Zirconia as an Implant Material in Dentistry: A Review

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ABSTRACT

The current review article aims to offer a thorough analysis of the materials used in dental implants. Studies on the mechanical characteristics of zirconia implants, osseointegration of zirconia, peri implant tissue response to zirconia implants, and plaque buildup with zirconia are all revealed in this article. Reviewing the chosen publications revealed that zirconia implants may be safely inserted into the jaw bone. In addition, zirconia implants have a material surface that is compatible with the surrounding tissue and less appealing to plaque. According to the reviewed literature, zirconia could replace titanium as the preferred material for dental implants, particularly for cosmetic restorations; nevertheless, several difficulties still need to be further researched.

Keywords: Zirconia, Zirconia Implant, Osseointegration, Plaque, Peri-implant Tissue

INTRODUCTION

Dental implants are a well-researched and widely recognized therapeutic option for restoring both partly and totally denuded patients.[27] Titanium has been the preferred material since dental implants were first used in clinical settings. Titanium was chosen because of its superior biomaterials, strong physical and mechanical qualities, and adaptability for the creation of implant placement and constituent parts. One- and two-piece titanium implant designs are the two basic categories that are offered.[19] Regardless of the design; it is widely known that titanium implants, in situations with a thin peri-implant mucosa or recession, may result in a dull grayish backdrop of the soft tissue. With a high lip line in particular, this discoloration may constitute an aesthetic detriment in the anterior visible region.[19] Additionally, research imply that metals have the potential to cause autoimmunity and nonspecific immunomodulation.[28] Also discussed are the adverse effects of fluoride and saliva on galvanic side effects.[29] Zirconia was first identified in 1892 as a mineral.[1] Due of the aesthetic issues with metal restoratives, metal-free therapy is becoming quite common in dentistry. Dental restorations have traditionally made use of metals. In dentistry nowadays, aesthetics is one of the main objectives.[2] High-strength zirconia ceramics have gained popularity as novel dental implant materials recently. When compared to metallic implants, they demonstrate negligible ion release and are thought to be nontoxic in the body. Due to their greater fracture resistance and flexural strength, yttrium-stabilized tetragonal zirconia polycrystals appear to be superior to aluminium oxide for dental implants.[3] On the other hand, a number of manufacturers are using yttria-stabilized tetragonal zirconia polycrystal (Y-TZP) as the primary component for ceramic implant creation. The outstanding mechanical qualities of zirconia are including its white colour and high flexural strength, fracture toughness, and acceptable Young's modulus. The adoption of this material for the creation of dental implants and related components was encouraged by its colour, low sensitivity to plaque development, and great biocompatibility.[4] There are now 9 zirconia dental implant systems on the market. The Sigma implant (Sandhause, Incermed, Lausanne, Switzerland), which was developed in 1987, was the first zirconia dental implant system. Additional zirconia implant systems are the CeraRoot system (Oral Iceberg, Barcelona, Spain), the ReImplant system (ReImplant, Hagen, Germany), the White Sky system (Bredent Medical, Senden, Germany), the Goei system (Goei Inc, Akitsu-HiroshimaJapan), the Konus system (Konus Dental,Bingen,Germany), the Z-systems (Z-systems, Konstanz, Germany), and the Ziterionsystem (Ziterion, Uffenheim, Germany).[5] Zirconia particles are utilised as a covering material for titanium dental implants in addition to being used as an implant material by itself. To improve the osseointegration of titanium implants, an alternate surface treatment can involve sandblasting with spherical zirconia particles.

Properties

1. **Mechanical Properties:** Due to its superior mechanical qualities, zirconia occupies a special position among oxide ceramics.[6] When compared to conventional dental ceramics, yttria stabilised tetragonal zirconia polycrystalline (Y-TZP) materials demonstrate superior corrosion and wear resistance and a high flexural strength (800 to 1000 MPa).[7,8] The structure is monoclinic at room temperature and after heating to 1170 °C. Between 1170 and 2370 °C, it takes on a tetragonal shape, and from 2370 °C on up to the melting point, it has a cubic structure. The surface area might undergo a tetragonal to monoclinic change as a result of dental operations like grinding or sandblasting.[6] This process is called known as transformation toughening, which enhances the fracture strength and fracture toughness of Y-TZP ceramics compared with other dental ceramics.

2. Stress Distribution: Kohal et.al found that yttrium-partially stabilized zirconia implants had very similar stress distribution to commercially pure titanium implants.[9]

3. Osseointegration: Depprich et al. discovered identical ultrastructural characteristics and similar adhesion of both implants to bone. Although the attachment and adhesion strength of primary cells was higher with titanium implants, an increase in osteoblast proliferation was seen surrounding zirconia implants. According to Mosgau et al. and Dubruille et al., zirconia has greater bone-to-implant contact (BIC) than titanium. According to Gahlert et al., submerged zirconia implants had a higher peri-implant bone volume thickness than titanium implants.[10,11,12] By using light microscopy, Franchi et al.[22] assessed the peri-implant tissues of zirconia-coated implant materials and titanium implants that had been acid-etched. At two weeks, all implants had intimate contact with pre-existing bone, vascularised medullary spaces, and new bone trabeculae.[13]

4. **Peri-Implant Tissue Compatibility:** According to Brakel et al., the mean probing depth decreased more in zirconia implants than in titanium. Orientation of collagen fibre around zirconia implant is parallel to the implant surface. Zirconia has minimum mucosal colour change as compared to titanium implant. Zirconia interacted favourably with the soft tissue. Cell adhesion depends on a surface made of zirconia with a high wettability utilising a carbon dioxide laser. Additionally, Zirconia demonstrated better soft tissue integration for an oral implant than titanium in terms of how it handled microorganisms.[13,5,14,15]

5. Plaque/Bacterial Accumulation: From an orthopaedics perspective, the adherence of oral bacteria to zirconia in vitro is assessed. Zirconia slows down plaque build-up on the implant surface, promoting healthy healing and a successful implant procedure. Compared to titanium, zirconia demonstrated much less bacterial adherence. Zirconia abutments could be a less desirable material surface for early plaque retention than titanium. Bacterial adhesion of zirconia and titanium is similar when titanium and zirconia coating with saliva is incubated with Streptococcus sanguis.[16,17,18]

DISCUSSION

Although zirconia has been proposed and offered as a substitute material for dental implants over 30 years ago, the scientific data appears to be significantly behind that of titanium implants. The restricted use of zirconia implants is a result of a number of variables, including manufacturing challenges, surface modification, the best material-stabilizer combination, long-term surface stability, restorative material choice, and clinical experience. The stability and longevity of zirconia implants is a very fascinating issue in this context. Zirconia's stability is impacted by LTD, which also significantly lowers its resistance to fracture.[1] We were interested in evaluating zirconia as an implant material because of its good cosmetic and mechanical qualities.[19] Zirconia implants have a biaxial flexural strength between 900 and 1100 MPa and a Weibull modulus between 10 and 13. It has been discovered that surface treatments like hand-grinding and airborne particle abrasion increase the flexural strength of zirconia implants. Zirconia has been discovered to have a uniaxial flexural strength between 409 and 899 MPa. One of the first factors to be considered when assessing a dental ceramic's performance, along with strength, is fracture toughness. Zirconia implants have been discovered to have a fracture toughness range of 4-6.2 MPa. Additionally, the stress distribution for zirconia that had been partly stabilised by yttrium resembled that of titanium. Zirconia implant groups, however, have demonstrated irreversible implant head fractures at relatively modest fracture stresses in several trials.[20,21] Evidently, surface change has a significant impact on surface stability over time. Sandblasting and grinding surfaces of zirconia cause the well-known t-M transition, which quickens LTD. As a result, coating or laser technology has been developed to shield zirconia implants from such harm. For instance, roughened zirconia surfaces treated with UV radiation had altered physical and chemical characteristics, which sped up the initial adherence and spreading of cells.[30,31] It is done to modify the surface to improve osseointegration. Zirconia implants demonstrated equivalent or greater levels of osseointegration than titanium implants, regardless of surface alteration. On the other hand, the soft tissue reaction is little understood. Most criteria rely on how things are organised or how long each component is.

Most research came to the conclusion that zirconia implants exhibited comparable or preferable soft tissue responses to titanium implants.[22,23,24] All-ceramic restorations adhered to using adhesive cement are suitable with zirconia implants, according to earlier investigations.[25,26]

CONCLUSION

Zirconia can be employed as an alternate implant material, but there are still numerous uncertainties about the optimal material composition, long-term stability, implant design, the implant-abutment interface, implant-restorative complex, and soft tissue reactions. Prior to advising its use in clinical settings, different zirconia materials and implants must first have the results of carefully planned preclinical research validated.

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