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Review Article

ZIRCONIA A MODERN CERAMIC MATERIAL IN DENTISTRY - A SYSTEMATIC REVIEW

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ABSTRACT

Among the dental ceramics, zirconia has emerged as a resourceful 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. The zirconia systems currently available for use in dentistry include ceramics with a 90% or higher content zirconium dioxide, which is the yttrium, stabilized tetragonal Zirconia (Y-TZP) and glass infiltrated ceramics with 35% partially stabilized zirconia. 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 unique property of zirconia and its wide application in dentistry, with more emphasis on prosthetic uses.

Keywords: Zirconia, Esthetics, Restorations, Mechanical properties.

INTRODUCTION

Ceramic materials are best able to mimic the appearance of natural teeth. Among all ceramics zirconia is commonly used material. Its mechanical properties are very similar to those of metals and its color is similar to tooth color[1]. Zirconia is a crystalline dioxide of zirconium. The name "Zirconium'' comes from Arabic word "Zargon'' which means "golden in color''. Zirconium dioxide (ZrO_2) was accidentally identified in 1789 by German chemist, Martin Heinrich Klaproth, while he was working with certain procedures that involved the heating of gems. Subsequently, zirconium dioxide was used as rare pigment for a long time[2]. Zirconia crystals can be organized in three different patterns: monoclinic (M), cubic (C), and tetragonal (T). By mixing ZrO_2 with other metallic oxides, such as MgO, CaO, or Y_2O_3, great molecular stability can be obtained.

Zirconia has been widely used in dentistry because of their superior mechanical properties compared to other available all-ceramic systems. Zirconia-based restorations are versatile and can be used for crowns, bridges and implant abutments in a variety of clinical situations, if the appropriate guidelines are followed.

Form of Zirconia used in Dentistry

Zirconia is the name given to zirconium dioxide (ZrO_2). Zirconia is a polycrystalline material, which can exhibit more than one crystalline structure depending on pressure and temperature conditions. The type of zirconia used in dentistry is yttria tetragonal zirconia polycrystal (Y-TZP) material which is zirconia oxide. Yttria (Y_2O_3) is an oxide of the metallic element yttrium (atomic no. 39). Y-TZP is a monophase ceramic material that is formed by directly sintering crystal together without any intervening matrix to form a dense, air free, polycrystalline structure. The yttria is added to zirconia to stabilize the structure and maintain the materials desirable properties.

Y-TZP Ceramics have a unique characteristic of "Stress Induced Transformation"[3-6] that gives them superior mechanical properties compared with other ceramics and that is why this material is referred to as a "Ceramic Steel"[7].

Application in dentistry

Zirconia has been widely used in dentistry because of their superior mechanical properties compared to other available all-ceramic systems. 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[8].

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[9].

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.

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[10].

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].

DISCUSSION

The demand for aesthetics in restorative dentistry has risen dramatically in the last few decades. Nowadays, some patients desire that their restorations should resemble natural tooth structure. Many attempts by manufacturers try to produce all-ceramic materials that could be restored extensively damaged tooth with the acceptable mechanical and physical properties.

Zirconia-based ceramics has been interested by many researchers to develop this material for fabricating high strength esthetic crowns. Nowadays, studies on zirconia-based ceramic

are focusing on the development of esthetic monolithic zirconia restorations[11,12]. Further investigations on the translucency, wear properties and fatigue resistance of monolithic zirconia should be performed. In addition, a novel IPCs ceramics have been developed for fabricating dental restorations. This material showed high fracture toughness that can resist to the brittle fracture of ceramic restorations[13, 14].

Zirconia copings have highest opacity among other all-ceramic system because of its polycrystalline nature. Therefore, the compatible esthetic ceramic is recommended to be veneered on the zirconia[15]. Zirconia restorations have been reported high clinical success rate. Örtorp et al. studied the fracture resistance of core-veneered zirconia crowns after 3 years of service and the result showed none of zirconia core fractured.

However, four cases of veneering porcelain chipping were observed[16]. Other studies showed the survival rates of zirconia single crowns ranged from 91.7% to 100 % after being used for 2-5 years[17]. Fracture of the veneering porcelain is the most commonly reported complication in Y-TZP-based restorations.

Veneer fracture rates were reported at 2% to 9% for single crowns after 2 - 3 years and 3% to 36% for FPDs after 1 – 5 years. The mismatch of thermal expansion coefficient between zirconia coping and veneering porcelain has been discussed as a contributing factor for fracture of veneering porcelain[18]. Residual stress in core-veneered crowns can be associated with the developing thermal gradients inside the structure during cooling. The low thermal conductivity of zirconia in core-veneered all-ceramic system results in the large temperature differences and therefore, high residual stress. In addition, thick layers of veneering ceramics on zirconia cores are highly susceptible to residual tensile stress resulting in cracking or chipping[19]. Frequently, delimitation, chipping and cracking of veneering porcelain were defined as minor complications in which the replacing of a restoration was not required. Depending on the size and location, cracks leading to veneer fractures can severely compromise the esthetics and function of restorations, eventually; the restorations have to be replaced.

CONCLUSION

The introduction of stabilized zirconia has created a new dimension for the application of ceramics in dental reconstructions. Zirconia restorative material is well-placed to satisfy esthetic requirements and to fulfill functional requirements. Further studies should be conducted to resolve the complications that may reduce restorations longevity.

Osseointegrative zerconia implants, more esthetic and strong crowns and veneers, to mention a few. Definitely, future is bound to witness a bigger revolution in field zerconia, with introduction of newer ceramics and nanotechnology for the betterment of dental restorations on the lines of form, function and esthetics, along with improved biocompatibility.

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