

Ceramics: In Recent Trends

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ABSTRACT

Background: Recent advancement in metal ceramic systems like the electroforming gold and captek has resulted in a restoration with excellent esthetics and strength. All-ceramic restorations, metal ceramic crowns can be bonded with composite cements, which further enhances the effects of marginal sealing and biocompatibility. In situations where one cannot provide enough compressive strength inside ceramic inlays and onlays second-generation laboratory composites would be the preferred as clinical choice. Advancement in the all-ceramic systems like the IPS EMPRESS 2 has resulted in a functionally durable all-ceramic restoration. Finally, advancements in CAD-CAM has resulted in an restoration with esthetics, strength and easy of fabrication done in a single visit. The only disadvantage with the CAD/CAM system is the occlusion with the opposing tooth, which requires manual refinement at present. But with the advent of newer softwares and advancement in technologies this minor hiccup is expected to be solved in the near future resulting in a restoration that is functionally durable, esthetically excellent with accurate margins and low wear on the opposing teeth, more importantly less technique sensitive with ease of fabrication and less time consuming.

Keywords: : Zirconia, Yttrium stabilized zirconia, Esthetic posts.

INTRODUCTION

Ceramics and polycrystalline ceramics has different physical and optical properties. However, the selection of these ceramics must be made with respect to the mechanical properties of the materials, tooth preparation design, and the ability to provide adequate insertion procedures such as traditional or adhesive luting. Zirconia is a polycrystalline ceramics without a glassy phase and exists in several forms. It exists in a monoclinic crystalline state at room temperature, then through sintering changes to tetragonal and cubic crystalline states. The cooling of either state will normally result in reversion to a monoclinic state. The most common method of stabilizing the tetragonal phase and maintaining zirconia in a metastable condition

at room temperature is by adding a small amount of yttria to the zirconia. Such treatment produces a material that is stronger and tougher than other available ceramics. Factors that facilitate tetragonal to monoclinic conversion include water/moisture and mechanical work such as polishing, which may aid, which has certainly accelerated its routine use in CAD/CAM technology for different types of prosthetic treatment.

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 in 1789. Subsequently, the impure zirconium was used as a

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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. 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. In 1990s, Zirconium material was used as endodontic posts and as implant abutments. 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.

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.¹ In prosthetic dentistry, the introduction of zirconia began with the InCeram Zirconia system (Vita Zahnfabrick, Germany).

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.

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

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 per implant 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.

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.

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.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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