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Prof. Michael Gahlert

Specialist in oral surgery and ceramic implantology

A beautiful smile—long-lasting and natural-looking

Cosmetically, a great deal can be concealed nowadays. However, what about sustainability? Have we as dental professionals not made the attempt to achieve *restitutio ad integrum* our highest goal? In oral surgery, this applies above all to the difficile rehabilitation of tooth gaps in the anterior area, which has unfavourable anatomical conditions for single-tooth restorations with dental implants.

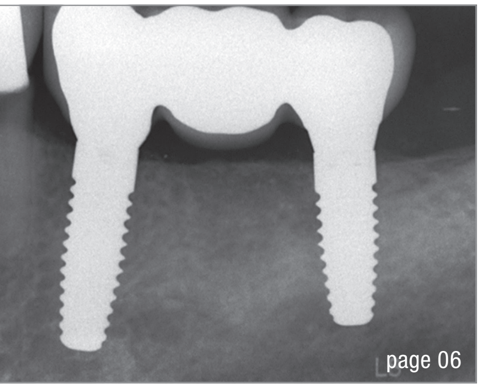
This so-called restoration of the original form and function is challenging and can only be achieved through compromise, tricks and superior clinical expertise. To this end, we use materials that today promise high biocompatibility, and it is at this very point that the wheat is separated from the chaff. What was considered highly biocompatible yesterday is already being critically examined and called into question today. Consider how often, for instance, autologous bone grafting materials are scrutinised at prestigious conferences, whereas in contrast, artificial biomaterials only backed by sparse long-term results are being marketed.

Unlike industrially produced biomaterials, there is no lobby for autologous bone grafting materials, although they have proved to be clinically reliable for decades.

In modern-day implantology, tooth-coloured ceramic implants made of zirconium dioxide—zirconia—are considered a viable alternative to established titanium implants when it comes to the replacement of teeth in the aesthetic zone. A 2018 meta-analysis by Roehling et al. concludes that these ceramic implants show a higher biocompatibility in terms of plaque affinity and soft-tissue healing and that peri-implantitis occurs significantly less around these implants, as opposed to comparable titanium implants. If we were to expand the sound evidence base with more data, we would have made a small—or perhaps even a giant—leap forwards in terms of the development of biomaterials. We would then also be one step closer to imitating nature in a sustainable manner and achieving *restitutio ad integrum*, at least in a cosmetic sense.

I therefore urge you to stay critical and judge what is new always with a view to scientific evidence. This is the only way we will be able to debunk many of the fairy tales that have established themselves within our profession. With this in mind, I wish you an exciting read with this new issue of *ceramic implants—international magazine of ceramic implant technology.*

Yours, Prof. Michael Gahlert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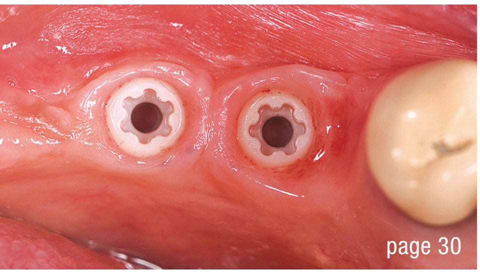
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Clinical application of zirconia implants

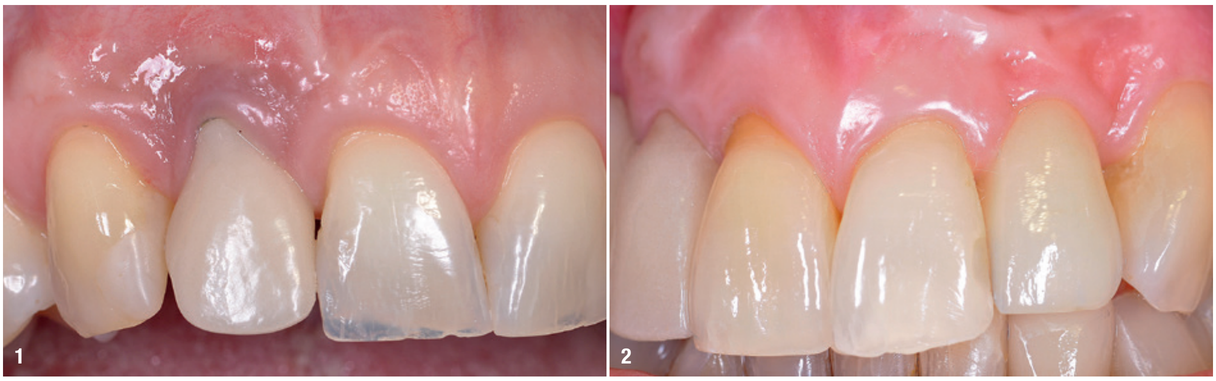
Results from comparative studies

Dr Elisabeth Jacobi-Gresser, Germany

Since the market entry at the end of the 1990s, the number of inserted zirconium oxide implants has been steadily increasing. Today, however, they constitute only an estimated 3 to 5 % of all inserted implants worldwide. Market analyses predict a significant rise in the coming years (Dental Implants Market Research Report 2017). This trend is due to the increasing confidence in the material zirconium oxide, the evolution from one-piece to two-piece configuration, as well as optimised abutment connections on ceramic implants.

Compared to titanium implants, one-piece zirconium oxide implants have shown equally good results in clinical studies with regard to osseointegration. In addition, they have obvious advantages in terms of soft-tissue acceptance. Titanium and zirconium both belong to the group of transition metals in the periodic table of elements. However, the physicochemical properties of these two metals and their oxides differ significantly. While titanium inside of a biological system is subject to tribocorrosion and subsequently triggers immunological reactions, the completely oxidised and sintered material zirconium dioxide is characterised by excellent corrosion resistance and therefore has a high biological compatibility.[11, 19] In a meta-analysis on titanium implants, the weighted average for the occurrence of mucositis was 43 % and for peri-implantitis it was 22 %.[9] There is a correlation between peri-implantitis and a reduced implant function time. The success rate of zirconium oxide implants of the younger generation is comparable to that of titanium implants.[2, 15, 24, 26] For one-piece implants made of alumina toughened zirconia (ATZ), the three-year success rate is 98.5 % and five-year success rate is 94.3 %. The seven-year success rate for one-piece implants made of yttria-stabilised zirconia (Y-TZP) is 88.6 %. The occurrence of fractures is generally rare, but it is observed with Y-TZP implants of the first generation owing to the use of diameter-reduced implants, aggressive surface treatment (aluminium powder blasting) during production, incorrect loading with an unfavourable implant-crown axis, occlusal overload, and bruxism.[29]

The availability of two-piece implants made of the more durable ATZ ceramics for ten years now extends the range of indications and facilitates clinical application. These factors contribute significantly to the further rise of ceramic implants and it is expected that they will be used even more strongly in the future. In addition to the advantages in the aesthetic zone owing to the white colour, the relatively low biofilm adhesion, as shown in *in vitro* and *in vivo* studies, and the higher corrosion resistance compared to titanium are emphasised in the literature.[1, 5, 25, 26, 19] The aesthetic advantages that the implant material zirconium oxide has over titanium, especially in the anterior aesthetic zone, are particularly evident in patients with thin gingiva of less than 2 mm (Figs. 1 & 2).[32]



Figs. 1 & 2: Aesthetic advantages of the implant material zirconium oxide (region #22) compared with the titanium-based material.

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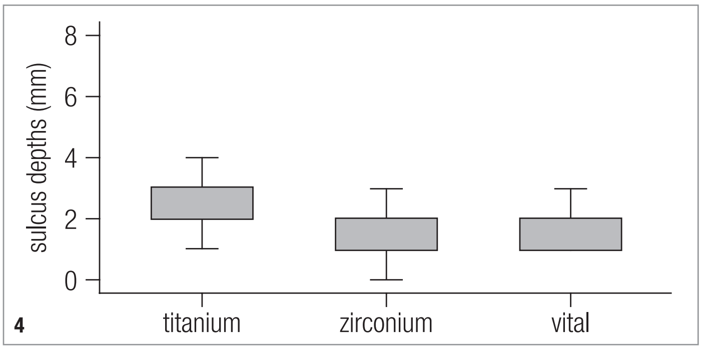

Fig. 3: Microbial load around a titanium implant in a patient with peri-implantitis. **Fig. 4:** The sulcus depths of titanium implants differ in a statistically significant way from the ones of zirconium oxide implants ($p = 0.03$). The average value of titanium implants is 2.3 mm, whereas the average value of zirconium oxide implants is at 1.8 mm (personal and unpublished data).

Possible effects of titanium implants

Comparative studies have examined the toxicological effects of nano-/microparticle load in tissues in addition to immunological-inflammatory parameters. They found increased formation of free radicals (ROS) in titanium particles compared to zirconium oxide particles.[19] Lipopolysaccharides (LPS) in bacterial membranes of periodontal-pathogenic germs and titanium particles stimulate inflammasomes in macrophages, resulting in a release of the pro-inflammatory cytokine interleukin-1. The stimulation effect by titanium particles was enhanced in LPS-exposed (*Aa*, *Pg*, *e.coli*) macrophages. Titanium ions alone do not affect the transcription of inflammasomes. The amount of titanium found in peri-implant tissues was enough to stimulate the release of IL-1b *in vitro*.[22,23] Microbial adhesion in the oral cavity additionally promotes the corrosion tendency on titanium implant surfaces. This milieu-altering microbial influence by periodontal early colonisers is reflected in the development of mucositis and peri-implantitis. It also triggers surface corrosion on the titanium implant which, in turn, leads to an increase in metal deposits (Fig. 3).[30]

As a consequence, the microbiome shifts from the "healthy" diversified to a pathological and less diversified germ load. The correlation between the amount of titanium corrosion products in the peri-implant tissue and the presence of peri-implantitis has been proven. The amount of particles found in inflamed peri-implant tissue was eight times higher compared to the tissue around "healthy" implants, which had no or only a low particle load. The authors argue that these findings confirm the correlation between corrosion products and peri-implantitis and that they also confirm the role of corrosion products in modifying the peri-implant microbial structure and diversity.[7,28] An evaluation of various inflammation markers in the tissue around implant healing caps made of titanium compared with zirconium oxide revealed that there is significantly higher evidence of inflammation when titanium is used in relation to all markers investigated.[8] Significantly increased systemic markers for "silent inflammatory" processes were also found in patients with grade V titanium implants (titanium alloy $TiAl_6V_4$), which had been *in situ* for more than ten years in combination with amalgam fillings, compared with the control group with neither implants nor fillings and also with the patient group who had amalgam fillings but no implants.[18] Histopathological examinations of rare oral soft- and hard-tissue pathologies associated with titanium implants show an increased particle load.[21] In the various extra- and intraosseous tissue lesions (with the exception of the traumatic bone cyst and the intraosseous metastasis of a renal carcinoma) an increased titanium particle load associated with inflammatory processes was found in 52.9 % of the 68 cases. The question arises whether these titanium particles could be involved in the development of these lesions as a promoting aetiological factor.

Clinically stable peri-implant tissue conditions around zirconia

Preclinical and clinical studies on periodontological parameters around "healthy" titanium and zirconium implants have shown that there are statistically significant differences with regard to sulcus depths.[16] The values prove to be higher for titanium implants than for zirconium oxide implants both in animals as well as in humans. As experience shows, sulcus probing on zirconium implants is more difficult owing to the dense fibrous tissue structure (Fig. 4). More than ten years of clinical experience confirm the stable peri-implant soft-tissue conditions and the lower incidence of peri-implantitis, which can develop if adhesive residues remain after abutment and crown fixation or if titanium particles remain in the tissue after loss of a titanium implant and re-implantation of a zirconium oxide implant in the same site or in close proximity (Figs. 5–7). Comparative analyses of the structure and the purity of ceramic implant surfaces were done on various Y-TZP and ATZ implants, which showed that all systems differ in their surface morphology and

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[1] Becker J, John G, Becker K, Mainusch S, Diedrichs G, Schwarz F. Clinical performance of two-piece zirconium implants in the posterior mandible and maxilla: a prospective cohort study over 2 years. Clin. Oral Impl. Res. 28, 2017, 29–35 doi: 10.1111/clr.12610