Effect of Zirconia Veneering Techniques and Materials on Color and Translucency Before and After Aging

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By

Mohamed Aly Mohamed Badr

Ain Shams University
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Faculty of dentistry
Ain Shams University
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SUPERVISORS

Dr. Tarek Salah Morsi

Assistant Professor of Fixed Prosthodontics

Faculty of Dentistry

Ain Shams University

Dr. Marwa Mohamed Wahsh

Lecturer of Fixed Prosthodontics

Faculty of Dentistry

Ain Shams University

كلما أدبني الدهر   أراني نقص علمي

وإذا ما ازددت علما   زادني علما بجهلي

ديوان الإمام الشافعي

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Dedication

Dad, My Backbone,

Mom, My password,

My wife, My warm soul,

My sisters, Reasons of my happiness,

I could never be grateful enough to you, for standing beside me all over the way and for being the reason of each and every step forward in my life.

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INTRODUCTION

In the last thirty years there was dramatical increase in patient`s demands for superior esthetics and naturally appearing restorations. The demand to achieve a natural looking restoration is one of the most challenging aspects in dentistry[1].

Successful aesthetic restorations require the integration of several factors as the individual`s perception of color, the light source used for color evaluation, the surface and structural characteristics of both the tooth and restorative materials used and knowledge of some basic principles of color perception. Thus, shade matching is considered more artistic than scientific[1].

Since the introduction of Alumina-reinforced feldspathic porcelain in 1965 [2], new materials and processing technologies for all ceramic restorations with significantly improved mechanical and physical properties have been available. Computer aid design/computer aid manufacture (CAD/CAM) technology has been used to fabricate infrastructures of all-ceramic restorations. Partially sintered yttrium blocks can be milled according to the frameworks designed by CAD software[2].

Then, after fully sintering at the second high temperature, outstanding mechanical properties, such as high flexural strength and fracture toughness of a yttria-stabilized zirconia polycrystalline (Y-TZP) ceramic, are achieved, so that Y-TZP all-ceramic restorations possess superior fracture resistance to withstand occlusal force[3], however, since Y-TZP substructure lacks color properties and offers less light transmission, it is necessary to veneer its surface to ensure the esthetic value of restorations which is partially influenced by translucency and color.

To achieve natural appearance of all-ceramic restorations, it is necessary to incorporate layers of porcelain of different opacity and shade. As a result of different composition, core materials for all-ceramic restorations come in different degrees of translucency or opacity[4,5]. The core translucency or opacity has been identified as one of the primary factors controlling esthetics and critical consideration in the selection of the materials[6].

Y-TZP is placed midway among the most translucent Empress 2 In-Ceram Spinell and the most opaque In-Ceram Zirconia[7].

Several veneering techniques, such as traditional layering technique, fully anatomical pressing technique, and CAD-on technique, can be applied on zirconia core material in the IPS e.max all-ceramic system. Each technique is said to be able to improve the esthetic properties of Y-TZP restorations; however, it has not been determined whether different veneering techniques have the same influence on the appearance of all-ceramic restorations.

In the oral environment, all-ceramic materials are prone to aging. Aging can lead all-ceramic materials to change color, to lower bending strength and to reduce anti-fracture toughness. Accelerated aging simulates the effects of long-term exposure to environmental conditions through an artificial weathering process that involves light exposure, temperature and humidity[8].

Therefore, the purpose of this study was to estimate the veneering technique and material that produce best color and translucency parameters and retain color stability and translucency after aging.

REVIEW OF LITERATURE

All ceramic systems have become increasingly popular due to their esthetic and biocompatible properties. They are however subject to brittle failure. Various ways have been suggested to improve their resistance to brittle fracture including the fusion to metal, and the selection of reinforced ceramic cores combined with esthetic veneer material [9].

For a long period of time, the porcelain fused to metal technique has proven to be a reliable treatment option for fixed dental prosthesis due to its high predictable strength and the reasonable esthetic of ceramics. However the disadvantage of such restorations is its artificial appearance due to the increased light reflectivity caused by the opaque porcelain needed to mask the metal substrate [4] and the graying effect of the metal at the gingival margin [10].

Numerous attempts have been made to develop all ceramic systems that eliminate metal infrastructure providing optimal distribution of reflected light [11].

Core veneered all ceramic restorations are possible substitutes for the strong but less esthetic metal core substructures. Combining the strength of ceramic cores and superior esthetics of a weaker veneer, ceramic can result in reliable and more biocompatible restoration [12].

The introduction of zirconium dioxide or zirconia opened the door for designing fixed all ceramic partial dentures without any limitation regarding the size of the fixed partial denture [13]. Its unique qualities, strength, transformation toughening, white color, chemical and structural stability made zirconia the core material of choice[14].

Zirconia:

Zirconia is a crystalline dioxide of zirconium. Its mechanical properties are very similar to those of metals and its color is similar to tooth color [15].

In 1975, **Garvie** proposed a model to rationalize the good mechanical properties of zirconia, by virtue of which it has been called ‘‘ceramic steel’’.

First biomedical application of zirconia was when it was introduced for the manufacture of ball heads for total hip replacements. It was later introduced in the dental field due to its excellent mechanical properties and improved esthetic properties compared to metal-ceramic restorations. Its first use for root canal dowels was in 1989, for orthodontic brackets in 1994, for implant abutments in 1995 and for all-ceramic fixed partial dentures was in 1998[16-18].

Pure unalloyed zirconia is polymorphic and allotropic –at ambient pressure- occurring in three crystalline forms. At room temperature, pure zirconia is monoclinic and remains stable at this phase up to 1170^{o}c. above this temperature, it transforms into tetragonal phase and then into cubic phase at 2370^{o}c. Upon cooling, phase transformation from tetragonal to monoclinic occurs and is accompanied by 4-5% increase in volume that is sufficient enough to cause catastrophic failure. Alloying pure zirconia with oxides such as CaO, MgO, Y_2O_3, CeO_2, allows the retention of the tetragonal phase at room temperature, thus controlling the stress induced t-m transformation, efficiently arresting the crack propagation and improving the fracture toughness[17].

There are many types of zirconia based ceramics used in dentistry which are:

A. Glass-infiltrated zirconia toughened alumina:

Uses high temperature sintered alumina glass-infiltrated copings. The flexural strength of the framework material ranges from 236 to 600 MPa, and the fracture toughness ranges between 3.1 and 4.61 MPa$(m)^{1/2}$ [19].

B. Magnesium partially stabilized zirconia(Mg-PSZ):

It consists of clusters of tetragonal crystals within stabilized cubic zirconia matrix with the added stabilizer being MgO(8-10 mol.%). This material isn't widely used due to its high porosity, large grain size, low stability and low overall mechanical properties [20].

C. Yttrium partially stabilized tetragonal zirconia polycrystals(3Y-TZP):

This is the principle kind of zirconia considered for current medical and dental use. It has 3 mol.%Yttria added as a stabilizer and consists of small equi-axed grains (0.2-0.5μm in diameter) depending on the sintering temperature. It has superior mechanical properties with flexural strength900-1200 MPa and fracture strength 9-10 MPa$(m)^{1/2}$ [16].

D. Ceria-stabilized zirconia/alumina:

Replacing Yttria(Y) with ceria (Ce) results in significantly increased fracture toughness, however, the flexural strength is affected [21-24].

To overcome this low flexural strength, Ce-TZP may be alloyed with alumina, thus, the flexural strength is improved while the fracture toughness remains high. The homogenous dispersion of Al_2O_3 in a Ce-TZP matrix suppresses grain growth and increases hardness, elastic modulus, and the hydrothermal stability of tetragonal zirconia [23-26].

The mechanical properties in terms of flexural strength and fracture toughness of Ce TZP-Al were suitable for short and intermediate span FPD restorations. On the other hand, its very low bond strength with the veneer ceramics would make such a layered restoration highly susceptible to chipping and delamination failure under function [27].

In addition to having good mechanical properties, the esthetics of core materials is an important factor for the all-ceramic restorations to match the natural dentition. **Kelly et al(1996)[28]** demonstrated that core translucency was one of the primary factors in achieving good esthetics and that it affected the shade of artificial restorations. However, zirconia-containing core materials have poor translucency and are difficult to satisfy the esthetic requirements that's because the chemical nature, the amount of crystals, the particle size, the pores and the sintered density determine the amount of light that is reflected, transmitted and absorbed and thus influencing the optical properties of the core materials[4]. Less crystalline scattering of light and since Y-TZP is polycrystalline and has a different refractive index to the matrix, most of the light passing through it is intensely scattered and diffusely reflected leading to an opaque appearance.

Anselmi- Tamburini et al (2007) [29] found that porosity plays large role in the transparency of YSZ, and only pores larger than 50 nm cause significant scattering and thus reduction of transmission and also demonstrated that the application of high pressure during SPS enhances the transparency of c-YSZ. The coupling of SPS with high pressures is effective for preparing other ceramics too such as alumina. Small particles (approximately 200 nm in diameter) could be less opaque because of less refraction and absorption [30,31].