ABSTRACT: Titanium and its alloys have been dominating the field of implantology for a long time. It is considered the gold standard in the field. Yet with the increasing demand of esthetics and the fear of potential immunological reactions, it is time to look towards new materials. Zirconia in this aspect is proving to be a promising product. It is being touted as an alternative to dental implants. With its high esthetic results, biocompatibility, low plaque affinity and good mechanical properties it is becoming a popular choice. The goal of the current article is to provide a comprehensive literature on the topic of zirconia implants. Major subtopics include its comparison with titanium implants and various properties. For zirconia implants further clinical trials and in vivo studies need to be conducted before it becomes the material of choice.

KEYWORDS: Zirconia, implant, gold standard, immunological reactions, titanium, clinical trials

Introduction

With the overwhelming increase in popularity of implantology in the dental field, it is an everyday challenge to provide a better treatment choice. The increase in information is becoming a challenging endeavour for the dentist to keep up and apply in practice. In order to achieve both safe and higher standards of excellence in this field it is necessary to keep exploring newer avenues. In implantology titanium has been the gold standard for years, yet it misses the mark when it comes to higher end aesthetics and also reports of allergic reactions have spawned an interest in other directions. Ceramics
were introduced in the year 1992 and since then its increasing application in the field of dentistry is enviable. Zirconia is a highly renowned biomaterial with various widespread positive effects. Its usage in the field of implantology is increasing day by day.

WHAT ARE CERAMIC IMPLANTS?

As an alternative to titanium, metal free implants came into being; starting with aluminium oxide. Since aluminium oxide did not show good compatibility with long term loading, the next material to be chosen was zirconia. Zirconia possesses enviable properties of high mechanical properties as in high flexural strength (900-1200 Mpa), hardness (1200 Vickers), and Weibull modulus (10-12) than aluminium oxide. This biomaterial also has a high biocompatibility and low plaque adhesion. Zirconia exists in three phases: Monoclinic (M), Cubic (C) and Tetragonal (T). A stress induced transformation toughening makes the zirconia exist in the Tetragonal state which is used in its applications.

EVOLUTION OF CERAMIC IMPLANTS

It began in 1960’s with the consideration of aluminium oxide implants, yet the first oral implant in ceramic was introduced by Sandhaus. In 1970’s Tubingen implant came into being, after which Sandhaus introduced the Cerasand oral implant. The Bioceram implant made of single crystal alumina came after this. In 1990 Muller, Piesold and Glien produced the Bionit implant system. Akagawa, Dubruille became the first to use zirconia implants on an experimental basis. Finally in 2004 Kohal and Klaus performed the first case of zirconia implant.

PROPERTIES OF ZIRCONIA IMPLANTS

The high strength and toughness seen in zirconia implants is due to transformation toughening seen in its constituent Y-ZTP. It possesses bio inertness, nonresorbability and excellent resistance to corrosion and wear. High flexural strength (900–1.200 MPa), Vickers hardness (1.200) and Weibull modulus (10–12), high fracture resistance, high radiopacity, low thermal conductivity. It has no effect
on magnetic fields, no cytotoxic effects, the mechanical strength and toughness seen is similar to stainless steel alloys. It is as biocompatible as titanium and it is gives more esthetic results due to whitish coloration. Zirconia has seen to be less tissue reaction provoking in comparison to titanium. Degidi et al\(^1\) confirmed this and he reported that the level of the bacterial products measured with nitric oxide synthase, inflammatory infiltrate, micro vessel density, and vascular endothelial growth factor expression were found higher around the titanium caps than around the ZrO\(_2\) ones. Zirconia can up- or down-regulate gen expressions, so zirconia can be a self-regulatory material that can modify turnover of the extracellular matrix.\(^2\) Implant success is contributed to by contact between bone and implant material. Animal studies have demonstrated that zirconia implants showed direct bone apposition, and it has been concluded that osteoblastic cells have good proliferation and surface attachment to zirconia.\(^3,4,5,6,7,8\) Also zirconia shows low porosity, high density and high compressive strength.

**ADVANTAGES OF ZIRCONIA IMPLANTS**

It serves as alternative to titanium in case of titanium induced allergic reaction. The higher esthetic results in comparison to titanium make it a more desirable material. It does not interfere with magnetic fields. It produces less tissue reaction. Hoffmann et al\(^9\) histologically assessed the degree of early bone apposition around zirconia dental implants (Z-system, Konstanz, Germany) at 2 and 4 weeks following insertion. The zirconia implants demonstrated a slightly higher degree of bone apposition (54%–55%) compared with the titanium implants (42%–52%) at the 2-week time point. Langhoff et al\(^10\) compared the BIC (Bone to Implant contact) of chemically modified (plasma-anodized or coated with calcium phosphate) titanium implants, pharmacologically coated (bisphosphonate or collagen type I with chondroitin sulphate) titanium implants, SLA titanium implants, and SLA zirconia implants. The zirconia implants presented 20% more bone contact than the titanium implants at 2 weeks, improved toward 4 weeks, then were reduced at 8 weeks. Although statistically not significant, a clear tendency was noted for the chemically and pharmacologically modified implants to show better BIC values at 8 weeks compared with the anodic plasma treated-surface of zirconia implants. All titanium implants had similar BIC at 2 weeks (57%–61%); only zirconia was found to be better (77%).
ZIRCONIA VERSUS TITANIUM DENTAL IMPLANTS

Even though clinical studies and research is less in zirconia as an implant material, excellent esthetics and biocompatibility has been established.\(^{11, 12}\) Most studies \(^{13, 14}\) reported no significant differences in bone-to-implant contact and removal torque value between zirconia and titanium implants. Bone-to-implant contact values ranged from 26% to 71% for zirconia implants compared with 24–84% for titanium implants.

In terms of soft tissue integration, comparison of the mucosal seal around zirconia and titanium implants with machined necks in five adult pigs found that collagen fibres in the connective tissue had a similar orientation (parallel and parallel-oblique) on both implant surfaces.\(^{15}\) Soft-tissue healing around abutments made of titanium or zirconia\(^{12, 16}\) was studied in another experiment in dogs, in which, it was seen that the dimensions of the peri-implant mucosa were similar around titanium and zirconia abutments, and that they remained stable over a period of 5 months. More mature soft tissue integration could be seen around zirconia implants.

Colonization and early adhesion of bacteria on zirconia surfaces were seen to be much less in comparison to titanium thus favouring higher implant success.\(^{17}\) It was also seen that zirconia abutments had a low surface free energy and surface wettability resulting in reduced adhesion of bacteria.\(^{18}\) In an in vivo study comparing 24-h plaque accumulation on zirconia and titanium disks with similar surface roughness, placed in a removable device\(^ {19}\), a significant difference was found in the area covered by bacteria between zirconium (12.1 ± 1.96%) and titanium (19.3 ± 2.9%) disks. Titanium surfaces also displayed higher proportions of rods and filamentous bacteria and fewer cocci compared with zirconia surfaces.

After its introduction in dentistry, zirconia has shown excellent biocompatibility. In study\(^ {20}\), gingival biopsies were harvested around titanium and zirconia healing caps placed on titanium implants in five patients. The inflammatory infiltrate around the titanium specimens was more prominent and there were signs of ulceration of the mucosa in a case. Also, the micro-vessel density, the expression of vascular endothelial growth factor and the expression of nitric oxide synthase were all higher in the mucosa around titanium healing caps compared with the mucosa around zirconia healing caps.
Peri-implantitis also seems to be of less concern in case of zirconia implants. Cases with peri-implantitis have till now only been described in one single series of 34 patients with 45 zirconia implants.\(^\text{21}\)

In all more clinical studies are required for more information on zirconia implants, a final verdict would be misplaced without further information. Yet the trend seen is towards the positive in case of zirconia implants.

**ZIRCONIA IMPLANT SYSTEMS**

Commercial zirconia implant systems currently available are: \(^\text{22}\)

- Ceraroot (Oral Iceberg, Barcelona, Spain)
- Sigma (Incermed, Lausanne, Switzerland)
- White Sky (Bredent Medical, Senden, Germany)
- Z-Systems (Z-Systems, Konstanz, Germany)
CONCLUSION

Titanium has been dominating the field of implantology since its arrival, yet there is room for further technical progress. Zirconia has been showing promising results and may become a viable alternative to titanium. At present more clinical trials and research need to be carried out to make zirconia a mainstay in the field of implantology. With increasing patient awareness it is the responsibility of the dentist to be aware and to be able to provide for higher demands.

REFERENCES


**BIOGRAPHY**

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