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ZIRCONIA IMPLANT-A LITERATURE REVIEW

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ABSTRACT

Titanium alloys are broadly used for fabrication of dental implants. Zirconia implants took the lead into dental implantology as an alternative to titanium implants. Zirconia seems to be a apt material because of its tooth-like color, low-plaque affinity, its mechanical properties and its biocompatibility. Zirconia renders the dentist , the benefit to work with a more aesthetic solution, some studies also specify its drawback. Though zirconia is already used in medicine for decades, there is a still insufficiency of peer-reviewed research on this material in dental implantology. This study signifies that zirconia dental implants are much better alternative for gold standard dental implant, i.e., titanium.

KEYWORDS: Zirconia implant, titanium VS zirconia, advantages of zirconia, disadvantages, surface roughness, osseointegration.

INTRODUCTION

Dental implants have been the best treatment option that improved the quality of life for many patients. The rehabilitation of completely and partially edentulous patients with dental implants is a scientifically accepted and well documented treatment modality. Titanium and titanium alloys are more commonly used dental implants due to their biocompatibility, excellent mechanical properties, and aesthetic solution. Though titanium is a popular material it has certain disadvantages such as greyish color, which is unaesthetic, especially in the anterior region where the gingival tissue is considerably thin and also the galvanic reaction that occurs after it comes in contact with saliva and fluoride.[1] In recent years, high strength zirconia ceramics have become attractive as new materials for dental implants. They are considered to inert in the body and exhibit minimal ion release compared with metallic implants. Yttrium-stabilized tetragonal zirconia poly-crystals appear to offer advantages over aluminum oxide for dental implants because of their high fracture resilience and high flexural strength. Zirconia seems to be a suitable dental implant material because its tooth-like color, mechanical properties, and therefore biocompatibility. The metal implant is exposed in the case of gingival recession and apical bone loss that reveals a bluish discoloration of the overlying gingiva. The use of zirconia implants avoids this complication and accedes to the request of many patients for metal-free implants. Zirconia also provides high strength, fracture toughness, and biocompatibility.

Manufacturing Process

The manufacturing process varies for each implant company, whereas the basic steps and phases of manufacturing a zirconia implant are,

1. Raw material formulation.
2. Pressing.
3. Sintering.
4. HIP (hot isostatic pressing) post-compaction.
5. Oxidizing.
6. Grinding.
7. Quality control.[2]

There are 2 among 5 companies commercializing zirconia dental implants that provides details about chemical composition and manufacturing of their implants. They are,

Y-TZP BIO-HIP SigmaR Implants (Incermed, CH-Lausanne)

By grinding and compressed by an isostatic process at high temperature up to approximately 2000°C the crystalline products are processed into powder. The unmixed pure powder of zirconium (for which the granulometric spectrum has been defined) is processed through pressure in high temperature molds. This obtains homogenous implants of perfect dimensions. The chemical composition is > 99.9% ZrO_2 + HfO_2 + Y_2O_3, out of which 5.2% is Y_2O_3 and 0.1% are other oxides.[2]

Y-TZP-A BIO-HIPR Implants (Metoxit AG, CH-Thayngen)

The manufacturing process for dental HIP Y-TZP-A implants are

a) material compaction, b) sintering, c) HIP, d) reoxidizing followed by e) machining (grinding), f) measurement proof testing and g) quality control. The chemical composition is > 95.0% ZrO2 (+HfO2), 4.0% is Y2O3 and 0.25% is Al2O3.[2]

Osseointegration

Zirconia-implants were lately established into dental implantology as an substitute to titanium implants. Most of the studies have revealed no significant difference between the osseointegration of zirconia implants and that of titanium implants. Depprich et al found similar attachment of both implants to bone, with similar features ultrastructurally. An increased proliferation of osteoblasts was found around zirconia implants as compared to titanium implants, though the attachment and adhesion strength of primary cells was more with titanium. Mosgau et al and Dubruille et al reported higher bone-to-implant contact (BIC) with zirconia than with titanium. Peri-implant bone volume density was superior with submerged zirconia implants as compared to titanium implants according to Gahlert et al.[3]

Histological evaluation shows no statistically significant difference in osseous integration between both zirconia implant and titanium implant. Zirconia implants revealed mean peri-implant bone density values of 42.3% (SD ± 14.5) at 4 weeks, 52.6% (SD ± 5.7) at 8 weeks and 54.6% (SD ± 11.5) at 12 weeks after implantation, whereas Ti-SLA implants demonstrated mean values of 29% (SD ± 10), 44.1% (SD ± 18) and 51.6% (SD ± 8.6) at corresponding time intervals.[4] With respect to the bone–implant contact ratio, the mean values for zirconia ranged between 27.1% (SD ± 3.5) and 51.1% (SD ± 12.4) and for Ti-SLA, it ranged between 23.5% (SD ± 7.5) and 58.5% (SD ± 11.4).[4]

Percentage of bone-to-implant contact around titanium and zirconia implants.[5]

% Bone implant contact	Zirconia	Titanium
Minimum % BIC	12.2	10.6
Maximum % BIC	100	100
Mean	72.2	60.2
(±SD)	(±23.6)	(±22.4)

Properties

Y-TZP is a bioinert and nonresorbable metal oxide that has excellent resistance to corrosion and wear, Young modulus similar to stainless stell alloy, high flexural strength (900–1.200 MPa), Vickers hardness (1.200) and Weibull modulus (10–12), high fracture resistance, high radiopasity, low thermal conductivity, an ivory color similar to the color of the natural tooth, ability to be machined, light transmitting, and good biocompatibility.[6]

When compared with other advanced ceramic materials, zirconia has exceptional strength at room temperature. Other principle properties of this material includes.

Flexural Strength

Flexural strength is an important mechanical property that avails in predicting the performance of fragile material. Milling may initiate residual surface compressive stresses that can increase the resistance of zirconia ceramics. On the other hand, severe wear can make profound defects, which act as stress concentrating areas. Other methods like wear free procedures and partially sintered method of ceramics manufacturing should be advanced to acquire crowns and bridges of the Y-TPZ system that increases strength and reliability. Biaxial flexural strength values from 93.4 ± 10.0 to 141.2 ± 11.6 MPa.[7]Chai et al.[3] compared various ceramic materials and found that yttrium-stabilized zirconia had the highest uniaxial flexural strength of 899 ± 109 MPa.

Fracture Toughness

Yilmaz et al[3] studied fracture toughness of different materials by measuring indentation strength and indentation fracture and concluded that the highest fracture toughness values (MPa) were obtained with the zirconia-based ceramic materials.

Stress Distribution

Kohal et al.[3] did a study on stress distribution patterns in implant with the help of three-dimensional finite element analysis made of pure titanium and yttrium-partially stabilized zirconia implants. It was found that yttrium-partially stabilized zirconia implants has a similar stress distribution to commercially pure titanium implants.

Peri-Implant Tissue Compatibility

Two studies evaluated the periodontal parameter of zirconia implants vs titanium implants. Bleeding on probing remained around 50% for zirconia throughout the study period, while in titanium it was initially 75% but later reduced to 50%.[3] Tete et al observed comparable collagen orientation to both zirconia and titanium implants. Further, lower values of distance from peri-implant mucosa to the apical termination of the barrier epithelium were obtained for zirconia implants according to Wellander et al.[3] In a Spectrophotometer analysis done by two groups of authors, it was found that colour change of mucosa was much lesser with zirconia implant than with titanium implant.

Plaque Acclumulation

Brakelet al.[3] Found more bacterial accumulation around titanium implants than around zirconia implants. Wellender et al.[3] found the least number of leukocytes residing around zirconia implants. Streptococcus mutans was found the least with rectified YTZP, comparable to titanium. Streptococcus sanguis showed much less adherence to both zirconia and titanium. The study by

Rimondini et al. Also showed significantly lesser cocci and rods in relation to zirconia than titanium.[3]

Future Trendings

Zirconia Toughened Alumina Composite

There is a trend today to develop Alumina-zirconia composite since alumina has moderate toughness and zirconia has aging issue. This may be the way to gain from zirconia transformation toughening without the drawback associated with its transformation under steam and body fluid condition. An outstanding tribological and mechanical properties for the composite material processed with 80% tetragonal zirconia poly-crystals (Zro_2-TZP) and 20% alumina (Al_2O_3. ceramtec AG (plochingen, Germany) recently develops BIOLOX delta, which consist of approximately 75% aluminium oxide, the basis for hardness and wear resistance, and approximately 25% zirconium oxide, for improved mechanical properties.[8] a strength higher than 1150MPa is reported, associated with a toughness of 8.5MPa√m. this product is now available in market.

The addition of alumina to zirconia clearly hinders ageing, or at least reduces drastically its kinetic.[8]

DISCUSSION

In the era of aesthetics, minimally invasive dentistry and growing recognition of immediately placed dental implant in fresh extracted socket to replace teeth in the aesthetic zone, adjuncts to titanium dental implants are urgently needed in order to overcome aesthetic complications arising from the latter with the last amount of morbidity, discomfort, cost and time [9].

Investigations suggest that zirconia ceramics are highly biocompatible and have sufficient mechanical properties to be used as a dental implant based material.[6] Substantially because of its tooth -like colour, zirconia is preferred to be a wise alternative material to titanium dental implants.

Osseous healing of modified implant surfaces from polished commercially pure titanium is been compared with zirconia implants. A clear gap between the implant surface filled with remodelling blood clot and bone tissue was observed after 4 days. Woven bone was growing in the direction of the implant two weeks after implantation and formation of lamellar bone was noticed after 28 days. After 8 weeks of complete healing period, close contact of implant surface to the lamellar bone was evident. However, the barrier resulting from the original gap was still visible with many osteoblast bridging the gap, which indicates a high biocompatibility of the used implant materials. [1]

CONCLUSION

The gold standard and most recommended dental implant for patients are titanium which is still irreplaceable. Yet, there are some issues that seeks advancement to this material in order to enhance aesthetics of dental implants. Zirconia offers an outstanding mechanical, biological, and aesthetic trait which fulfils this purpose. Zirconia could potentially be the alternative to titanium implants.

REFERENCES

1. Depprich, Rita, et al. "Osseointegration of zirconia implants: an SEM observation of the bone-implant interface." *Head & Face Medicine*, 2008; 4.1: 25.
2. Schweizerische Zahnärzte." The osseointegration of zirconia dental implants. "research and science, 2012; 4.
3. DR Prithviraj, S Deeksha, KM Regish, N Anoop."A systematic review of zirconia as an implant material."Indian journal of dental research, 2012; 2.
4. Gahlert, M., et al. "Osseointegration of zirconia and titanium dental implants: a histological and histomorphometrical study in the maxilla of pigs." Clinical Oral Implants Research 20.11, 2009; 1247-1253.
5. Siddiqi, A., et al. "One-Piece Zirconia Ceramic versus Titanium Implants in the Jaw and Femur of a Sheep Model: A Pilot Study." *BioMed Research International*, 2016; 6.
6. Merve bankoglu gungor, cemal aydin, handan yilmaz, esma basak gul. "an overview of zirconia dental implants: basic properties and clinical application of three cases. Journal of oral implantology, 2014; 2-6.
7. Fischer, J., B. Stawarczyk, and C. H. F. Hämmerle. "Flexural strength of veneering ceramics for zirconia." *journal of dentistry*, 2008; 36(5): 316-321.
8. Jerome chevalier. "what future for zirconia as a biomaterial. Elsevier. National Institute of Applied Science (INSA), 2005; 8.
9. Ahmad a.jum'ah, bart M.N. beekmans, david j. wood, Hassan maghaireh."zirconia implants: the new arrival in the armoury of successful aesthetic implantvdentistry. Smile dental journal, 2012; 14.