implants were placed. After a healing period with immediate provisional reconstructions of at least 4 month in the upper jaw and 2 month in the lower jaw, the final all-ceramic single crowns (SCs) or 3-unit fixed dental prostheses (FDPs) were cemented on the implants. Patients were followed up 6 months after prosthetic insertion and subsequently on an annual basis up to the 5 years follow-up. Clinical parameters (probing depth, plaque, bleeding on probing and clinical attachment level) and radiological measurements (marginal bone level) of the implants and the neighboring teeth were assessed. For the statistical analysis of the clinical parameters and of the mean marginal bone level linear mixed models were applied.

RESULTS:

Out of the 71 inserted implants, a total of 63 in 53 patients could be evaluated after a mean observation time of 5.59 ± 0.38 years after implantation. 6 patients with a total of 7 implants did not attend the 5 years follow-up for different reasons and were counted as dropouts. One implant, indicated as single crown abutment, did not achieve osseointegration and had to be removed 5 weeks after implantation. No further implant loss was recorded. Therefore, the 5 years survival rate was calculated as 98.44 %. A statistically significant mean marginal bone loss could be observed after 5 years in function (0.74 ± 0.62 mm $P = 0.001$). However, after an initial mean marginal loss (0.68 ± 0.56 mm) between implantation and prosthetic insertion, no further statistic significant change in marginal bone level could be observed (0.05 ± 0.63 mm $P = 0.46$). Neither type of reconstruction (SC FDP+ $P = 0.419$) nor implant diameter ($P = 0.625$) and length ($P = 0.174$) had a significant influence on marginal bone level changes.

CONCLUSIONS AND CLINICAL IMPLICATIONS

The presently investigated one-piece zirconia implant showed a high survival rate and a stable marginal bone level after prosthetic insertion. It proved its potential indication as abutment for SCs and FDPs. However, more research with longer observation periods and higher numbers of implants are needed to confirm these findings.

Evaluation of zirconia-based posterior single crowns supported by zirconia implants: preliminary results of a prospective multicenter study.

Spies BC, Kohal RJ, Balmer M, Vach K, Jung RE.

ABSTRACT

OBJECTIVE:

The aim of this uncontrolled prospective multicenter study was to determine the success and survival rate of posterior single crowns composed of zirconia frameworks hand-layered with a leucite-reinforced feldspathic ceramic supported by one-piece zirconia oral implants.

MATERIAL AND METHODS:

In two centers, sixty patients received 71 zirconia oral implants. To obtain a clear indication of posterior implant-supported single crowns (ISSCs), 14 patients (25 implants) were excluded from the analysis (11 bridges, three anterior crowns). The remaining patients were provided with single implants in posterior regions. As one patient lost his implant and another refused further participation after final prosthesis insertion, 44 ISSCs/patients (19 females, 25 males) were available for evaluation. Of these patients, all were seen at prosthetic delivery and the 6- and 12-month follow-up appointments. Evaluations were performed using modified United States Public Health Service (USPHS) criteria. Restorations within Alpha and Bravo ratings were regarded as success. This included minor chippings, a slight roughness, slightly soundable restoration margins and minimal contour deficiencies. In case of more distinct defects that could, however, be repaired to a clinically acceptable level, restorations were regarded as surviving. Kaplan-Meier plots and log-rank tests were used for the success/survival analyses and the calculation of potential group differences (gender, jaw and center).

RESULTS:

After a mean observation period of 12.5 months (SD: 0.8 months), no ISSC had to be replaced, resulting in a Kaplan-Meier survival rate of 100 %. The Kaplan-Meier success rate was 90.9 % (one major chipping, one obvious roughness, one significant crevice and one pronounced over-contouring). Minor chippings and occlusal roughness were frequent complications. No significantly different survival/success rates could be observed between the mentioned groups.

CONCLUSION:

The frequent incidence of minor chippings suggests a high technique sensitivity when providing zirconia implants with veneered zirconia-based crowns questioning its suitability for this indication.

Three-year analysis of zirconia implants used for single-tooth replacement and three-unit fixed dental prostheses: A prospective multicenter study.

Balmer M, Spies BC, Vach K, Kohal RJ, Hämmerle CHF, Jung RE.

ABSTRACT

AIM:

The aim of the present investigation was to evaluate clinically and radiographically the outcome of zirconia oral implants after 3 years in function.

MATERIALS AND METHODS:

In 60 patients in need of either a single-tooth replacement or a three-unit fixed dental prosthesis (FDP), a total of 71 one-piece zirconia implants were placed and immediately restored with temporary fixed prostheses. After a period of at least 2 months in the mandible and at least 4 months in the maxilla, zirconia-based reconstructions were cemented. The implants were clinically and radiologically examined at implant insertion, prosthetic delivery, at 6 months and then yearly up to 3 years. A linear mixed model was used to analyze statistically the influence of prognostic factors on changes in the marginal bone level.

RESULTS:

Seventy-one implants (48 in the mandible, 23 in the maxilla) inserted in 60 patients were restored with 49 crowns and 11 FDP. One patient lost his implant after 5 weeks. Five patients with one implant each could not be evaluated after 3 years. Based on 55 patients with a total of 66 implants, the mean survival rate was 98.5 % after 3 years in function. A statistically significant mean marginal bone loss (0.70 mm \pm 0.72 mm) has been detected from implant insertion to the 3-year follow-up. The largest marginal bone loss occurred between implantation and prosthetic delivery (0.67 mm \pm 0.56 mm). After delivery, no statistically significant bone level change was observed (0.02 mm \pm 0.59 mm). None of the investigated prognostic factors had a significant influence on changes in the marginal bone level.

CONCLUSIONS:

After 3 years in function, the investigated one-piece zirconia implant showed a high survival rate and a low marginal bone loss. The implant system was successful for single-tooth replacement and three-unit FDPs. Further investigations with long-term data are needed to confirm these findings.

A prospective clinical study to evaluate the performance of zirconium dioxide dental implants in single-tooth edentulous area: 3-year follow-up.

Bormann KH, Gellrich NC, Kniha H, Schild S, Weingart D, Gahlert M.

ABSTRACT

BACKGROUND:

Traditionally, dental implants have been made from titanium or titanium alloys. Alternatively, zirconia-based ceramic implants have been developed with similar characteristics of functional strength and osseointegration. Ceramic implants offer advantages in certain settings, e.g. in patients who object to metal dental implants. The aim of this study was to investigate the mid-term (36 months) clinical performance of a ceramic monotype implant in single-tooth edentulous area.

METHODS

This was a prospective, open-label, single-arm study in patients requiring implant rehabilitation in single-tooth edentulous area. Ceramic implants (PURE Ceramic Implant, Institut Straumann AG, Basel, Switzerland) with a diameter of 4.1 mm were placed following standard procedure and loaded with provisional and final prostheses after 3 and 6 months, respectively. Implant survival rate and implant success rate were evaluated and crestal bone levels were measured by analysing standardized radiographs during implant surgery and at 6, 12, 24 and 36 months.

RESULTS:

Forty-four patients received a study implant, of whom one patient withdrew consent after 3 months. With one implant lost during the first 6 months after surgery, the implant survival rate was 97.7 % at 6 months. No further implants were lost over the following 30 months, and 3 patients were lost to follow-up during this time frame. This led to a survival rate of 97.5 % at 36 months.

Six months after implant surgery 93.0% of the implants were considered "successful", increasing to 97.6 % at 12 months and remaining at this level at 24 months (95.1 %) and 36 months (97.5 %).

Bone loss was most pronounced in the first half-year after

implant surgery (0.88 ± 0.86 mm). By contrast, between 12 and 36 months the mean bone level remained stable (minimal gain of $0.06 [\pm 0.60]$ mm). Hence, the overall bone loss from implant surgery to 36 months was $0.97 (\pm 0.88)$ mm.

CONCLUSIONS:

In the follow-up period ceramic implants can achieve favourable clinical outcomes on a par with titanium implants. For instance, these implants can be recommended for patients who object to metal dental implants. However, longer term studies with different edentulous morphology need to confirm the present data.

One-piece zirconia oral implants for single-tooth replacement: Three-year results from a long-term prospective cohort study.

Bormann KH, Gellrich NC, Kniha H, Schild S, Weingart D, Gahlert M.

ABSTRACT

AIM:

This 3-year report of a prospective long-term cohort investigation aimed to evaluate the clinical and radiographic outcomes of a one-piece zirconia oral implant for single-tooth replacement.

MATERIALS AND METHODS

Sixty-five patients received a 1-stage implant surgery with immediate temporization. Standardized radiographs were taken at implant insertion, after 1 year, and after 3 years to monitor peri-implant bone levels. A univariate analysis of the association of different baseline parameters on marginal bone loss from implant insertion to 36 months was performed. Soft-tissue parameters were evaluated at prosthesis insertion, after 6 months, after 1 year, and at the 3-year follow-up.

RESULTS:

After 3 years, six posterior site implants were lost, giving a cumulative survival rate of 90.8 %. The mean marginal bone loss was 1.45 mm; 35 % of the implants lost at least 2 mm bone, and 22 % more than 3 mm. The univariate analysis did not identify any parameter associated with marginal bone loss. Probing depth, clinical attachment level, and bleeding index increased over 3 years, and plaque index decreased.

CONCLUSIONS:

The low survival rate of the presented ceramic implant and especially the high frequency of advanced bone loss are noticeable but remain unexplained.

1.2.5 General Reviews and Meta-Analyses

CLIN ORAL IMPLANTS RES. 2009 SEP;20 SUPPL 4:32-47.

Are ceramic implants a viable alternative to titanium implants? A systematic literature review.

Andreiotelli M, Wenz HJ, Kohal RJ.

ABSTRACT

AIM:

The aim of this systematic review was to screen the literature in order to locate animal and clinical data on bone-implant contact (BIC) and clinical survival/success that would help to answer the question 'Are ceramic implants a viable alternative to titanium implants?'

MATERIAL AND METHODS

A literature search was performed in the following databases: (1) the Cochrane Oral Health Group's Trials Register, (2) the Cochrane Central Register of Controlled Trials (CENTRAL), (3) MEDLINE (Ovid), and (4) PubMed. To evaluate biocompatibility, animal investigations were scrutinized regarding the amount of BIC and to assess implant longevity clinical data were evaluated.

RESULTS:

The PubMed search yielded 349 titles and the Cochrane/MEDLINE search yielded 881 titles. Based upon abstract screening and discarding duplicates from both searches, 100 full-text articles were obtained and subjected to additional evaluation. A further publication was included based on the manual search. The selection process resulted in the final sample of 25 studies. No (randomized) controlled clinical trials regarding the outcome of zirconia and alumina ceramic implants could be found. The systematic review identified histological animal studies showing similar BIC between alumina, zirconia and titanium. Clinical investigations using different alumina oral implants up to 10 years showed survival/success rates in the range of 23 to 98 % for different indications. The included zirconia implant studies presented a survival rate from 84 % after 21 months to 98 % after 1 year.

CONCLUSIONS:

No difference was found in the rate of osseointegration between the different implant materials in animal experiments. Only cohort investigations were located with questionable scientific value. Alumina implants did not perform satisfactorily and therefore, based on this review, are not a viable alternative to titanium implants. Currently, the scientific clinical data for ceramic implants in general and for zirconia implants in particular are not sufficient to recommend ceramic implants for routine clinical use. Zirconia, however, may have the potential to be a successful implant material, although this is as yet unsupported by clinical investigations.

J ORAL IMPLANTOL. 2011 JUN;37(3):367-76.

Zirconia dental implants: a literature review.

Özkurt Z, Kazazoğlu E.

ABSTRACT

Titanium and titanium alloys are widely used for fabrication of dental implants. Because of potential immunologic and possible esthetic compromises with titanium implants, novel implant technologies are being developed. However, these novel technologies must maintain the characteristics that provide titanium implants with their high success rates. Zirconia implants were introduced into dental implantology as an alternative to titanium implants. Zirconia seems to be a suitable implant material because of its toothlike color, mechanical properties, biocompatibility, and low plaque affinity. The aim of this study is to review clinical and research articles conducted on zirconia dental implants, compare them with titanium dental implants, and provide information on zirconia dental implant osseointegration and mechanical strength. Zirconia dental implants have the potential to become alternative dental implants to titanium dental implants, but they are not yet in routine clinical use.

CLIN IMPLANT DENT RELAT RES. 2014
FEB;16(1):124-37.

Current findings regarding zirconia implants.

Depprich R, Naujoks C, Ommerborn M, Schwarz F, Kübler NR, Handschel J.

ABSTRACT

PURPOSE:

The present article aims to analyze the available clinical data on the survival and success rate of dental zirconia implants (ZI).

MATERIAL AND METHOD:

Studies (2006-2011) listed in the bibliography were obtained by using the key words "zirconia, zirconium, implants, dental, clinical" and combinations of these in different databases and on the internet. These articles served as a basis for the article.

RESULTS:

A total of 17 clinical studies were found, involving 1,675 implants and 1,274 patients. In 16 studies, one-piece implant systems were investigated. The survival rates for ZI range from 74-98 % after 12-56 months, with success rates between 79.6-91.6 % 6-12 months after prosthetic restoration. However, the design of most of the studies show considerable shortcomings, and only low evidence level.

CONCLUSION:

The small number of studies and the limited period of observation permit only a qualified statement on the clinical success of ZI. The results available to date indicate that ZI are inferior to titanium implants (TI) with regard to survival and success rates. Well-conducted long-term studies are urgently needed to permit a meaningful assessment of the survival or success rates of ZI and a statement concerning their application as an alternative to TI.

FULL DENT. SCI. 2014; 5(20):535-545.

Ceramic implants: scientific evidence for its use.

Hochscheidt CJ, Shimizu R, Andrighetto AR, Leme P, Salgado CV, Volz KU.

ABSTRACT

Ceramic zirconia (ZrO₂) has been the subject of many biomedical researches due to its excellent biocompatibility and chemical stability. In recent years it has been used as an alternative to metallic dental implants, and mainly for its aesthetic periosteal integration qualities. The purpose of this literature review was to evaluate some of the characteristics of ceramic Y-TZP (tetragonal zirconia polycrystalline yttria stabilized) and ATZ (zirconia toughened alumina), pointing its limitations of use as alternative materials in Implantology. Many in vitro and in vivo studies have demonstrated that the ceramics Y-TZP exhibit aesthetic and biological advantages over other biomaterials. The values of fracture toughness are clinically acceptable, being higher in ATZ composites. Some cyclic loading tests with ATZ dental implants showed resistance equal or superior to titanium (Ti). New surface treatments for ceramics have shortened the cure time, allowing immediate loading. Animal experiments have confirmed the good potential for osseointegration of ceramic, with the amount of BIC comparable to Ti and less accumulation of biofilm. Studies up to 5 years with dental implants Y-TZP one-piece in humans have success rates between 84.4 and 100 %, whereas the survival rate in 7 years with ATZ implants was 99 %. Despite the good results with the ceramic Y-TZP and ATZ, the authors suggest caution in their indications and further long-term prospective studies are required.

INT J ORAL MAXILLOFAC IMPLANTS. 2014 MAR-APR;29(2):311-20. DOI: 10.11607/JOMI.2817.

Comparison of clinical performance of zirconia implants and titanium implants in animal models: a systematic review.

Manzano G, Herrero LR, Montero J.

ABSTRACT

PURPOSE:

This study aimed to compare the values of removal torque (RT) and bone-implant contact (BIC) reported in different animal studies for zirconia and titanium implants.

MATERIALS AND METHODS:

A systematic review of the literature was performed to analyze BIC and RT of animal studies in which both zirconia and titanium dental implants were used. To identify the studies to include in this systematic review, an exhaustive search of PubMed was performed of animal studies published in English with reports on the quantification of the osseointegration of both titanium and zirconia implants by means of BIC and/or RT. The results were aggregated and analyzed within each of the animal models (pig, rabbit, rat, monkey, dog, and sheep).

RESULTS:

The selection process resulted in a final sample of 16 studies. In general, no significant differences were found between titanium and zirconia. The significant differences in terms of BIC and RT reported by the authors were attributable to the different surface treatments and microporosities of the implant surfaces studied, not to the materials themselves. Only two articles reported significantly lower BIC for modified zirconia implants as compared to modified titanium implants. Four authors described statistically significant differences in terms of RT between zirconia and titanium implants in the different animal models, regardless of the surface treatment received by the implants.

CONCLUSIONS:

Within the limitations of this study, the values for the BIC and RT of zirconia implants in most of the studies analyzed did not show statistical differences compared with titanium implants. Modified-surface zirconia may have potential as a candidate for a successful implant material, although further clinical studies are necessary.

J INT SOC PREV COMMUNITY DENT. 2015 MAY-JUN; 5(3): 147-156.

Zirconia in dental implantology: A review.

Apratim A, Eachempati P, Krishnappa S, Saliyan KK, Singh V, Chhabra S, Shah S.

ABSTRACT

BACKGROUND:

Titanium has been the most popular material of choice for dental implantology over the past few decades. Its properties have been found to be most suitable for the success of implant treatment. But recently, zirconia is slowly emerging as one of the materials which might replace the gold standard of dental implant, i.e., titanium.

MATERIALS AND METHODS:

Literature was searched to retrieve information about zirconia dental implant and studies were critically analyzed. PubMed database was searched for information about zirconia dental implant regarding mechanical properties, osseointegration, surface roughness, biocompatibility, and soft tissue health around it. The literature search was limited to English language articles published from 1975 to 2015.

RESULTS:

A total of 45 papers met the inclusion criteria for this review, among the relevant search in the database.

CONCLUSION:

Literature search showed that some of the properties of zirconia seem to be suitable for making it an ideal dental implant, such as biocompatibility, osseointegration, favourable soft tissue response and aesthetics due to light transmission and its color. At the same time, some studies also point out its drawbacks. It was also found that most of the studies on zirconia dental implants are short-term studies and there is a need for more long-term clinical trials to prove that zirconia is worth enough to replace titanium as a biomaterial in dental implantology.

Crestal bone loss and periimplant inflammatory parameters around zirconia implants: A systematic review.

Vohra F, Al-Kheraif AA, Ab Ghani SM, Abu Hassan MI, Alnassar T, Javed F.

ABSTRACT

STATEMENT OF PROBLEM:

Zirconia implants have been used for oral rehabilitation; however, evidence of their ability to maintain crestal bone and periimplant soft tissue health is not clear.

PURPOSE:

The purpose of this systematic review was to evaluate crestal bone loss (CBL) around zirconia dental implants and clinical periimplant inflammatory parameters.

MATERIAL AND METHODS:

The focus question addressed was, "Do zirconia implants maintain crestal bone levels and periimplant soft tissue health?" Databases were searched for articles from 1977 through September 2014 with different combinations of the following MeSH terms: "dental implants," "zirconium," "alveolar bone loss," "periodontal attachment loss," "periodontal pocket," "periodontal index." Letters to the editor, case reports, commentaries, review articles, and articles published in languages other than English were excluded.

RESULTS:

Thirteen clinical studies were included. In 8 of the studies, the CBL around zirconia implants was comparable between baseline and follow-up. In the other 5 studies, the CBL around zirconia implants was significantly higher at follow-up. Among the studies that used titanium implants as controls, 2 studies showed significantly higher CBL around zirconia implants, and in 1 study, the CBL around zirconia and titanium implants was comparable. The reported implant survival rates for zirconia implants ranged between 67.6 % and 100 %. Eleven studies selectively reported the periimplant inflammatory parameters.

CONCLUSIONS:

Because of the variations in study design and methodology, it was difficult to reach a consensus regarding the efficacy of zirconia implants in maintaining crestal bone levels and periimplant soft tissue health.

A systematic review of the clinical survival of zirconia implants.

Hashim D, Cionca N, Courvoisier DS, Mombelli A.

ABSTRACT

OBJECTIVES:

The aim of this review was to evaluate the clinical success and survival rates of zirconia ceramic implants after at least 1 year of function and to assess if there is sufficient evidence to justify using them as alternatives to titanium implants.

MATERIALS AND METHODS:

An electronic search in MEDLINE, EMBASE, and the Cochrane Central Register of Controlled Clinical Trials (CENTRAL) databases was performed in April 2015 by two independent examiners to retrieve clinical studies focusing on the survival rate of zirconia implants after at least 1 year of function. Implant survival was estimated using the overall proportion reported in the studies with a Clopper-Pearson 95 % confidence interval (random effect model with a Der-Simonian Laird estimate).

RESULTS:

Fourteen articles were selected out of the 1519 titles initially screened. The overall survival rate of zirconia one- and two-piece implants was calculated at 92 % (95 % CI 87-95) after 1 year of function. The survival of implants at 1 year for the selected studies revealed considerable heterogeneity.

CONCLUSIONS:

In spite of the unavailability of sufficient long-term evidence to justify using zirconia oral implants, zirconia ceramics could potentially be the alternative to titanium for a non-metallic implant solution. However, further clinical studies are required to establish long-term results, and to determine the risk of technical and biological complications. Additional randomized controlled clinical trials examining two-piece zirconia implant systems are also required to assess their survival and success rates in comparison with titanium as well as one-piece zirconia implants.

CLINICAL RELEVANCE:

Zirconia implants provide a potential alternative to titanium ones. However, clinicians must be aware of the lack of knowledge regarding long-term outcomes and specific reasons for failure.

INT J ORAL MAXILLOFAC IMPLANTS. 2017
MAY/JUNE;32(3):E125-E134.

Zirconia Implants as an Alternative to Titanium: A Systematic Review and Meta-Analysis.

Elnayef B, Lázaro A, Suárez-López Del Amo F, Galindo-Moreno P, Wang HL, Gargallo-Albiol J, Hernández-Alfaro F.

ABSTRACT

PURPOSE:

The aim of the present study was to systematically evaluate the marginal bone loss (MBL), success, and survival of zirconia (Zi) implants and compare them with the widely studied titanium (Ti) implants.

MATERIALS AND METHODS:

An electronic and manual literature search of several databases was performed by two independent reviewers for articles up to July 2015 that reported the use of Zi implants and survival, success, and MBL with at least 12 months' follow-up. In addition, random effects meta-analyses of selected studies were applied to analyze the weighted mean difference of survival, success, and MBL between groups. Meta-regression analysis was conducted to investigate any potential influence of confounding factors.

RESULTS:

Twenty-one articles were included, analyzing a total of 1,948 Zi implants with a survival rate of 91.5% and a success rate of 91.6 % for 1,250 Zi implants. In addition, three studies were included in the quantitative synthesis and were meta-analyzed for the comparison of survival between Zi and Ti implants, with Zi implants having an 89 % greater risk of failure compared with Ti implants (OR = 1.89). There were no statistically significant differences ($P = .968$) in the success of Zi and Ti implants (odds ratio [OR] = 1.02; 95 % confidence interval [CI], 0.47-2.20). MBL (\pm SD) for Zi implants was 0.89 ± 0.18 mm, which was greater than the MBL for Ti implants (mean difference = 0.14 mm). Also, survival of Zi implants (91.5 %) was significantly lower than that of Ti implants (OR = 1.89). Metaregression analysis revealed a similar survival rate for one-piece versus two-piece implants. Similarly, no significant differences were found between immediate and delayed loading.

CONCLUSIONS:

The survival rate of Zi implants was significantly lower than that for the commonly used Ti implants. However, for certain clinical conditions, such as a thin tissue biotype or in the highly esthetic anterior area, Zi implants may offer some benefit when compared with Ti implants.

J DENT RES. 2017 JAN;96(1):38-46.

Clinical Outcomes of Zirconia Dental Implants: A Systematic Review

Pieralli S, Kohal RJ, Jung RE, Vach K, Spies BC.

ABSTRACT

To determine the survival rate and marginal bone loss (MBL) of zirconia dental implants restored with single crowns or fixed dental prostheses. An electronic search was conducted up to November 2015 (without any restriction regarding the publication time) through the databases MEDLINE (PubMed), Cochrane Library, and EMBASE to identify randomized controlled clinical trials and prospective clinical trials including >15 patients. Primary outcomes were survival rate and MBL. Furthermore, the influence of several covariates on MBL was evaluated. Qualitative assessment and statistical analyses were performed. This review was conducted according to preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines for systematic reviews. With the applied search strategy, 4,196 titles could be identified. After a screening procedure, 2 randomized controlled clinical trials and 7 prospective clinical trials remained for analyses. In these trials, a total of 326 patients received 398 implants. The follow-up ranged from 12 to 60 mo. Implant loss was mostly reported within the first year, especially within the healing period. Thereafter, nearly constant survival curves could be observed. Therefore, separate meta-analyses were performed for the first and subsequent years, resulting in an implant survival rate of 95.6 % (95 % confidence interval: 93.3 % to 97.9 %) after 12 mo and, thereafter, an expected decrease of 0.05 % per year (0.25 % after 5 y). Additionally, a meta-analysis was conducted for the mean MBL after 12 mo, resulting in 0.79 mm (95 % confidence interval: 0.73 to 0.86 mm). Implant bulk material and design, restoration type, and the application of minor augmentation procedures during surgery, as well as the modes of temporization and loading, had no statistically significant influence on MBL. The short-term cumulative survival rates and the MBL of zirconia implants in the presented systematic review are promising. However, additional data are still needed to confirm the long-term predictability of these implants.

A systematic review and meta-analysis on the clinical outcome of zirconia implant-restoration complex.

Haro Adánez M, Nishihara H, Att W3.

ABSTRACT

PURPOSE:

This systematic review evaluates the clinical outcome of zirconia implant-associated survival and success rates, marginal bone loss, and implant-restoration complex integrity.

STUDY SELECTION:

Using the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines, studies including ≥ 10 patients restored with zirconia implants supporting single crowns (SCs) or fixed dental prostheses (FDPs) prior to January 2017 were identified. Primary outcomes were survival rates and marginal bone loss around one and two-piece zirconia implants and the associated implant-restoration complex integrity.

RESULTS:

1349 studies were selected; after duplicate removal and title screening, 36 remained for full-text screening. 17 studies met the inclusion criteria: 2 randomized controlled clinical studies, 11 prospective clinical studies and 4 retrospective studies. In total, 1704 implants from 1002 patients were evaluated, including 1521 one-piece and 183 two-piece zirconia implants with follow-up between 1 and 7 years. The mean survival rate was 95 % (95 % CI 91-97 %). The overall mean marginal bone loss was 0.98mm (95 % CI 0.79-1.18); the mean marginal bone loss after 1 year was 0.89mm (95 % CI 0.60-1.18). No meta-analysis regarding prosthetic outcomes was possible.

CONCLUSIONS:

Survival and marginal bone loss values after one year for one-piece zirconia implants are acceptable, but long-term studies are required to support their clinical use. No particular restoration material can be recommended; this decision is apparently based on clinicians' preferences. Results from two-piece implants do not provide sufficient data to support their clinical use and no abutment or cementing materials for two-piece zirconia implants can be recommended.

Performance and outcome of zirconia dental implants in clinical studies: A meta-analysis.

Roehling S, Schlegel KA, Woelfler H, Gahlert M.

ABSTRACT

OBJECTIVES:

To evaluate implant survival, peri-implant marginal bone loss, technical, and biological complications as well as aesthetic outcomes of zirconia implants in clinical studies.

MATERIAL AND METHODS:

Electronic (Medline, Embase) and hand searches were performed to identify clinical studies published between January 2004 and March 2017 investigating zirconia dental implants with a mean follow-up of at least 12 months. Primary outcomes were implant survival and peri-implant marginal bone loss. Secondary outcomes included technical and biological complications as well as aesthetic outcomes. Meta-analyses were performed to estimate implant survival and marginal bone loss.

RESULTS:

From 943 titles, 264 abstracts were selected. Subsequently, 80 full-text articles were screened, and 18 studies were included for data extraction. One- (14 studies) and 2-piece zirconia implants (4 studies) were investigated. Commercially available (CA) (510 implants, 398 patients) and not commercially available (NCA) zirconia implants (618 implants, 343 patients) were identified. For CA implants (follow-up: 12-61.20 months), technical complications (1.6 %), implant fractures (0.2 %) and biological complications (4.2 %) were reported. Meta-analyses estimated 1- and 2-year survival rates of 98.3 % (95 % CI: 97.0 %-99.6 %) and 97.2 % (95 % CI: 94.7 %-99.7 %), respectively, and a mean 1-year marginal bone loss of 0.7 mm (95 % CI: 0.4-1.0 mm).

CONCLUSIONS:

Since 2004, the survival rates of CA implants significantly improved compared with NCA implants. CA 1-piece zirconia implants showed similar 1- and 2-year mean survival rates and marginal bone loss after 1 year compared with published data for titanium implants. However, more clinical long-term data are needed to confirm the presently evaluated promising short-term outcomes.

A systematic review of the survival and complication rates of zirconia-ceramic and metal-ceramic single crowns.

Pjetursson BE, Valente NA, Strasding M, Zwahlen M, Liu S, Sailer I.

ABSTRACT

OBJECTIVES:

The aim of the present systematic review was to analyze the survival and complication rates of zirconia-based and metal-ceramic implant-supported single crowns (SCs).

MATERIALS AND METHODS:

An electronic MEDLINE search complemented by manual searching was conducted to identify randomized controlled clinical trials, prospective cohort and retrospective case series on implant-supported SCs with a mean follow-up time of at least 3 years. Patients had to have been clinically examined at the follow-up visit. Assessment of the identified studies and data extraction was performed independently by two reviewers. Failure and complication rates were analyzed using robust Poisson's regression models to obtain summary estimates of 5-year proportions.

RESULTS:

The search provided 5,263 titles and 455 abstracts, full-text analysis was performed for 240 articles, resulting in 35 included studies on implant-supported crowns. Meta-analysis revealed an estimated 5-year survival rate of 98.3 % (95 % CI: 96.8-99.1) for metal-ceramic implant supported SCs (n = 4,363) compared to 97.6 % (95 % CI: 94.3-99.0) for zirconia implant supported SCs (n = 912). About 86.7 % (95 % CI: 80.7-91.0) of the metal-ceramic SCs (n = 1,300) experienced no biological/technical complications over the entire observation period. The corresponding rate for zirconia SCs (n = 76) was 83.8 % (95 % CI: 61.6-93.8). The biologic outcomes of the two types of crowns were similar; yet, zirconia SCs exhibited less aesthetic complications than metal-ceramics. The 5-year incidence of chipping of the veneering ceramic was similar between the material groups (2.9 % metal-ceramic, 2.8 % zirconia-ceramic). Significantly (p = 0.001), more zirconia-ceramic implant SCs failed due to material fractures (2.1 % vs. 0.2 % metal-ceramic implant SCs). No studies on newer types of monolithic zirconia SCs fulfilled the simple inclusion criteria of 3 years follow-up time and clinical examination of the present systematic review.

CONCLUSION:

Zirconia-ceramic implant-supported SCs are a valid treatment alternative to metal-ceramic SCs, with similar incidence of biological complications and less aesthetic problems. The amount of ceramic chipping was similar between the material groups; yet, significantly more zirconia crowns failed due to material fractures.

Is zirconia a viable alternative to titanium for oral implant? A critical review.

Sivaraman K, Chopra A, Narayan AI, Balakrishnan D.

ABSTRACT

PURPOSE:

Titanium based implant systems, though considered as the gold standard for rehabilitation of edentulous spaces, have been criticized for many inherent flaws. The onset of hypersensitivity reactions, biocompatibility issues, and an unaesthetic gray hue have raised demands for more aesthetic and tissue compatible material for implant fabrication. Zirconia is emerging as a promising alternative to conventional Titanium based implant systems for oral rehabilitation with superior biological, aesthetics, mechanical and optical properties. This review aims to critically analyze and review the credibility of Zirconia implants as an alternative to Titanium for prosthetic rehabilitation.

STUDY SELECTION:

The literature search for articles written in the English language in PubMed and Cochrane Library database from 1990 till December 2016. The following search terms were utilized for data search: "zirconia implants" NOT "abutment", "zirconiaimplants" AND "titanium implants" AND "osseointegration", "zirconia implants" AND compatibility.

RESULTS:

The number of potential relevant articles selected were 47. All the human in vivo clinical, in vitro, animals' studies were included and discussed under the following subheadings: Chemical composition, structure and phases; Physical and mechanical properties; Aesthetic and optical properties; Osseointegration and biocompatibility; Surface modifications; Peri-implant tissue compatibility, inflammation and soft tissue healing, and long-term prognosis.

CONCLUSIONS:

Zirconia implants are a promising alternative to titanium with a superior soft-tissue response, biocompatibility, and aesthetics with comparable osseointegration. However, further long-term longitudinal and comparative clinical trials are required to validate zirconia as a viable alternative to the titanium implant.

Zirconia compared to titanium dental implants in preclinical studies – A systematic review and meta-analysis.

Roehling S, Schlegel KA, Woelfler H, Gahlert M.

ABSTRACT

OBJECTIVES:

To evaluate whether zirconia implants demonstrate differences in hard and soft tissue integration compared to titanium implants in preclinical studies.

MATERIAL AND METHODS:

In March 2017, electronic (MEDLINE, EMBASE) and hand search was performed to identify preclinical studies comparing zirconia and titanium implants. Primary outcomes were bone-to-implant contact (BIC) and removal torque out (RTQ), respectively, push-in (PI) measurements. Secondary outcomes included biologic width (BW) dimensions.

RESULTS:

A total of 37 studies were included for data extraction after screening of 91 from 1,231 selected titles. Thirty-seven experimental studies using six different species were identified. The follow-up periods ranged between 0.4 and 56 weeks. For titanium, mean values of 59.1 % (95 % CI: 53.3 – 64.8), 102.6 Ncm (95 % CI: 81.5 – 123.6), and 25.1 N (95 % CI: 20.2 – 30.0) for BIC, RTQ, and PI were estimated, respectively. The mean values for zirconia were 55.9 % (95 % CI: 51.6 – 60.1), 71.5 Ncm (95 % CI: 51.1 – 91.9), and 22.0 N (95 % CI: 13.2 – 30.7) for corresponding parameters. Confounding factors such as animal species, implant material, loading protocol, and study or loading duration significantly influenced the outcomes. Similar qualitative soft tissue integration was reported for zirconia and titanium implants. However, faster maturation processes of epithelial and connective tissues around zirconia implants were assumed. Quantitatively, similar BW dimensions were evaluated for titanium (3.5 mm; 95 % CI: 2.9 – 4.2) and zirconia (3.2 mm; 95 % CI: 2.7 – 3.7), whereas the loading protocol significantly influenced the outcomes.

CONCLUSIONS:

Zirconia and titanium implants demonstrate a similar soft and hard tissue integration capacity. However, titanium tended to show a faster initial osseointegration process compared to zirconia. Importantly, not only material characteristics but predominantly animal species and study protocols can significantly influence the outcomes.