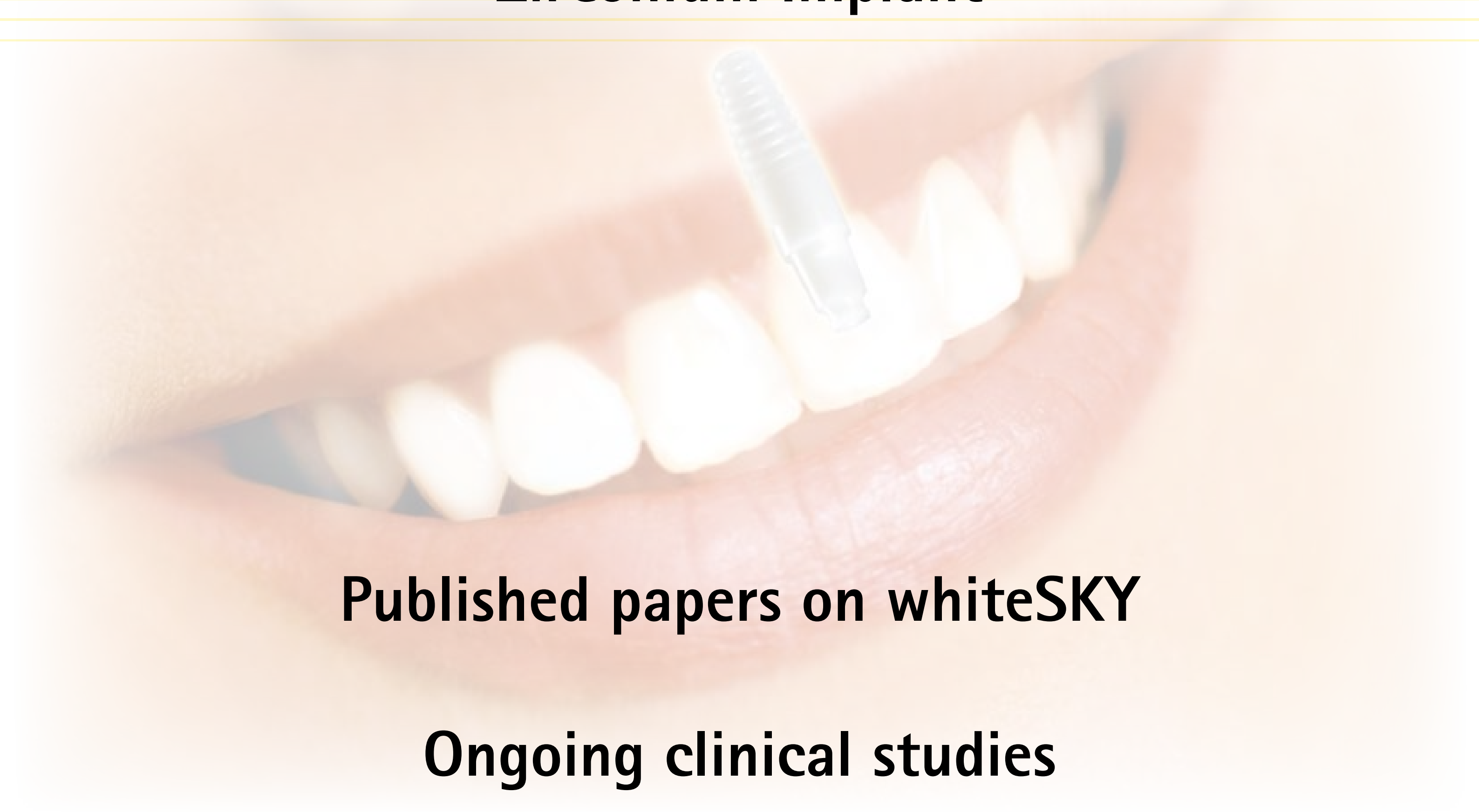
whiteSKY IMPLANT SYSTEM

whiteSKY
Zirconium Implant



Published papers on whiteSKY

Ongoing clinical studies

Literature list on zirconia implants

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whiteSKY
Zirconium Implant

Published papers on whiteSKY

15. Congresso Nazionale "Collegio Dei Docenti", Rome, April 2008

Implantat-supported prosthetic restoration with zirconium dioxide implants
A. Borgonovo O. Arnaboldi, D. Farronato, G. Tavecchia, G. Santoro, F. Pietrobon
(Clinica odontoiatrica e Stomatoologica,Scuola di Specializzazione in Chirurgia Odontostomatologica Universita' degli Studi di Milano, Dir: Prof. F. Santoro)

KIM, Germany, 05/2008
Effect on Regulation, Meridian-, Lymph und Immune Systems
Complementary Dentistry Implantology: Titanium - zircon dioxide
Christoph Arlom, Berlin

AO-Meeting 2008 Boston, USA, March 2008 - Poster presentation
Osteogenic Differentiation of Mesenchymal Progenitor Cells from Human teeth on different implant surfaces *in vitro*
Dr. Dr. Martin Scheer et. al.

Springer Publishing House International Vienna, Austria: Zahn&Arzt, April 2008
Closure of a complex gap in the upper anterior dentition with an all-ceramic restoration on a whiteSKY zirconium implant - Case report
Dr. Burghard PETER, Salzburg, Austria

Quintessenz Publishing House Berlin, Germany: Implantology - the magazine for the dental praxies, December 2007
Biocompatibility and Soft Tissue Integration of Single-stage
Surfacestructured Zirconia Implants – A Combined In Vitro / In Vivo Study
Zirconia, implants, biocompatibility, bone-implant contact, cell adhesion, osteoblasts
Daniel Rothamel, Daniel Ferrari, Monika Herten, Frank Schwarz, Jürgen Becker

spitta Publishing House, Balingen, Germany: ZMK – Special interest magazine for Dentistry, Management, Culture, November 2007
Concept and clinical use of one-piece zirconium dioxide ceramic implants
Dr. Joerg Neugebauer, University of Cologne

3. Remagener Physik Days, March 2007 - Poster presentation
Evaluation of Various Ceramic Implants After Immediate Loading
B. Nolte, J. Neugebauer, T. Buzug, M. Weinländer, V. Lecovic, F. Vizethum, C. Khoury, J. E. Zöller

AO-Meeting 2007 San Antonio, USA, März 2007 - Poster presentation
Immediate Loading of Ceramic Implants with Various Surfaces and Designs
J. Neugebauer, M. Weinländer, V. Lecovic, T. Buzug, F. Vizethum, C. Khoury, J. E. Zöller

Dent Implantologie, Flohr Verlag, September 2007
Ceramic implants in the posterior region – for the first time in dentistry after a period of 3000 years:
Metal-free restorations, fixed, biocompatible
Dr. Achim Sieper, MSc

Implantologie Zeitung, October 2007
Revolution of esthetic front teeth restoration by zirconia ceramic implants and crowns – case report
Dr. med. dent. Svea Baumgarten, MSc

15° Congresso Nazionale "Collegio Dei Docenti"
ROMA 16-17-18-19 aprile 2008

Implant-supported prosthetic restoration on zirconium dioxide implants

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Implant-prosthetic rehabilitation in the aesthetic anterior region presents a special challenge for implantologists. To achieve advantageous functional distribution of loads and an aesthetic structure of the periimplant soft tissue, correct positioning of the implants based on specified three-dimensional parameters is essential. Some authors discovered that an approximate thickness of 2 mm of the vestibular cortical bone avoids periimplant gingival recession. An adequate distance of implant-natural tooth or implant-implant allows to preserve both the hard and the soft tissue. To create an inter-dental papilla, an adequate attachment surface for the gingiva to the natural tooth is required. Accordingly, a minimum distance of the implant of at least 1.5-2 mm is demanded. If several implants are to be placed, an interimplant distance of at least 3 mm must be adhered to. If possible, the diameter of the prosthetic platform should be identical with the diameter of the missing root, i.e. in the anterior region, implants should have a diameter of 4 or 5 mm for the central incisors and the cuspids and 3-3.3 mm for the upper lateral incisors and the lower anterior teeth. The implant should be inserted 2-3 mm below the gingiva height and placed at the same distance to the surrounding structures (tissues). If these dimensions are adhered to, a highly natural emergence profile can be prepared. If the implant is mostly lowered in the apical direction, excessive bone resorption may result . If the implant is placed almost exclusively in coronal bone, a suitable emergence profile is not obtained since the metal components of the implant and the suprastructure elements (abutments) are exposed and the aesthetic result is unsatisfactory unless zirconium dioxide implants are used. Major problems that may occur over time are bone resorption of the vestibular cortical bone and recession of the periimplant soft tissue. The titanium components that are normally used may be visible and cause discoloration of the gingiva which may be quite unpleasant to the patient, in particular in cases of a high smile line. The use of ceramic components based on alumina or yttrium-stabilized zirconium oxide in conjunction with all-ceramic restorations allows to solve aesthetic problems and achieve high strength, which was examined in animal experiments in vivo and in vitro. The authors present a clinical-therapeutic treatment protocol for the restoration of the aesthetic regions through the use of the most recent zirconium dioxide implants.

MATERIALS and METHODS

Yttrium-stabilized zirconium dioxide implants made of brezirkon (whiteSKY from bredent medical, Senden, Germany) were used for treatment of single tooth gaps and inter-dental gaps in the dental clinic of the institute for dental training of the University of Milan.

Zirconium dioxide is a highly resistant ceramic material which is obtained by cleaning zirconium dioxide and zirconium silicate. The cleaning process is carried out by injecting zirconium silicium ($ZrSiO_2$ particles) into a plasma flame: the zirconium silicium is melted and decomposes into ZrO_2 and SiO; first the ZrO_2 solidifies in a dentritic structure in the colder section of the plasma chamber; further cooling results in solidification of the silicium and the formation of a glassy conglomerate of the zirconium dioxide constituents. This synterization process is the first stage in the processing sequence to shape the zirconium dioxide ceramic elements that are to be processed later on. Partially yttrium-stabilized zirconium dioxide has been used in dentistry for quite some time to produce die suprastructures, crowns and bridges using CAD/CAM systems. Highly promising results were obtained in clinical studies. Zirconium dioxide features three polymorphous, temperature-related structures (cubic, tetragonal and monoclinic). Since these changes during the cooling phase are associated by a volume increase of 3-5%, internal stress results in pure zirconium dioxide which leads to crack formation. By adding oxides (MgO, CaO) that stabilize the structure, dangerous increase in volume is avoided and the tetragonal phase is stabilized until room temperature is reached. The implant used in the clinical test phase featured a conical implant body and a double, cylindrical thread. To obtain a rough surface, the implant body had been sandblasted and the prosthetic section (with a height of 8.8 mm) was smooth. The protocol called for using a guide device to position the implants; this guide device was prepared on a diagnostic wax-up and a set of special diamonds burs was used to prepare the prosthetic section. The implants were inserted using a torque of 40 Ncm (or a higher torque) and a temporary restoration was placed on the implants; occlusal and lateral stress was avoided. For implants that were inserted with a lower torque a temporary restoration was fabricated which included the adjacent teeth as abutments or that was attached to the adjacent teeth by means of composite bonding (for 6 - 8 weeks) in order to avoid mobility and thus loss of the implant. The definitive restoration was integrated after 6 months for implants inserted into native bone and after 8-9 months for implants in augmented bone. X-ray pictures were taken during the follow-up (every six months). 18 implants have been inserted in 8 patients since 2007: a single tooth restoration was fabricated for 3 patients; several implants were placed in 7 cases. The implants were inserted into the augmented bone of 5 patients (1 patient with autogenous bone, 4 patients with bone replacement material); there was a total of 9 implants in the augmented bone and 9 implants in the native bone. The most frequently used implant featured a diameter of 4 mm and a length of 12 mm. A single failure was documented for an implant placed in the premolar region with a temporary crown that was not attached to the adjacent teeth; loss occurred 3 months after placement of the implant.

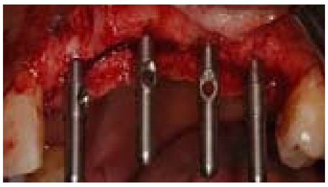
CLINICAL CASE


Pre-surgical OPG


Initial situation - front view


Lateral view of the edentulous quadrant


Mucoperiosteal flap with exposure of the remaining ridge - front view


Parallell indicators in situ - front view


Final milling in situ to confirm the correct implant alignment


Zirconium dioxide implants in situ


Suture


Inserting the original partial denture rebased with acrylate


Healing of tissue after 4 months


Temporary restoration after 4 months


Postoperative OPG

DISCUSSION

Along with the growing expectations of the patients the demand for aesthetic restorations has increased tremendously during the past few years. In order to satisfy all demands, numerous solutions were suggested: some authors started to use white ceramic implants to replace the root of tooth not only with regard to the function but also to esthetics; it was attempted to reproduce the shade of the tooth. At the beginning of the 70s the first ceramic implants were examined in clinical tests; the material used to produce these implants was aluminium oxide (Al_2O_3) (Tübingen immediate implant). This type of implant had a high failure rate which was attributed to insufficient primary stability, a smooth surface and a variety of implant losses after 10 years due to material fatigue of Al_2O_3. Already in 1992 Hyashi et al. demonstrated in histological studies that 1 and 3 months after placement of the implants there were no significant differences in the affinity to bone between the materials in use - alumina, zironium dioxide (bioinert) and stainless steel and sintered hydroxyapatite. In 1993 Akagawa et al. demonstrated the osseointegration of zirconium dioxide implants in experiments on Beagle dogs. Clinical and histological tests 3 months after insertion of the implants did not reveal any differences in deposition of bone compared to titanium. At the height of the ridge, however, loaded implants revealed a higher level of vertical bone resorption and it was concluded that non-loading during the intial phase contributed to achieving osseointegration. Chang et al. examined bone regeneration and the relevance of implant positioning of three different ceramic implants (alumina, zirconium, hydroxapatite) 6 months after insertion of the implants; the results indicated that the differences in bone regeneration depended on the osseoconductivity of the materials and the tissue's capacity of bone regeneration In 1997 Thomsen et al. studied the interaction between gold, oxidized zirconium, titanium and bone tissue: the morphometric analysis showed that after 1 and after 6 months there was a smaller quantity of bone between the threads and a smaller area at the bone-implant contact for gold than for titanium and zirconium. In experiments on dogs Dbruille et al. examined the contact area (for titanium, alumina and zirconium dioxide implants) between bone tissue and implant with the help of a morphometric analysis and a scanning electron microscope. The study did not produce any relevant difference between the three implant types. In 1999 Guglielmotti et al. examined the osseointegration of zirconium dioxide, aluminium and zirconium dioxide implants coated with diamond-like carbon in experiments in rats. One month after placement of the implants, the coated zirconium dioxide implants produced a better result than the titanium implants. Aluminium, however, caused toxic tissue reactions with bone lesions. In 1998 Akagawa et al. examined zirconium dioxide implants placed in monkeys, which were partially fixed under different load patterns. Three different restoration types were inserted after three months: single implant (without support), implant-implant and implant-natural tooth. 12 and 24 months after loading, the periimplant tissue was examined histologically and histomorphometrically. No significant clinical differences were determined but direct bone apposition was observed for all groups. By taking the size of the contact area into account, a lower level of apposition was found for the non-supported implants after 12 months; the cause for this difference is unknown but could be attributed to the parafunctions and the tongue pressure. Histomorphometrically, a bone contact area ranging from 66 to 81 % was found after 24 months: these data show that there was no difference in the stability for all three fixation types and all types resulted in osseointegration without fracture of the implant. In a study on rabbits Scarano et al. examined bone growth behavior of twenty zirconium dioxide implants after one month. Formation of new bone around the implants and a high number of osteoblasts, which adhered directly to the zirconium dioxide, were observed. No inflammatory cells were detected, which confirms the high biocompatibility and osseoconductivity of the zirconium dioxide implants. In a histological study Kohal et al. examined the osseointegration of cylindrical, yttrium-stabilized zirconium dioxide implants in monkeys and compared it to the osseointegration of titanium implants of the same type under load. When inserting the implants, all of them revealed good primary stability; 9 months after the insertion, the implants were loaded and no significant difference to the titanium implants was found after a healing period of 14 months. This important study allows to conclude that the zirconium dioxide implants showed a similar osseointegration behavior as the titanium implants. In a study (histological and biomechanical) on 12 rabbits in 2005 Sennerby et al. examined the reaction of bone to machined and non-machined zirconium dioxide implants in comparison to titanium implants. A microscopical examination of the bone-implant contact area was carried out. The best results were produced by the roughest surface of the titanium implants followed by the machined and the non-machined zirconium dioxide implants. The study revealed a considerable reaction of the bone for the modified zirconium dioxide implants after 6 weeks. The machined implants showed a similar level of resistance as titanium implants, which allowed to achieve perfect stability. Oliva et al. examined the success of 100 zirconium implants placed in the anterior and posterior region and also in the augmented bone and for sinus lifting in a follow-up after one year. The anterior implants were immediately loaded; the definitive restoration was inserted in non-augmented bone after 4 months and in augmented bone after 8 months. Implants with a lower torque of 35 Ncm were fixed at the adjacent teeth or at implants to reduce potential movement as far as possible and thus to avoid failure. The results showed a success rate of 98 % and confirm the enhanced capacity of the rough zirconium dioxide surface to support osseointegration. In July 2007 Sollazzo et al. once more confirmed that zirconium dioxide - thanks to its biocompatibility and its chemical and mechanical properties - is widely used. Literature research has showed that research and scientific development triggered an evolution since the days of the first aluminium oxide implants to the latest generation of partially yttrium-stabilized zirconium dioxide implants.

CONCLUSION

To sum up it can be stated that it is logical to use a ceramic material for the aesthetic regions; zirconium dioxide is particularly suitable since it features tissue friendliness and resistance comparable to titanium. Clinical results obtained so far with more than 320 inserted implants and failure of only 6 implants, i.e. a success rate of more than 95 %, are highly promising. The increased tensile strength, superior mechanical properties, possbility of easy fabrication of the prosthetic restoration and the unsurpassed integration into the tissue and the aesthetic appearance provide perfect preconditions for partially yttrium-stabilized zirconium dioxide to become the most commonly used material in implant dentistry. Despite the excellent results, the use of zirconium dioxide implants can not yet be generally recommended since there is no histological study on humans and no clinical follow-up over a period of more than 24 months.

KIM, Germany, 05/2008

Effect on Regulation, Meridian-, Lymph und Immune Systems Complementary Dentistry Implantology: Titanium – zircon dioxide

Christoph Arlom, Berlin

Implants are artificial tooth roots used to secure in place fixed and/or removable dentures. In 2007 dentists and dental surgeons in German speaking countries inserted more than 600.000 implants. There are over 100 mostly titanium based implant systems currently being used. How can the use of these implants be evaluated?

Osteogenic Differentiation of Mesenchymal Progenitor Cells From Human Teeth on Different Implant Surfaces *in vitro*

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Introduction

Osteointegration of dental implants on the cellular level depends on surface characteristics as well as attachment of surrounding osteoblasts. Recruitment as wells migration and differentiation of mesenchymal progenitor cells (MPCs) into the osteogenic lineage are crucial steps in osteointegration. In order to improve the osteoconductive properties of implants, coating with osteoinductive agents, mainly bone morphogenetic protein-2 (BMP-2) have been propagated. The *in vitro* approach with cell culture models is a useful tool for studying cell-biomaterial interactions. Up to now only limited data investigating cell attachement and differentiation of MPCs on different titanium and zirconia ceramic surfaces is available. The purpose of our *in vitro* study was to compare the influence of different implant surfaces on proliferation, osteogenic differentiation and attachment of MPCs derived from human pulp tissue. Additionally the effects of BMP-2 on MPCs formation on implant surfaces were evaluated.

Material and Methods

MPCs rich cultures form human pulp tissue were cultivated in DMEM, supplemented with 10% FCS, penicillin/streptomycin and 50 mg/ml ascorbic acid under standard conditions (Fig 1). MPCs (5000 cells) from passages 3-6 were cultivated on 10 mm Titanium (blasted and blasted/etched) and ZrO-ceramic discs with grid blasted surface (Bredent Medical, Senden, Germany, Fig. 2). Low cell adherence 24-well plates were used for all experiments in order to evaluate cell growth on discs only. Cell viability was assessed quantitatively by WST-1 assay (Roche, Germany) on day 2, 4 and 7 respectively. The osteogenic phenotype of adherent cells was proved by alkaline phosphatase assay. Cell numbers were counted on different surface specimens after Collagen I staining. The effect of BMP-2 supplementation (0.2 µg/ml, Invitrogen, Germany) on MPC adherence over a 7 day period as well as incorporation of BMP-2 on the implant specimens. Biomimetic coating of implant specimens was performed according to LIU et al., 2005. Briefly, implant specimens were coated with a layer of calcium phosphate and BMP-2 was incorporated (0.15 µg/ml) prior to seeding of MPCs.

Results

Cell viability tested with WST-1 assay on blasted titanium and Zirconia ceramic as well as blasted and etched Titanium surfaces showed no significant differences (Fig. 3). BMP-2 supplementation of MPCs over 1 week revealed only minor effects on cell differentiation. However the alkaline activity on all specimens was increased (Fig. 4). Collagen I Expression production as prove for bony differentiation is shown in MPCs (Fig. 5). On Zirconia ceramic specimens the number of proliferating cells was increased significantly in contrast to Titanium specimens (Fig. 6-9). The BMP coated discs showed an significantly increased activity of bone specific alkaline phosphatase after 7 days of culture (Fig. 10).

Conclusion

MPCs could be cultivated on all tested surfaces and the cell viability in different experiments was similar on Titanium and Zirconium dioxide as well. The supplementation of BMP-2 over 1 week increased the number of MPCs especially on Zirconia ceramic disks significantly. However, the alkaline phosphatase activity was only slightly increased. Since differentiation of MPCs into the osteogenic phentotype needs more time than one week, the short observation could explain the missing effect on alkaline phosphatase activity. The biomimetic calcium-phosphate coating and BMP-2 incorporation seems to be an easy and promising approach in compromised implantation sites.

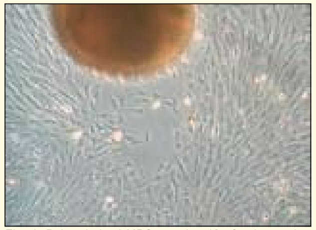
Fig. 1: Pulpa derived MPCs on day 12 after harvesting


Fig. 2: Blasted Titanium surface (left), blasted Zirconium dioxide surface (middle) and etched/blasted Titanium specimen (right) all 1 cm diameter

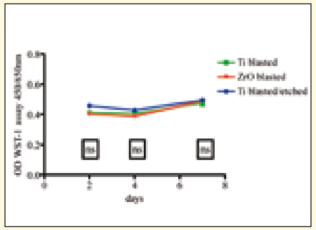

Fig. 3: Cell viability after 2, 4 and 7 days in culture (ns= non significant, ANOVA Test)

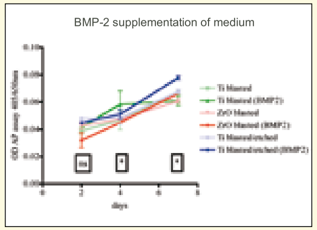

Fig. 4: Alkaline phosphatase activity with BMP-2 supplemented medium

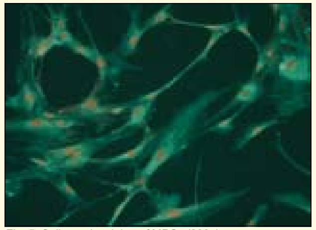
Fig. 5: Collagen I staining of MPCs (200x)

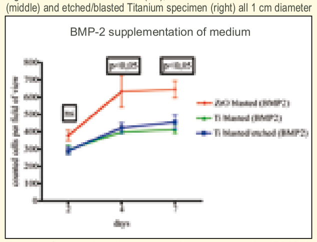

Fig. 6: Counted cells on day 2, 4 and 7 with BMP-2 supplemented medium (ANOVA-Test)

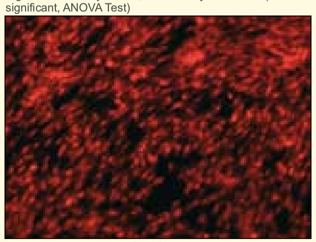
Fig. 7: Nuclear staining of MPCs on blasted titanium surface on day 7

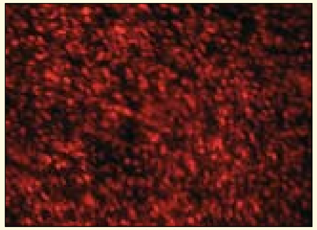
Fig. 8: Nuclear staining of MPCs on blasted and etched titanium surface on day 7

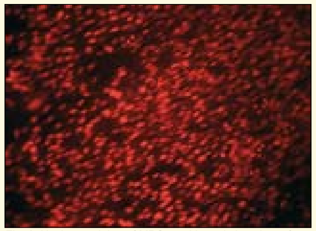
Fig. 9: Nuclear staining of MPCs on blasted zirconia surface on day 7

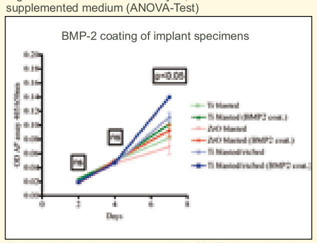

Fig. 10: Alkaline phosphatase activity of BMP-2 coated implant specimens (ns= not significant, ANOVA test)

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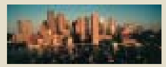

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Closure of a complex gap in the upper anterior dentition with an all-ceramic restoration on a whiteSKY zirconium implant – Case report

Dr. Burghard PETER, Salzburg, Austria

The ceramic material zirconium oxide is used more and more frequently in implantology because of economic and medical reasons. The specific properties of this material result in high resistance to fracture and flexural strength and excellent biocompatibility. In addition to zirconium abutments and crowns, there is a growing demand for zirconium oxide implants not only among patients with known allergies to metals.

In the case described in this report, a zirconium oxide implant (whiteSKY, bredent medical) was inserted in region 21 of a 44-year old female patient in a two-stage approach following bone augmentation and tissue regeneration. After a healing period of 3 months a zirconium oxide crown was integrated. 12 months after completion of the treatment, stable and highly aesthetic results were achieved.

According to what is currently known, all-ceramic restorations appear to be fully functional alternatives to conventional restorations based on titanium materials.

Quintessenz Publishing House Berlin, Germany: Implantology - the magazine for the dental praxies,
December 2007
The original article is written in German.

Biocompatibility and Soft Tissue Integration of Single-stage Surfacestructured Zirconia Implants – A Combined In Vitro / In Vivo Study

Zirconia, implants, biocompatibility, bone-implant contact, cell adhesion, osteoblasts

Daniel Rothamel, Daniel Ferrari, Monika Herten, Frank Schwarz, Jürgen Becker

Zirconia implants are now increasingly used in oral rehabilitation to improve the esthetic result while providing comparable therapeutic safety. The present study report describes cell-culture and animal experiments related to the biocompatibility and soft tissue integration of single-stage surfacestructured zirconia implants (whiteSKY, bredent medical, Senden, Germany). The cell-culture experiment included groups of 32 specimens, each with sandblasted or machined zirconia surfaces or with a polished titanium surface. The specimens were incubated with cells reminiscent of SAOS-2-osteoblasts, examining cell proliferation at 2 hours, 2 days, 5 days, and 7 days by ATP assay (n = 6). Aspects of cellular morphology were examined under the scanner electron microscope (n = 2). The positive control consisted of tissue culture polystyrene not spiked with specimens. In the

animal experiments, the mandibular molars of four dogs were extracted; after 2 months of healing, each animal received 2 surface-structured zirconia implants in a transgingival procedure. The implants were retrieved after 4, 14, 28, and 56 days (n = 2). Following histologic processing of the hard tissues, the specimens were examined, and the bone-implant contact (BIC) area was determined as an indicator of bony integration. Proliferation of SAOS-2 osteoblasts could be demonstrated on all tested surfaces, with the structured zirconia surface exhibiting a higher proliferation of cells than either the machined titanium surface or the sandblasted zirconia surface ($p < .05$, ANOVA). Scanner electron microscope studies showed comparable cell morphologies, although cell adhesion seemed to occur earlier on machined zirconia. Histomorphometric analysis showed that the BIC increased

steadily over time, from 44.8% ± 2.6% on day 4 to 59.5% ± 1.2% on day 14, 63.5% ± 2.6% on day 28 and 71.8% ± 3.9% on day 56. Given the small number of cases (n = 2), no inductive statistical analysis of the BIC was performed. The examined zirconia implant system is highly biocompatible and osseointegrates rapidly, therefore meeting the requirements for dental implants.

spitta Publishing House, Balingen, Germany: ZMK – Special interest magazine for Dentistry, Management, Culture, November 2007

Concept and clinical use of one-piece zirconium dioxide ceramic implants

Dr. Joerg Neugebauer, University of Cologne

There are numerous good reasons for the use of ceramic implants made from zirconium oxide: excellent esthetic appearance, soft tissue management, high patient acceptance and considerably reduced accumulation of plaque. Dentists, however, need to ensure proper usage of the material and to adapt the treatment procedure, which differs from that of titanium implants. The one-piece implant body, for example, must be protected against any micromovement and healing under such conditions can not be attained by a non-functional implant restoration. To obtain such conditions, on the other hand, high primary stability is needed which is achieved by the preparation of the implant site. All ceramic implants require a standard healing period of six months. The detailed procedure is described in this publication based on the use of whiteSKY implants.

Evaluation of Various Ceramic Implants After Immediate Loading

B. Nolte [1], J. Neugebauer [1], T. Buzug [2], M. Weinländer [3], V. Lecovic [4], F. Vizethum [3], C. Khoury [5] and J.E. Zöller [1]

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[3] Private Dental Practice for Implantology and Periodontology, Vienna
[4] Department of Periodontology, University of Belgrade
[5] School of Dentistry, University of Beirut

Introduction

In the past clinical use of ceramic implants showed nice soft tissue behavior but clinical success was compromised due to lack of osseointegration in the early stage and mechanical complication like fracture under occlusal load long term. Materials like yttrium stabilized zirconia promise higher mechanical stability. While mechanical stability can be tested at a high level of safety by in-vitro-testing, the course of osseointegration has to be determined under in-vivo conditions. A pilot study on four mongrel dogs was performed to compare the course of osseointegration of root-form and parallel-wall one-piece ZrO_2-ceramic implants in comparison to titanium implants.

Material and Methods

A total of 64 implants were placed under conditions of immediate loading. The root form ceramic implants (whiteSKY, bredent medical, Senden, Germany) had machined (CM), grit-blasted (CG) and a collagen-coated (CC) surface. The control implants were cylindrical ceramic implants (CZ) (Z-Lock, Z-Systems, Konstanz, Germany) and titanium root form implants (TG) (SKY, bredent medical, Senden, Germany). The bone-to-implant contact was evaluated by flourescence and thin grinding histological sections and the 3d-evaluation of µ-computertomography.

Experimental Design

Tissue punch for flap less implant procedure

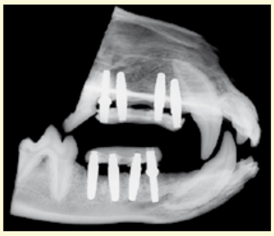
Implant site preparation according to the bone quality for placement of SKY implants

Seating of three whiteSKY and one titanium control implant

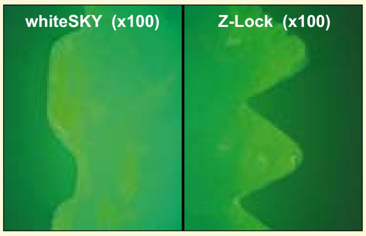
Immediate restoration at end of surgery with acrylic bridge

Results

After removal of the premolars a healing period of 8 weeks was applied. In each quadrant four implants were placed according to the test plan and immediate restoration with a resin bridge was performed. The root form implants showed a higher insertion torque than the parallel-wall implants. If an insertion torque above 50 Ncm occurred, the implant sites received an additional preparation to avoid over-compression of the peri-implant bone. After 3 months of loading the animals were sacrificed and radiological and histological investigations were performed. Two implants with machined surfaces showed no osseointegration. All other implants were stable. The bone-to-implant-contact was ranked in the following order CM < ZC < CG < TG < CC. The preliminary result of the histomorphometric evaluation shows a woven structure at the peri-implant bone for the conical implants. The cylindrical implants showed a concentric formation of the peri-implant bone remodelling.

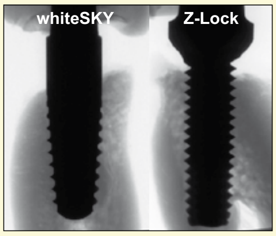


Radiological control of specimen with complete implant bridges in maxilla and mandible

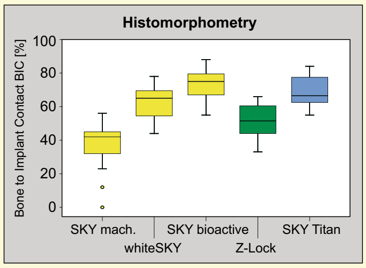


Woven bone structure for whiteSKY implant

Concentric bone remodelling for Z-Lock implant



µ-CT image of whiteSKY and Z-Lock implant for digital histomorphometry



Discussion

The use of ceramic implants is possible if a high primary stability could be achieved and a stabilization of the implants within one bridge is possible. Due to the one piece design special clinical consideration should be performed to achieve a high clinical success. Conical implants with a standardized undersized implant cavity inducing micro-fractures show a earlier bone remodelling in comparison to cylindrical implants.

3. Remagener Physiktage
(RPT 2007)
- Schwerpunkt Biomedizinische Technik -
mit dem
2. Workshop für Medizinische Robotik, Navigation und Visualisierung
(MRNV 2007)
RheinAhrCampus Remagen
7.-9. März 2007

Dr. Joerg Neugebauer
Interdisciplinary Outpatient Dept. for Oral Surgery and Implantology
Dept. for Craniomaxillofacial and Plastic Surgery
University to Cologne
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Immediate Loading of Ceramic Implants with Various Surfaces and Designs

Jörg Neugebauer[1], Michael Weinländer[2], Voja Lecovic[3], Thorsten Buzug[4], Charles Khoury[5], Freimut Vizethum[1], Joachim E. Zöller[1]

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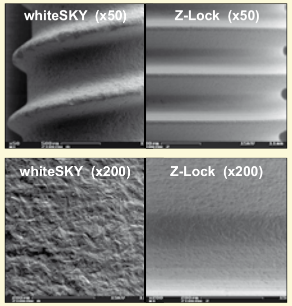
[4] University of Applied Sciences, Remagen, Germany
[5] School of Dentistry, University of Beirut

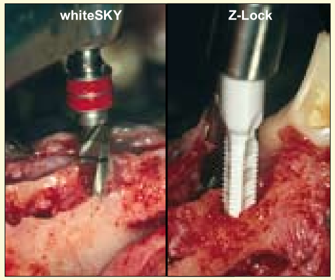
Introduction

In the past clinical use of ceramic implants showed nice soft tissue behavior but clinical success was compromised due to lack of osseointegration in the early stage and mechanical complication like fracture under occlusal load long term. Materials like yttrium stabilized zirconia promise higher mechanical stability. While mechanical stability can be tested at a high level of safety by in-vitro-testing, the course of osseointegration has to be determined under in-vivo conditions. A pilot study on four mongrel dogs was performed to compare the course of osseointegration of root-form and parallel-wall one-piece ZrO_2-ceramic implants in comparison to titanium implants.

Material & Method

A total of 64 implants were placed under conditions of immediate loading. The root form ceramic implants (whiteSKY, bredent medical, Senden, Germany) had machined (CM), grit-blasted (CG) and a collagen-coated (CC) surface. The control implants were cylindrical ceramic implants (CZ) (Z-Lock, Z-Systems, Konstanz, Germany) and titanium root form implants (TG) (SKY, bredent medical, Senden, Germany).



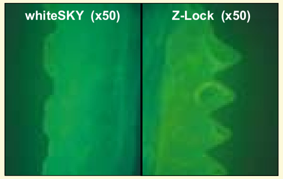


Bone adapted preparation with different burs

Thread forming by zirconia thread tap

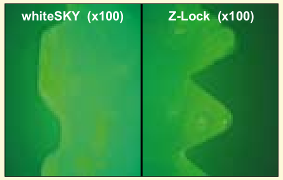
Results

After removal of the premolars a healing period of 8 weeks was applied. In each quadrant four implants were placed according to the test plan and immediate restoration with a resin bridge was performed. The root form implants showed a higher insertion torque than the parallel-wall implants. If an insertion torque above 50 Ncm occurred, the implant sites received an additional preparation to avoid over-compression of the peri-implant bone. After 3 months of loading the animals were sacrificed and radiological and histological investigations were performed. Two implants with machined surfaces showed no osseointegration. All other implants were stable. The bone-to-implant-contact was ranked in the following order CM < ZC < CG < TG < CC.



Complete bone coverage similar to a contact osteogenesis

Combination of contact and distance osteogenesis



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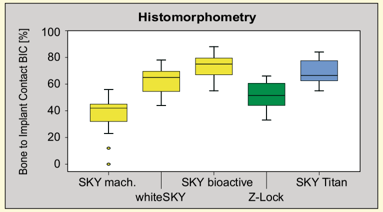

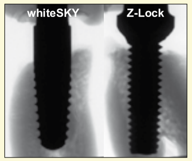

µ-CT image of whiteSKY and Z-Lock implant for digital histomorphometry

Radiological control of specimen with complete implant bridges in maxilla and mandible

Academy of Osseointegration
Annual Meeting
March 8-10, 2007
San Antonio, TX

Dr. Jörg Neugebauer
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University to Cologne, Head: Prof. Dr. Dr. Joachim E. Zöller
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Experimental Design

Tissue punch for flap less implant procedure

Implant site preparation according to the bone quality for placement of SKY implants

Seating of three whiteSKY and one titanium control implant

Insertion of SKY implants and Z-Lock implant after flap preparation

Seating of vacuum stent for fabrication of chair-side temporary bridge

Immediate restoration at end of surgery with acrylic bridge

Conclusion

Ceramic implants show osseointegration also under conditions of immediate loading. High primary stability and stabilization of the implants within one bridge provide sufficient protection of implant interface against micro-movement. Due to the one piece design, clinical procedures have to support these aspects for reliable clinical success.

0PNEU1GB

whiteSKY IMPLANT SYSTEM

Dent Implantologie Flohr , 09/2007

Ceramic implants in the posterior region – for the first time in dentistry after a period of 3000 years: Metal-free restorations, fixed, biocompatible

Dr. Achim Sieper, MSc Implantology

Original article in German

Ceramic implant restorations have been well established in oral implantology as well as in the field of endoprosthetics for numerous years. Basically, the idea behind the use of ceramic implants in the past was to avoid dark crown margins in the anterior region even in cases of gingival recession. Yet there are only a few publications about one-piece implants used to improve the aesthetic appearance in the anterior region. This may be attributed to the fact that one-piece ceramic implants rendered aesthetic alignment of anterior crowns quite difficult. Literature, however, documents much more and highly aesthetic cases of restorations with angled, aesthetic ceramic abutments. Without any doubt, the introduction of the zirconium dioxide material brought new life to the discussion about ceramic implants.

whiteSKY
IMPLANT SYSTEM

Implantologie Zeitung, October 2007

Revolution of esthetic front teeth restoration by zirconia ceramic implants and crowns – case report.

Dr.med. dent. Svea Baumgarten, MSc Implantologie

Summary: The restitution of an age-conforming and esthetically appealing front teeth profile by zirconia ceramic implants (bredent medical whiteSKY) in position 5,3,3,2 of a 34-years old male patient with persisting primary teeth (hypodontia) is presented and documented. The prospects for success of this measure are dependent on adequately structured and dense bone, on primary stability of the implant and on the prevention of micromotions during the extended phase of osseointegration. The biocompatibility of zirconia ceramics and their esthetic aspects appear to surpass those of titanium.

whiteSKY
Zirconium Implant

Current Clinical Studies

Universitätsklinikum Schleswig-Holstein (University Clinic of Schleswig-Holstein), Campus Kiel

Institute: Klinik für Mund-, Kiefer- und Gesichtschirurgie
(Clinic for Oral and Maxillo-facial Surgery)
(Head: Prof. Dr Dr. J. Wiltfang)

Study performed by: Prof. Dr. Dr. J. Wiltfang

Subject: **Prospective examination concerning the use of zirconium oxide ceramic implants for interdental spaces in the upper and lower jaw**

The objective of the study is to examine and evaluate the survival rate and the parameters of success of zirconium oxide ceramic implants in 25 patients over a period of 2 years.

The target parameters of this study are the survival rate of the implants, the stability of the implants which are determined with the help of periotest measurements after the insertion of a temporary restoration, and other clinical parameters such as bleeding on probing and probing depths.

Universität Köln (University of Cologne)

Institute: Dental Surgery and Oral and Maxillofacial Surgery

Head: Prof. Dr. med. Dr. med. dent. E.J. Zöller

Study performed by: Dr. Joerg Neugebauer

Subject: **Histological comparison of different ceramic implants used in a study in dogs**

The objective of the study is the comparison of osseointegration of various zirconium dioxide implants, in particular the whiteSKY and Z-Lock implants, which were placed within the scope of a controlled study in dogs in combination with titanium implants.

Universität Belgrad

Institute: Dept. Oral Surgery. Prof. Dr. V. Lekovic.

Study performed by: Prof. Dr. V. Lekovic

Subject: **Comparison of the survival rate and stability of immediately loaded titanium or zirconium implants**

The goal of this study will be to investigate the survival rate and stability of immediately loaded titanium or zirconium implants. A minimum of 15 Kennedy class I edentulous patients with posterior mandible bilateral extensions will be included in the study. Patients should have their own dentition in opposing jaw, or implant restorations that are at least six months old.

University of Freiburg

Institute: Unversitätsklinik für Zahn, Mund- und Kieferheilkunde
(University Clinic for Dentistry, Oral and Maxillofacial Surgery)

Study performed by: Prof. Dr. R.J. Kohal

Subject: **Survival rate and resistance to fracture of whiteSKY Zirconium dioxide implants after simulated chewing**

The objective of this study is to examine the survival rate and resistance to fracture of whiteSKY ZrO^2 implants - in the milled and non-milled condition - using in-vitro test methods.

University of Regensburg

Institute: Klinik und Poliklinik für MKG-Chirurgie
(Clinic and Policlinic for Oral and Maxillofacial Surgery)

Study performed by: Prof. Dr. Dr. Torsten E. Reichert
Director of the Clinic

Subject: **Surgical protocol for ceramic implants**

The subject of this study is the evaluation of the surgical protocol for ceramic implants based on the example of the whiteSKY implant for safe insertion of the implants in the various indications with the respective recommended torques to ensure long-term success of implant placement.

white **SKY**
IMPLANT SYSTEM

University of Dresden
University Clinic Carl Gustav Carus of the Technical University of Dresden

Institute: Clinic and Policlinic for Oral and Maxillofacial Surgery

Study performed by: Prof. Dr. med. habil. Dr. med. dent. Eckelt
Director of the Clinic

Subject: **Animal experimental evaluation of whiteSKY implants in the osseous implant site of the minipig**

The objective of this experimental study is to examine the osseous integration (healing) of whiteSKY implants during the early stage. The objects that are examined in this study are dental implants made from zirconium oxide ceramic.

Universitity of Bari, Italy

Institute: Dept. For Dental medical care and oral surgery
(Prof. Roberto Grassi)

Study performed by: Dr. Walter Wille-Kollmar

Subject: **Immediate loading of zirconium implantats in the front with temporary crowns made from a diagnostical wax model.**

Clinic Ludwigshafen

Institute: Clinic for Oral and Maxillofacial Surgery Ludwigshafen

Study performed by: Adj. Prof. Dr. Dr. Horst E. Umstadt

Subject: **Bone and soft tissue integration of implants – a comparison of titanium vs. zirconium implants**

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Abstracts and list of literature

Zirconium implants in implantology

Quintessenz Publishing House Berlin, Germany: Implantology - the magazine for the dental praxies, December 2007
Zirconia in Implantology Fundamentals and Actual Aspects
Joachim Tinschert, Kosta Tokmakidis, Peter Latzke, Gerd Natt, Hubertus Spiekermann

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Osseointegration and Clinical Success of Zirconia Dental Implants: *A Systematic Review*
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Metal Allergies - Clinically Relevant in Implant Dentistry?
Regina Fölster-Holst, Peter Thomas

Clin Oral Implants Res., October 2007
Zirconia implants with varying surface textures
Gahlert M, Gudehus T, Eichhorn S, Steinhauser E, Kniha H, Erhardt W.

Clinical Implant Dentistry and Related Reserch, Volume 7, Supplement 1, 2005
Bone Tissue Responses to Surface-Modified Zirconia Implants: A Histomorphometric and Removal Torque Study in the Rabbit
Lars Sennerby, DDS, PhD; Amir Dasmah, DDS; Birgitta Larsson, PhD; Mattias Iverhed, MSc

J Periodontol. 2004 Sep; 75(9):1262-8.
Loaded custom-made zirconia and titanium implants show similar osseointegration: an animal experiment.
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Are restorations made from zirconium dioxide radioactive and can they cause cancer?
By Dr. med. dent. Johann Lechner

Quintessenz Publishing House Berlin, Germany: Implantology - the magazine for the dental praxies,
December 2007

Zirconia in Implantology Fundamentals and Actual Aspects

Joachim Tinschert, Kosta Tokmakidis, Peter Latzke, Gerd Natt, Hubertus Spiekermann

KEYWORDS
Zirconia, yttrium oxide, phase transformation, implant material, all-ceramic abutment, fracture strength

Yttrium oxide-reinforced zirconia, a polycrystalline, fine-grained material in a metastable tetragonal crystal phase, is almost exclusively preferred for dental use. Due to the addition of alumina in very small concentrations, it also shows sufficient corrosion resistance in a moist environment. With regard to strengthening via phase transformation, zirconia provides ideal mechanical properties as weil as a certain tolerance for surface and volume errors inside the cristalline structure. Unlike zirconia use in fixed prosthodontic restorations, sintered zirconia use for implant materials needs to be optimized further through isostatic pressing to achieve a favorable cristalline structure. Several studies indicate promising values for both short-and long-term fracture strength of recent zirconia materials. Therefore, zirconia should offer satisfactory results for use in implant abutments and possibly also in endosseous implants.

Quintessenz Publishing House Berlin, Germany: Implantology - the magazine for the dental praxies,
December 2007

Osseointegration and Clinical Success of Zirconia Dental Implants: *A Systematic Review*

Hans-Jürgen Wenz, Johannes Bartsch, Stefan Wolfart, Matthias Kern

KEYWORDS
Dental implant, zirconia, osseointegration, systematic review, success rates

Various ceramic implant systems made of yttria-stabilized tetragonal zirconia polycrystal (Y-TZP) ceramie have become commercially available during recent years. Based on a systematic search of the literature, the c1inical success of dental Y-TZP implants was reviewed to determine whether the 05 oseointegration of Y-TZP is comparable to titanium as standard implant material. The internet data base medpilot was searched cumulatively for the keywords zircon' and dent" and implant as weil as for zircon" and osseointegration. The last search was conducted on January 31, 2007.
Subsequently, the reference lists of the relevant publications were searched, Furthermore, a letter was sent to the five identified manufacturers of zirconia dental implants to ask for peer-reviewed publications.
A total of 96 articles were found by this search strategy. No controlled clinical study in humans regarding c1inical outcome or osseointegration could be identified. Clinical data were restricted to case studies and case series. Only seven animal studies fulfilled the inclusion criteria. Osseointegration was evaluated from 4 weeks to 24 months after insertion in different animal models and sites and under different loading conditions. The mean bone-implant contact ratio was above 60% in almost all experimental groups. In studies using titanium implants as a control, Y-TZP implants were comparable or even better than titanium. Surface modifications may further improve initial bone healing and resistance to removal torque. Y-TZP implants may have the potential to become an alternative to titanium implants but can currently not be recommended for routine clinical use, as no long-term clinical data are available.

Quintessenz Publishing House Berlin, Germany: Implantology - the magazine for the dental praxies,
December 2007

Metal Allergies -
Clinically Relevant in Implant Dentistry?

Regina Fölster-Holst, Peter Thomas

KEYWORDS
Metal allergies, dental materials, immune responses, mucosal changes, patch tests

Of the different materials used in dentistry, metals are most frequently implieated in possible allergie reactians. These reactions are eell-mediated immune responses
that manifest themselves on a mucosal level in the form of an oral burning sensation, gustatory disorders, stomatitis, bueeal aphthae, erosions, and lichen ruber; and on the skin in the form of eezemas. The diagnostie of first ehoiee eontinues to be the familiar pateh test in eonneetion with taking the patient history an-site, in temporal and loeal eonneetion with the insertion of the implant.

Clin Oral Implants Res., October 2007

Zirconia implants with varying surface textures

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

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 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.

Clinical Implant Dentistry and Related Reserch, Volume 7, Supplement 1, 2005

Bone Tissue Responses to Surface-Modified Zirconia Implants: A Histomorphometric and Removal Torque Study in the Rabbit

Lars Sennerby, DDS, PhD; Amir Dasmah, DDS; Birgitta Larsson, PhD; Mattias Iverhed, MSc

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 monomodified ZrO_2 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 fiveold increase compared with machined zirconia implants. The findings suggest that surfacemodified zirconia implants can reach firm stability in bone.

KEY WORDS: dental implants, histology, rabbit, removal torque, zirconia

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, Bachle M, Strub JR.

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kohal@zmk2.ukl.uni-freiburg.de

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.

PMID: 15515343 [PubMed - indexed for MEDLINE]

J Oral Implantol. 2003; 29(1):8-12.

Bone response to zirconia ceramic implants: an experimental study in rabbits

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This study analyzes the bone response to zirconia ceramic implants inserted in New Zealand white mature male rabbits. The implants were inserted into the tibia, and each rabbit received 4 implants. All the animals were euthanatized after 4 weeks.
A total of 20 implants were retrieved. Implants and surrounding tissues were immediately fixed in 4% paraformaldehyde and 0.1% glutaraldehyde in 0.15 molar cacodylate buffer at 4 degrees C and pH 7.4 to be processed for histology.
The specimens were processed to obtain thin ground sections with the Precise 1 Automated System. The slides were observed in normal transmitted light under a Leitz Laborlux microscope. A great quantity of newly formed bone was observed in close contact with zirconia ceramic surfaces; in some areas, many osteoblasts were present directly on the zirconia. Percentage of bone-implant contact was 68.4% +/- 2.4 %. Mature bone, with few marrow spaces, was present. Small actively secreting osteoblasts were present in the most coronal and apical portions of the implant. No inflamed or multinucleated cells were present. This study concluded that these implants are highly biocompatible and osteoconductive.

PMID: 12614079 [PubMed - indexed for MEDLINE]

Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2000 Jan; 89(1):91-8.

Osseointegration of endodontic endosseous cones: zirconium oxide vs titanium.

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OBJECTIVE: The purpose of this investigation was to investigate the osseointegration of zirconium oxide (ZrO(2)) ceramic cones in comparison with that of titanium cones in apicectomy. STUDY DESIGN: To evaluate the bone/implant interface, 20 ZrO(2) cones and 20 titanium cones were inserted into the mandibles of 4 Gottinger minipigs. During the 6-month healing period, intravital polychrome sequence marking was performed. Qualitative light microscopic, fluorescence microscopic, and quantitative histomorphometric assessment was carried out. Differences between continuous histomorphometric measures were tested through use of a 2-way analysis of variance.

RESULTS: Light microscopy revealed zones of direct bone contact with the ZrO(2) and titanium surfaces. Fluorescence microscopy revealed remodeling processes directly adjacent to both material surfaces. There was no significant difference in the distances of the fluorescence bands of each fluorescence marker for either the ZrO(2) surfaces or the titanium surfaces. Quantitatively and histomorphometrically, the mean ratio between the total cone/bone contact and the total cone/fibrous tissue contact was 0.95 (SD 1.10) on the titanium surface (n = 38) and 1.47 (SD 1.12) on the ZrO(2) surface (n = 78; P =.02). CONCLUSIONS: The qualitative results show that the biocompatibility of ZrO(2) was similar to that of titanium. The use of ZrO(2) cones for sealing purposes in resected teeth after apicectomy appears to be acceptable.

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Materials characteristics of uncoated/ceramic-coated implant materials.

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In this paper, the biocompatibility of dental implant materials is discussed in the context of both the mechanical characteristics of the materials and the type of surface presented to the surrounding tissues. The proper functioning of the implant depends on whether it possesses the strength necessary to withstand loading within the expected range, with other properties such as elongation being of importance in some instances. A suitable modulus of elasticity may be of major importance in situations when optimum load transmission from the implant into the surrounding bone is key to the successful functioning of the device. Dental implants present a wide range of surfaces to the surrounding tissues based on surface composition, texture, charge energy, and cleanliness (sterility). Metallic implants are characterized by protective oxide layers, but ion release is still common with these materials, and is a function of passivation state, composition, and corrosion potential. An effective surface treatment for titanium appears to be passivation or anodization in a suitable solution prior to implantation. Inert ceramic surfaces exhibit minimal ion release, but are similar to metals in that they do not form a high energy bond to the surrounding bone. Some of the newly developed dental implant alloys such as titanium alloys, which contain zirconium and niobium, and high-strength ceramics such as zirconia may offer some advantages (such as lower modulus of elasticity) over the conventional materials. Calcium phosphate ceramic coatings are commonly used to convert metallic surfaces into a more bioactive state and typically cause faster bone apposition. There is a wide range of ceramic coatings containing calcium and phosphorus, with the primary difference in many of these materials being in the rate of ion release. Although their long-term success rate is unknown, the calcium phosphate surfaces seem to have a higher potential for attachment of osteoinductive agents than do uncoated titanium and other more inert implant materials.

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Int J Oral Maxillofac Implants. 1999 Mar-Apr; 14(2):271-7.

Evaluation of combinations of titanium, zirconia, and alumina implants with 2 bone fillers in the dog.

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The quality of the tissue-implant interface was evaluated using light and scanning electron microscopy with morphometric analysis. Nine dogs were implanted with 3 types of dental implants (titanium, zirconia, or alumina). A total of 24 dental implants was placed in mandibular bone previously filled with coral carbonate calcium (corail) or hydroxyapatite. The study results in breaking the concept of osseointegration into 2 phases: "osseocoaptation," which concerns only the interface (physical contact between the implants and the bone without interpenetration process), and "osseocoalescence," which relies on an interpenetration of the bioactive material, which almost entirely disappears, being substituted by newly formed bone. There was no significant statistical difference between the 3 types of implants. Both fillings showed good ossecoalescence properties. However, hydroxyapatite led to fibrous encystment, preventing osseocoaptation of implants. In contrast with calcium carbonate filling.

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

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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.

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J Biomed Mater Res. 1996 Jan; 30(1):117-24.

Bone remodeling around implanted ceramics.

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Bone formation and remodeling around implanted materials is influenced by the kind of material, its surface properties, and the anatomical site of implantation. In this study, differences in bone formation around three kinds of ceramics and the importance of the implant location in the tibia were investigated. In the first experiment, we placed three kinds of ceramics--alumina, zirconia and hydroxyapatite (HA)--into the medullary cavity of rabbit tibiae and examined histologically the timedependent formation of bone around the materials for up to 24 weeks postoperatively. We found that bone formation depends on whether or not the materials are in direct contact with the endosteum. In the second experiment, the same three ceramic materials were implanted transcortically into rabbit tibiae. The bone formed around the implants was most abundant in regions adjacent to the periosteum, followed by the endosteum and the marrow cavity in the approximate ratios of 70%, 40%, and 10%, respectively. In these two experiments, the difference between bioactive and bioinert ceramics could be seen in the interface between the implanted material and the bone. It can be concluded that bone formation around these materials is related to the osteoconductivity of the materials and to the osteogenic capacity of the tissues.

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Shanghai Kou Qiang Yi Xue. 1994 Dec;3(4):208-11.

[An experimental study on the HA-coated zirconia ceramic material for an endosseous implant]

[Article in Chinese]

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HA layer is sintered onto the surface of zirconia ceramic material.These column-like composite implants and titanium implants were inserted into the femurs of the dogs.The speciments were taken at the third month after operation,and the shear strengths between the implants and bone were measured.The undecalcified bone section containing the composite ceramic implant were cut for light microscopy, scanning electron microscopy and elemental analyses of C,P and Zr.Mechanical testing results revealed that the attachment strength of HA-coated zirconia samples is more stronger,as companied with the titanium samples.Histologic evaluations of the undecalcified specimens showed that extremely close juxlaposition of bone to HA-coated zirconia ceramic implants was seen.

PMID: 15160127 [PubMed - as supplied by publisher]

Biomaterials. 1993 Dec; 14(15):1173-9.

Bone-implant interface mechanics of in vivo bio-inert ceramics.

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We have previously demonstrated that there was no significant difference between the affinity of bone to bio-inert ceramics and stainless steel in a histological study. In this study, the bone-implant interface shear strength of alumina ceramics ($Al2O3$), zirconia ceramics ($ZrO2$), stainless steel (SUS316L) and sintered hydroxyapatite (HA) were compared in 19 dogs using a transcortical push-out model of the femur 4 and 12 wk after implantation. The interface shear strength of HA was significantly greater than that of alumina ceramics, zirconia ceramics and stainless steel ($P < 0.001$). There was no significant difference between bio-inert ceramics and stainless steel.

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

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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.

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Biomaterials. 1992; 13(4):195-200.

Re-evaluation of the biocompatibility of bioinert ceramics in vivo

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The affinity of bone for bioinert ceramics and stainless steel was compared using calcified bone specimens. We implanted cylinders of alumina ceramics (Al_2O_3), zirconia ceramics (ZrO_2) and SUS-316 L stainless steel into the distal femoral epiphyses of dogs and then made observations from 4 to 96 wk post-operatively. Irregularities in the histological specimens suggested the presence of artefacts due to the insertion technique. We subsequently used screws inserted into holes tapped with a tap that had a diameter identical to the screws, and observed these implants from 4 to 96 wk after insertion. There was no detectable difference in the affinity index for all three materials from 4 to 96 wk after implantation. The affinity index was calculated as the ratio of the new bone directly adjoining the implant without any intervening fibrous membrane or bone marrow to the total length of the bone-implant interface x 100 %.

PMID: 1520824 [PubMed - indexed for MEDLINE]

Biomaterials. 1990 Sep; 11(7):505-8.

Mechanical behaviour of zirconia and zirconia-toughened alumina in a simulated body environment.

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The mechanical properties of a zirconia-toughened alumina (ZTA) and three tetragonal zirconia polycrystal ceramics (TZPs), together with a biograde alumina, have been assessed in a simulated body solution (Ringer's solution). The hardness and fracture toughness of these materials were unchanged from the values in air when the tests were carried out in Ringer's solution; there was an instantaneous fall in strength in Ringer's solution but this was considered acceptable. However, ageing for long periods in Ringer's solution promoted a surface layer of monoclinic zirconia. This was accompanied by a strength decrement and it is concluded that these yttriastabilized ZTA and TZP materials are unsuitable as implant materials.

PMID: 2242399 [PubMed - indexed for MEDLINE]

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Are restorations made from zirconium dioxide radioactive and can they cause cancer?

By Dr. med. dent. Johann Lechner

Lack of clarity, uncertainty and incorrect statements on «radioactive radiation» in general and ceramic frameworks made from zirconium oxide (ZrO2) in particular are fairly common. This publication attempts to present own experiences as well as the facts currently known. The author, however, does not intend to create the impression that, eventually, zirconium oxide is a tooth replacement material which does not cause any problems. Compared to metals and composites/acrylics, however, the author found a considerably higher biocompatibility of more than 4000 integrated zirconium oxide units over 5 years than for composites/acrylics and metal alloys and astonishing mechanical resistance to fracture compared to other ceramic materials. The possibilities of highly accurate processing of ZrO2 using modern CAD/CAM techniques allow the fabrication of complex metal-free restorations. Thanks to the high flexural strength of industrially presintered ZrO2 blocks (ZrO2 = 1300 MPa; Al2O3 ceramics = 400 - 600 MPa; glass ceramics = 100 - 200 MPa) large span bridges can also be fabricated.

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