

Zirconia: Creating a New Perspective to Dentistry.

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ABSTRACT

Though zirconia has been available for use in restorative dentistry for several years, there has been an increased interest recently in these materials. Partially stabilised Zirconia based restorations are quite versatile and can be used for crowns, bridges, implant abutments and fixtures and as post materials. This article reviews the history and unique property of zirconia and its wide application in dentistry, with more emphasis on prosthetic uses.

INTRODUCTION

Today's era is an esthetic era. Attempts have been going on to replace the infrastructure of metallic dental prostheses, with a more esthetic alternative. Among the dental ceramics, zirconia has emerged as a versatile and promising material because of its biological, mechanical and optical properties, which has certainly accelerated its routine use in CAD/CAM technology for different types of prosthetic treatment [1].

History

The name "Zirconium" comes from Arabic word "Zargon" meaning "golden in colour". Zirconium dioxide (ZrO₂) was accidentally identified by German chemist Martin Heinrich Klaproth [2] in 1789. Subsequently, the impure zirconium was used as a pigment. The first recommended use of Zirconium as a ceramic biomaterial was documented for total hip replacements (THR). In later years, focus was more upon the development of zirconia- yttrium ceramics combinations commonly known as Tetragonal Zirconia polycrystals (TZP). TZP is being used as application in space shuttle, automobiles, cutting tools, and combustion engines because of its good mechanical and dimensional stability, such as mechanical strength and toughness [3]. In vitro evaluation of the mutagenic and carcinogenic capacity of the high purity Zirconia ceramic confirmed that it did not elicit such effects on the cells [4]. In 1990s, Zirconium material was used as endodontic posts [5] and as implant abutments [6]. This led to the use of Zirconium in dentistry. It has excellent physical properties, white colour, and superior biocompatibility and hence proves to be an esthetic alternative to the metal and porcelain fused to metal crowns and bridges.

Unique Property of Zirconia

High fracture toughness and strength of Zirconia is because of its property called as "Transformation toughening". Zirconium is a polycrystalline ceramic without any glass component. It is a polymorph that occurs in three forms, monoclinic (M), cubic (C) and tetragonal (T). Pure Zirconia at room temperature is in the monoclinic form and stable till 1170 °C. Above this temperature it transforms itself into tetragonal form and then further into cubic phase at 2370 °C. During cooling, a Tetragonal -Monoclinic transformation takes place at the temperature range of about 100 °C below 1070 °C. The phase transformation, which takes place during cooling, is associated with volume expansion of approximately 3-4%. Different oxides, such as yttrium oxide (Y₂O₃), calcium oxide (CaO) or magnesium oxide (MgO), can be added to zirconia to stabilize it, allowing the tetragonal form to exist at room temperature after sintering. The tetragonal zirconia phase is stabilized, but under stress, the phase may change to monoclinic, with a subsequent 3% volumetric size increase. This dimensional change takes energy away from the crack and can stop it in its tracks. This is called transformation toughening". Also, the volume change creates compressive stress around the particle, which further inhibits crack growth. The addition of varying amounts of

stabilizers allows the formation of partially or fully stabilized zirconia which, when combined with changes in processes, may result in ceramics with exceptional properties such as high flexural strength and fracture toughness, high hardness, excellent chemical resistance and good conductivity ions [7].

Applications in dentistry

The first study on the use of zirconia in dentistry was to evaluate the ceramic coatings on metal implants, with the aim of improving their biocompatibility in the oral cavity. Histological examinations revealed fibro integration of these implants, but with a higher clinical success of those coated with alumina. With the advancement in technology and an understanding of zirconia's property of transformation toughening, several studies were developed to evaluate the use of zirconia as a structural material in dentistry. This led to the development of zirconia implants. Thereafter, several studies involving the peri-implant bone remodelling the quality of bone apposition directly on ceramic implants, the stability and contour of the mucosa around these implants, the use of a zirconium ceramic based post in the interior of root canals, prosthetic systems obtained by machining CAD/CAM and the construction of abutments on implants were reported in the literature, reinforcing the viability of this material.⁴ In prosthetic dentistry, the introduction of zirconia began with the InCeram Zirconia system (Vita Zahnfabrick, Germany).

Applications from a Prosthodontic Perspective

Zirconia for Fixed Restorations

Zirconium dioxide (zirconia) ceramics are currently used for fixed restorations as a framework material due to their mechanical and optical properties. In terms of fracture resistance, zirconia based fixed partial dentures (FPDs) have the potential to withstand physiological occlusal forces applied in the posterior region, and therefore provide interesting alternatives to metal-ceramic restorations. Although certain clinical evaluations have indicated an excellent clinical survival of zirconia-based FPDs and crown restorations, some studies have revealed a high incidence of chipping of veneered porcelain. Long term research is going on to assess the survival rate of zirconia restorations for posterior fixed partial dentures [8].

Zirconia as an Esthetic Post System

Cast metal post-core systems have been successfully used till date because of their superior physical properties. However, their high elastic modulus can cause stress concentrations within the surrounding radicular dentin, resulting in root fractures. Moreover, the increasing demand for more esthetically appealing and biocompatible restorations has led to the development of tooth-colored, translucent, metal-free post-core systems. Prefabricated zirconia ceramic post systems have been introduced to for better esthetics, whereby the translucency of all-ceramic crowns can be successfully maintained with the use of ceramic post-core materials. In particular, a patient who has a high lip line and thin gingival tissue would require the use of a zirconia post with an all-ceramic crown to optimize the esthetic effect at the root, while maintaining an adequate level of strength [5].

In addition, zirconia is indicated for teeth with severe coronal destruction, because composite materials lack the strength to resist deformation when used to support crowns. Disadvantages of zirconia as a post material include higher rigidity of zirconia posts, as compared to FRC posts, which may predispose vertical root fractures. Therefore, zirconia is not indicated for patients with bruxism. Besides, it is almost impossible to retreat teeth restored with zirconia posts because it is too difficult to grind away the zirconia post and remove it from the root canal [5].

Zirconia as an Implant Material

Ceramic implants are more esthetic and mimic natural teeth better than the grey titanium. Using white ceramic implants would preclude the dark shimmer of titanium implants when the soft periimplant mucosa is of thin biotype or recedes over time. Ceramic materials for oral implants were already investigated and clinically used some 30–40 years ago. At that time, the ceramic material utilized was aluminium oxide (polycrystal or single crystal). Currently the material of choice for ceramic oral implants is Y-TZP or Ce-TZP (ceria-stabilized TZP). Compared with alumina, Y-TZP has a higher bending strength, a lower modulus of elasticity and higher fracture toughness [9].

Zirconia as Implant Abutments

Esthetic abutments were introduced in the form of aluminium oxide. Though these abutments showed stable peri-implant soft tissue and osseointegration, many clinical studies have reported fractured alumina abutments. Due to these short comings in their mechanical properties yttrium stabilized zirconia which has better fracture resistance was introduced as an alternative material for implant abutments and it has overtaken alumina as the preferred ceramic abutment material [10].

CONCLUSION

The introduction of stabilized zirconia has created a new dimension for the application of ceramics in dental reconstructions. Due to its excellent strength and esthetics, zirconia is rapidly replacing the metallic restorations. More clinical trials to assess the long term success rates can help in wider applications of this material.

Table 1: Applications of Zirconia in Dentistry

Single crowns
Anterior and Posterior fixed partial dentures
Splinted crowns
Zirconia implants and Crowns on Implants
Cantilever bridges (excluded for patients with bruxism)
Inlay and onlay bridges (excluded for patients with bruxism)
Anterior adhesive bridges (excluded for patients with bruxism)

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