Clear trend towards metal-free reconstructions

Dr Stefan Röhling is a fellow and speaker of the International Team for Implantology (ITI) specialising on zirconia implant research. Georg Isbaner, editorial manager of *ceramic implants* interviewed Dr Röhling (Fig. 1) on his experience with ceramic implants, scientific research insights, market developments and perceived treatment chances and challenges with zirconia implants in comparison to titanium implants.

Ceramic dental implants have already been known since their introduction in the late 1960s. However, titanium and titanium alloys are still the material of choice for most dental professionals. What do you assume to be the reasons?

Titanium or titanium alloy implants are a reliable, scientifically well-investigated and popular treatment option today, especially as the development from machined to micro-roughened titanium implant surfaces has constantly improved their clinical performance. The first ceramic implants were made of alumina and were clinically in use until the early 1990s. Based on poor biomechanical properties alumina could never be considered a reliable alternative to titanium. The first generation of zirconia implants was introduced at the beginning of the 2000s. Since then, manufacturing processes have constantly been improved to produce high-strength micro-rough zirconia implants with reliable biomechanical properties.

In summary, since the 1960s different materials were used for the fabrication of ceramic implants and various generations of zirconia implants have been rolled out

Fig. 1

Fig. 1: Dr Röhling at the IAOCI World Congress 2017 in Miami, USA.

since the beginning of the 2000s. Many dental professionals are not aware of this fact and attribute the poor clinical performance of alumina implants in general to "ceramic implants". It is important to realise that zirconia is a completely different material and that zirconia implants of the latest generation show similar clinical outcomes as titanium implants.

When it comes to the scientific evidence, what do we know and where do we need to know more about ceramic implants?

Experimental studies have shown that zirconia implants of the newest generation have the ability to withstand oral forces and that artificial aging does not have any significant effect on the biomechanical long-term stability. Moreover, zirconia implants when compared to titanium implants show a similar capacity to integrate in bone as well as in soft tissue. In comparison to titanium or other metals, significantly reduced bacterial biofilm formation and reduced peri-implant soft tissue inflammation has been reported for zirconia. Clinically, survival rates of more than 95 per cent were reported for one-piece zirconia implants of the latest generation for investigation periods of up to five years. However, meta-analyses investigating clinical outcomes are limited to follow-up periods of only one year. Thus, a long-term status as known from titanium implants is currently not yet available. Moreover, only few clinical data is obtainable regarding the performance of two-piece zirconia implants.

Zirconium, zirconium dioxide and zirconia: What are the differences?

Zirconium is a pure metal characterised by a metallic bond and metal properties (e.g. free electrons and electrical conductivity). Zirconium dioxide, also called zirconia, is an oxide ceramic consisting of zirconium, oxygen and other supplements (e.g. yttria). Using ionic bonding, these different elements are firmly interconnected in a crystal lattice building a new class of material. Based on the characteristics of the ionic bond, there are localised electrons indicating typical ceramic properties like no electrical conductivity for zirconia.

Zirconium dioxide is one of the toughest dental materials that exist. Can you explain in more detail what its capabilities are and what it means for the dental application, especially as implant material?

Compared to other ceramics, zirconia shows superior biomechanical properties like high fracture toughness and bending strength, giving zirconia implants the ability to withstand oral forces. In this context the "fracture toughening mechanism" of zirconia is very important. This mechanism can be considered as a self-healing process and describes the transition from a fracture proof tetragonal zirconia phase into a more fragile monoclinic zirconia phase. This tetragonal to monoclinic transi-


Fig. 2a

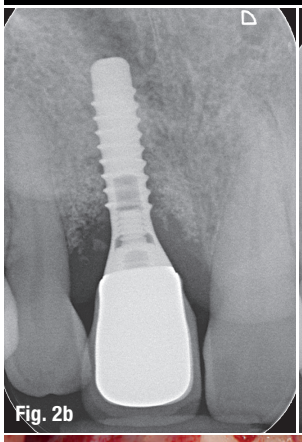
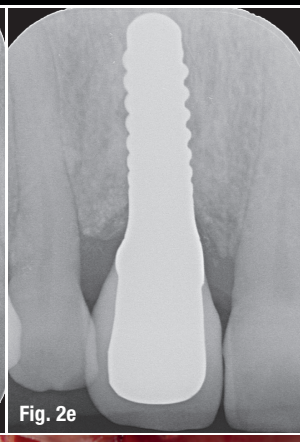


Fig. 2b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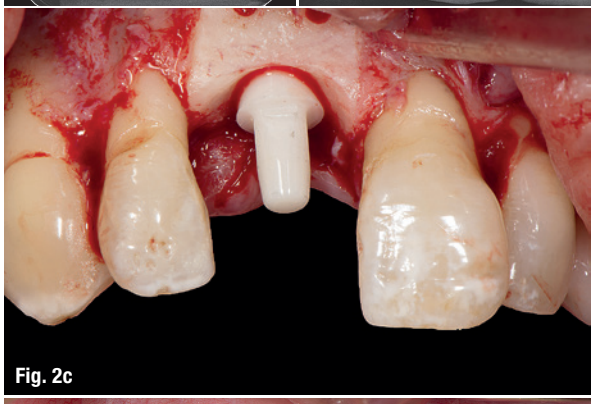
Fig. 2c


Fig. 2d

Fig. 2a: Initial clinical situation after non-surgical peri-implantitis pre-treatment. **Fig. 2b:** Radiograph showing evident peri-implant bone loss. **Fig. 2c:** Clinical situation at implant placement (PURE Ceramic Implant Monotype, Straumann) four months after implant removal and subsequent augmentation with autogenous bone. **Fig. 2d:** Clinical situation four weeks after cementation of definitive crown. **Fig. 2e:** Radiographic control at delivery of definitive crown.


Fig. 3a


Fig. 3c

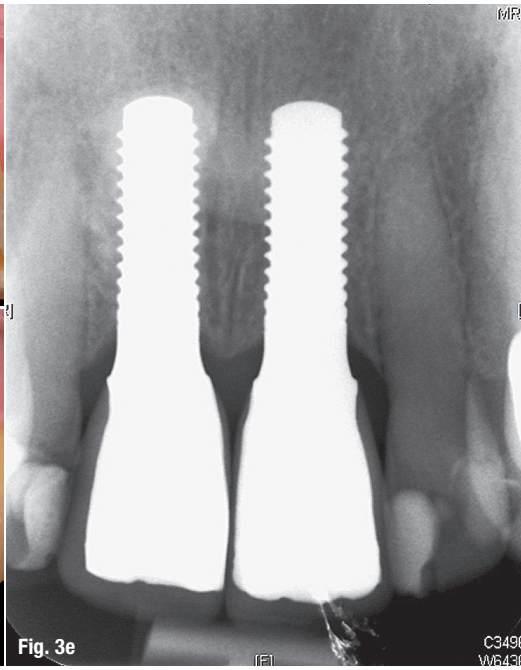
Fig. 3e

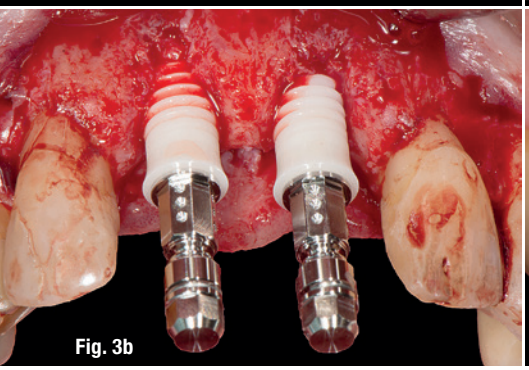
Fig. 3b


Fig. 3d

Fig. 3a: Initial clinical situation: Secondary root caries and longitudinal fractures in teeth #11 and #21 (implant location according to WHO). **Fig. 3b:** Clinical situation at implant placement eight weeks after tooth extraction. Two-piece zirconia implant (PURE Ceramic Implant, Straumann) with metal transfer piece. **Fig. 3c:** Clinical situation five months after implant placement. Delivery of definitive crown. **Fig. 3d:** Clinical situation at delivery of definitive screw-retained crown. **Fig. 3e:** Radiographic control at delivery of definitive crown.

tion is associated with a volume expansion which inhibits the propagation of mechanically induced micro-cracks in the material structure. Interestingly, uncontrolled implant surface treatment or grinding procedures might induce premature phase transformation, probably reducing the fracture toughening mechanism.

What medical indications do you recognise as the most suitable for ceramic implants?

In my opinion, there are no specific indications or contraindications for ceramic implants. Especially in the anterior region, ceramic implants might provide advantages over metal implants regarding pink and white aesthetics. Moreover, patients who do not want

> "One-piece implants are the most natural and biological way to replace missing teeth."

to be treated with metal implants, periodontally compromised patients and patients who have made bad experiences with titanium implants (e.g. implant loss caused by peri-implantitis) are highly relevant indication groups (Figs. 2a–e).

Regarding the surgical protocol and prosthetics how do ceramic implants differ from titanium implants?

In general, the surgical steps for placing zirconia implants do not differ from the protocols for titanium implants. While two-piece ceramic implants can be surgically handled similar to two-piece titanium implants, several special features should be considered when using one-piece implants.

Firstly, implant placement must be performed prosthetically driven to guarantee a correct implant axis. Further, only transgingival healing protocols might be applied and especially when implant placement was combined with bone augmentation procedures, overloading during the early healing phase has to be avoided, e.g. by protective stents or specifically adapted temporary prostheses. On the restorative side, there are less flexibilities for one- and two-piece ceramic compared to titanium implants.

In this respect, how important is the digital workflow when placing ceramic implants?

Especially when using one-piece ceramic implants, an adequate pre-surgical planning is evident since there are less possibilities on the restorative side to correct the implant axis and angulation compared to two-piece implant designs. Consequently, the digital workflow represents a very important tool for a serious backward planning in order to avoid incorrect implant positioning and angulation.

What are the benefits of a one-piece and a two-piece ceramic implant system?

In my opinion, one-piece implants are the most natural and biological way to replace missing teeth. Since the abutment is an inherent part of the implant body, there are no micro-gaps on the abutment level. However, avoiding implant overloading during the early healing phase might be a challenge in larger edentulous or completely edentulous spaces. On the restorative side, there are less possibilities to correct a wrong implant axis whereas the prosthetics can only be cement-retained.

Regarding two-piece ceramic implants, the abutments and prosthetics can be cement- as well as screw-retained whereas a reliable screw-retained connection is still considered as a technical challenge for the manufacturers. Since individual abutments can be fabricated, there is more flexibility on the restorative side for two-piece compared to one-piece ceramic implants.

What is the general patient awareness? Do they already know and explicitly ask about ceramic implants?

In dentistry, there is a clear trend towards metal-free reconstructions. In one of our latest studies we have found out that four times more patients would favour ceramic over titanium implants and that more than 50 per cent of the patients would even accept higher ceramic implant treatment costs. Obviously, without having detailed knowledge about dental implants, tooth-coloured ceramic implants are more attractive to patients than metal-coloured titanium implants. This fact has to be considered in the clinical daily routine. More and more patients will ask for ceramic implants and dental professionals must be prepared and informed to be able to give sound answers (Figs. 3a–e).

Nowadays more and more companies are offering ceramic implants. How do you decide for a system, what is important for you?

The ceramic implant market has become quite confusing because of the many different generations of zirconia implants having been rolled out since the beginning of the early 2000s. The most critical factor is that not every zirconia implant system that is currently commercially available has been scientifically investigated. When deciding for an implant system, it must be mandatory that the offered zirconia implant and respectively the implant surface have been scientifically investigated in preclinical and clinical studies. These experimental data must not be exclusively based on internal test series from the manufacturers but should mainly be collected in independent scientific investigations. Moreover, implant companies must apply strict quality controls with regard to the manufacturing processes of zirconia implants.

How important is the surface of the ceramic implant regarding the overall success when inserting ceramic implants?

The implant surface is one of the most critical factors for the achievement of a successful and long-lasting osseous integration. Owing to optimised manufacturing processes fracture-proof zirconia implants with a similar surface topography as micro-rough titanium implants can be produced. The development of micro-rough ceramic implant surfaces, such as the ZLA® surface (Straumann), must be considered as a main reason why zirconia implants of the latest generation have become a reliable treatment alternative showing similar survival rates compared to established titanium implants.

> “Without having detailed knowledge about dental implants, tooth-coloured ceramic implants are more attractive to patients than metal-coloured titanium implants.”

It has been suggested that with ceramic implants, surgeons can now treat patients that formerly refused to have an implant therapy with titanium implants. Do you agree?

Zirconia implants of the latest generation are a reliable and reasonable extension of the available treatment range of dental professionals. Thus, patients that formerly refused implant therapy with metallic titanium implants can now predictably be treated with ceramic implants.

Dr Röhling, thank you for taking the time to answer our questions.

contact

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