CERCON® Implant Abutments: Beauty Follows Function

INTRODUCTION People have always valued their teeth, and have developed innovative cosmetic solutions for tooth loss throughout the ages. The materials used have varied over time. However, it is only the profession of dentistry that has made prostheses, bridges and crowns available to the public in general. Implant dentistry is now the most advanced response to tooth loss, with implant-supported restorations combining a high degree of function, comfort and esthetics. Modern dental research is devoted to the development of solid materials with refined qualities offering similar refractive properties to those of the tooth enamel (Figs. 1a, 1b). The art of looking natural has been perfected with ceramics. Their application in implant prosthodontics has opened up a new era in esthetic tooth replacement. Newest research has led to the development of implant abutments of high-quality zirconium oxide that are anatomically shaped, customizable and available in different shades. Their outstanding biochemical, physical and light dynamic properties make zirconium oxide the material of choice for the production of prefabricated implant abutments.

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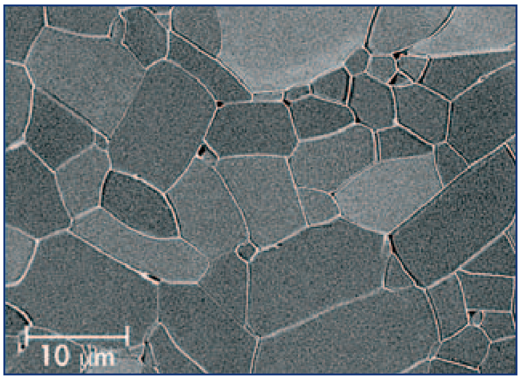
Zirconium Oxide To be considered a true alternative, the mechanical and biological qualities of ceramic implant abutments must be equal to or better than those of widely used titanium abutments. These requirements can only be met by high-performance and biocompatible oxide ceramics (Figs. 2a, 2b). Oxide ceramics are equal to metals from a mechanical standpoint, but biologically stronger (Fig. 3). However, one exception is the high brittleness of ceramics, and the potential to crack. Until now, the use of full ceramic implant abutments for implant restoration has been limited due to this feature.

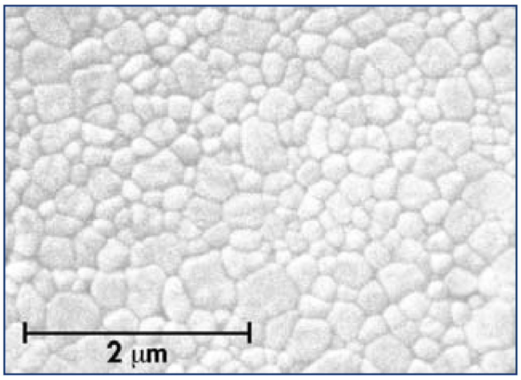
Zirconium oxide surpasses the high loading characteristics of aluminum oxide (Fig. 4). The name zirconium oxide, implemented in our habitual language, represents a simple form of the chemically correct name zirconium dioxide. The German chemist M. H. Klaproth discovered zirconium dioxide in 1789 by heating zirconium rocks. The name zircon is derived from the Persian word "zargon," which means "gold color." The main material used for the extraction of zirconium dioxide, is the mineral zircon ($ZrSiO_4$). Zircon is found in volcanic rocks (granites, syenites and gneisses). The majority of zircon is mined in Australia, the United States, India and South Africa. Zirconium oxide is gained by melting coke with lime and zircon. A highly purified raw product must be used to develop high performance ceramics. For this reason, a special synthesis method was developed to obtain extremely pure zirconium oxide.

[Figure 1a] ›
Light dynamic characteristics of natural tooth.
[Figure 1b] ›
Light dynamic characteristics of FRIALIT®/XiVE® CERCON® abutment with hexagonal implant-abutment connection.

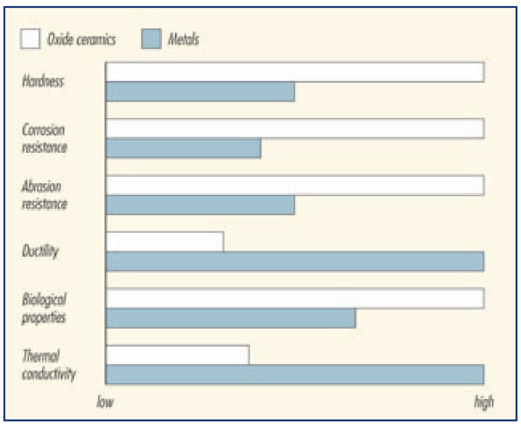
Transformation toughening Zirconium oxide has "self-repairing" properties, preventing crack propagation.[1] It is existent in three crystal conditions, even if the chemical composition is identical (Fig. 5). This material characteristic is called polymorphism. At temperatures exceeding 2,300 °C, zirconium oxide is found as a cubic crystal phase



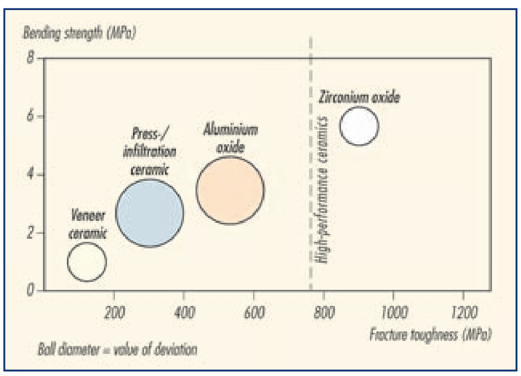
[Figure 2a] Structure of Al_2O_3 ceramics.



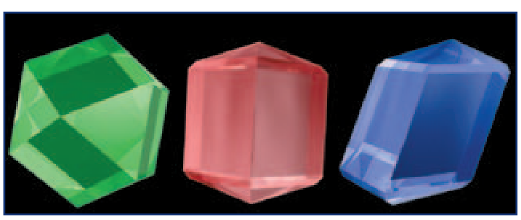
[Figure 2b] Structure of (Y-TZP) ZrO_2 CERCON® ceramics.



[Figure 3] Characteristics of oxide ceramics vs. metals.



[Figure 4] Ceramics in dentistry, material characteristics.



[Figure 5] Zirconium oxide crystal phases (polymorphism): cubic, tetragonal, monoclinic.

and changes into a tetragonal crystal phase when it cools down. Zirconium oxide transforms into a monoclinic phase at temperatures below 1,200 °C. The transformation from tetragonal to monoclinic is completed with a volume increase of approximately three to five percent. These volume changes will lead to very high inner structure tensions and component fracture. For this reason oxide additives (e. g., magnesium oxide, calcium oxide or yttrium oxide) are necessary to completely or partially stabilize the high temperature phases (cubic or tetragonal) down to room temperature. This reduces compression stress within the structure to a controlled level and prevents component destruction while cooling-off. The phenomenon of preventing micro crack propagation resulting from high material tension is called transformation toughening.

In medicine and dentistry, zirconium oxide is used primarily because of its chemical stability, high mechanical loading, outstanding biocompatibility and unique esthetic qualities.[2] New zirconium oxide ceramics were developed for different applications. The most significant dental application is the polycrystalline stabilization of zirconium dioxide with yttrium oxide (Y-TZP). In comparison to other stabilizing oxides, this is the finest-grained, most densely packed and mechanically highest-grade structure. Transformation toughening and the resulting pseudo-elastic reaction is at its maximum if five volume percent yttrium oxide is added.

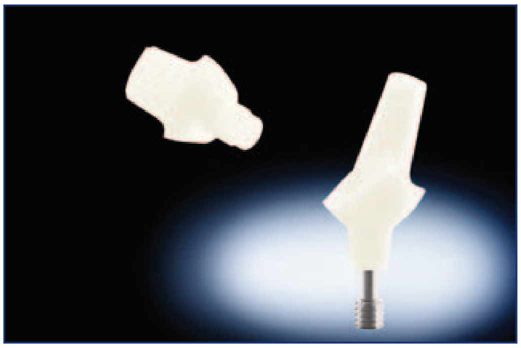
Light Dynamics The ideal synergy of mechanical, functional, biological and esthetic features contributes significantly to the esthetic result of a full-ceramic implant restoration. Conventional titanium abutments can produce a bluish metallic shimmer at the restoration's margin especially in cases of thin soft tissue. This results in a significant loss of esthetic quality and may contribute to an unsatisfactory treatment outcome, particularly for patients with a high smile line.

In order to represent a truly alternative treatment option, ceramic implant abutments must have the same cosmetic and functional characteristics as the natural dentition.[3] With the introduction of Y-TZP zirconium oxide abutments (Friadent® Cercon®, Dentsply Friadent, Mannheim, Germany) new horizons open up in esthetic implant dentistry (Fig. 6). Similar to teeth, Y-TZP zirconium oxide optimally combines hardness, strength, durability, and light dynamics, such as opalescence and translucence (Figs. 7a, 7b). Opalescence is an optical characteristic of teeth and ceramics and refers to the ability to transfer a specific range of light (red-orange shades) as well as to reflect the other wavelengths (blue-violet shades). Translucence is the stage between the appearance of complete opacity (such as ivory) and complete transparency (such as glass).

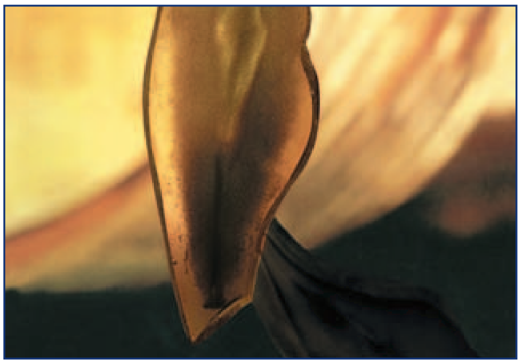
Biocompatibility The use of zirconium oxide has been successfully proven since 1969 in implantology. It is increasingly used in the field of dental medicine. The degradation behavior of zirconium oxide has been tested under physiological conditions since its introduction to medical use. Fatigue and loading tests[4] confirm its suitability even after 50 years of clinical use. Numerous studies document the biological safety of zirconium.[5,6] No toxic effects occur at the interface of zirconium oxide with bone or soft tissue. Tests of the mutagenic effects (chromosome aberration test) and carcinogenic effects (Ames test) yield the same positive results.[5]

An intact implant restoration requires the effective maintenance of the peri-implant margins, including low plaque adhesion to the implant abutment. Inadequate soft tissue attachment may lead to bacterial penetration, resulting in peri-implantitis and progressive loss of hard and soft tissues. Recent studies by Scarano et al.[7] confirm a 40% reduction in bacterial adhesion on zirconium oxide Cercon® (DeguDent, Hanau, Germany) compared to titanium with comparable roughness (Figs. 8a, 8b).

Consequently, Cercon® actively contributes to peri-implant tissue protection. The degree of adhesion between bacteria and abutment depends on the abutment's and bacteria's free surface energy, the roughness of the surface, and the saliva's ionic conductivity.[8] Most infections in the oral cavity are due to the initial adhesion of bacterial colonization. It starts from surface irregularities, such as grooves or abrasive defects, and extends gradually over the entire abutment. In the sub-peri-implant region bacteria are inaccessible to mechanical removal. This allows bacteria to attach strongly to the abutment. The adhesion of bacteria directly correlates to the roughness and the number of surface defects. Abutments with low roughness values show a significant reduction in plaque adhesion and

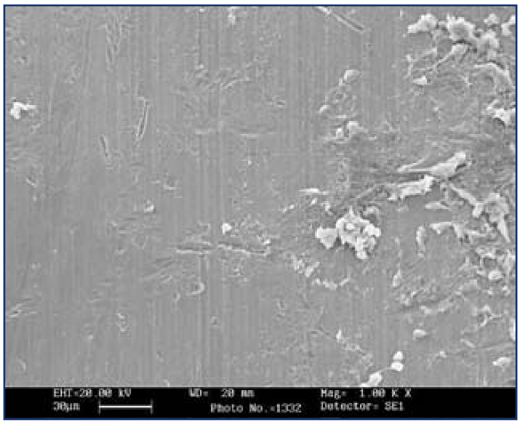


[Figure 6]
FRIADENT® CERCON® abutments for Ankylos and FRIALIT®/XiVE® implants.

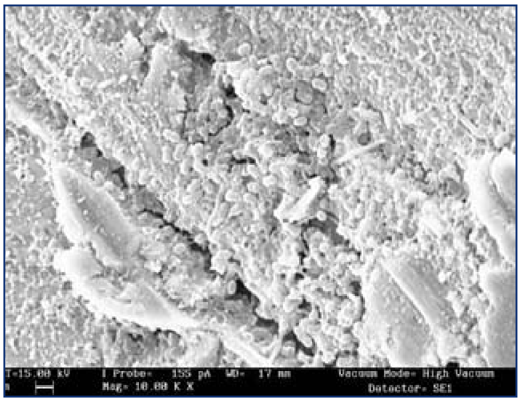


[Figure 7a]
Natural translucence of maxillary incisor.

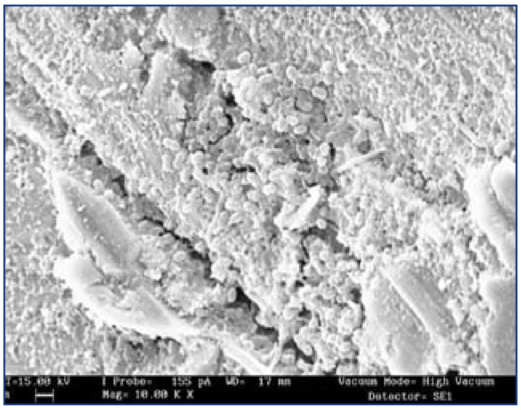
[Figure 7b]
Translucence of Ankylos® CERCON® abutment.
Thin-ground section 50x magnification.



[Figure 8a]
Reduced bacteria adhesion to CERCON®.

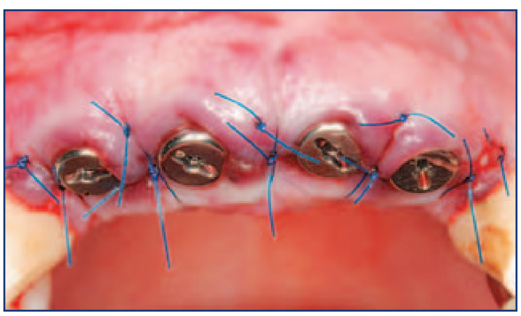


[Figure 8b] Bacteria adhesion to titanium (cocci layer and filamentus microorganisms).



[Figure 9]

[Figure 10]



[Figure 11]

[Figure 12]

plaque growth. Poortinga et al.[9] demonstrated the significant influence of energy on bacterial adhesion, besides surface roughness. Bacteria absorbing and passing electrons from the fluid substrate adhere in stronger and greater numbers compared to bacteria only receiving electrons. These results prove that the electron transfer between bacteria and their substrate also influences the adhesion and thus plaque formation.

Case presentation Today, the ideal material properties of zirconium oxide allow us to fabricate gracile and very precise configurations that are able to bear extreme forces. Besides a supremely gracile design and ideal translucence with a natural gingival outcome in the transgingival region, the full-ceramic zirconium oxide abutments allow a high degree of individual shaping in order to support the papilla. However, the evidence-based biological factors of zirconium oxide, e.g., reduction of plaque accumulation and the advantage of close adaptation of epithelial structures, are still underestimated in their positive influence on achieving long-term esthetics.

The concept of achieving high esthetic results in the anterior region by using implant restorations based on zirconium oxide is demonstrated in the following case presentation. The patient presented with mobile anterior teeth in the maxilla caused by an accident. Clinical examination revealed a tooth mobility of class 3 for teeth 12, 11, 21, 22. The radiological findings showed severe resorption and extended periodontal gaps, presumably due to repeated apicoectomies. Preservation of the affected teeth was impossible and they were consequently extracted, followed by immediate implant placement. According to a standardized protocol, immediate non-functional loading at an adequate insertion torque of >30 Ncm was also planned.

After atraumatic tooth extraction and removal of granulation tissue, each alveolar socket was inspected very carefully using a probe. To place implants immediately an unscathed buccal lamella is mandatory. Subsequently, implant site preparation was performed with the drills in their sequence of use. However, the implant axes were angulated palataly to avoid trauma of the vestibular bony plate. Four XiVE® CELLplus Implants (D 3.8) were inserted (Dentsply Friadent, Mannheim, Germany) (Figs. 9, 10). Additional cooling was avoided in order to

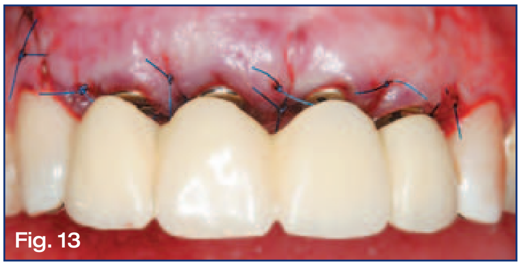


Fig. 13

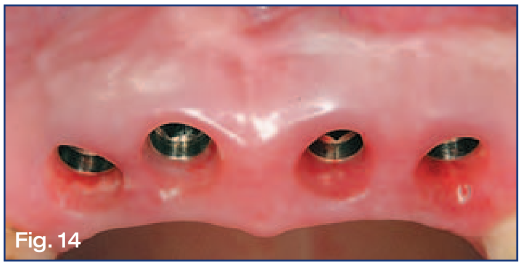


Fig. 14


Fig. 15a


Fig. 15b


Fig. 16


Fig. 17


Fig. 18


Fig. 19

preserve the primarily adapted blood clot for bone regeneration. Since contrary to the initial protocol, the insertion torque was less than 30 Ncm, the option of immediate function was abandoned. Standard gingiva formers were placed and the patient was temporarily restored with an adhesive Maryland-bridge (Figs. 11–13). After 8 weeks the standard titanium gingiva formers were replaced by acrylic anatomical shaped abutments based on Friadent® EsthetiCaps (Dentsply Friadent, Mannheim, Germany). These naturally shaped gingiva formers allow for an anatomical expansion of the previously narrowed and round-shaped emergence profile (Figs. 14, 15). After a healing period of three months, the final restoration was integrated. Zirconium oxide caps (Cercon® Smart Ceramics (DeguDent, Hanau, Germany), were completely veneered and cemented with composite-reinforced glass ionomer cement on to Friadent® Cercon® abutments (Figs. 16–20). Esthetics and function were successfully restored due to ideal material properties. The beauty of the crowns matches the soft tissue architecture ideally (Figs. 21, 22).

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Fig. 20


Fig. 21


Fig. 22

summary

Today, custom implant abutments fabricated from titanium are considered a standard treatment option for implant-supported restorations. Improved materials, coupled with the increased demand by clinicians and patients for highly esthetic results, have contributed significantly to the development of a new generation of ceramic abutments. Full-ceramic abuments, fabricated from yttrium stabilized – zirconium oxide (Y-TZP), have been noted for their tooth-analog color, high loading strength, tissue tolerability and intra-sulcular design enhancement. The phenomenon of transformation toughening of zirconium oxide results in extremely high component stability, extraordinary bending and tensile strength, fracture and chemical resistance.

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