

“Effect of surface treatment on color, translucency and surface roughness of cubic zirconia”

Thesis

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قالوا

لسبتانك لا علم لنا
إلا ما علمتنا إنك أنت
العليم العظيم

صدق الله العظيم

سورة البقرة الآية: ٣٢

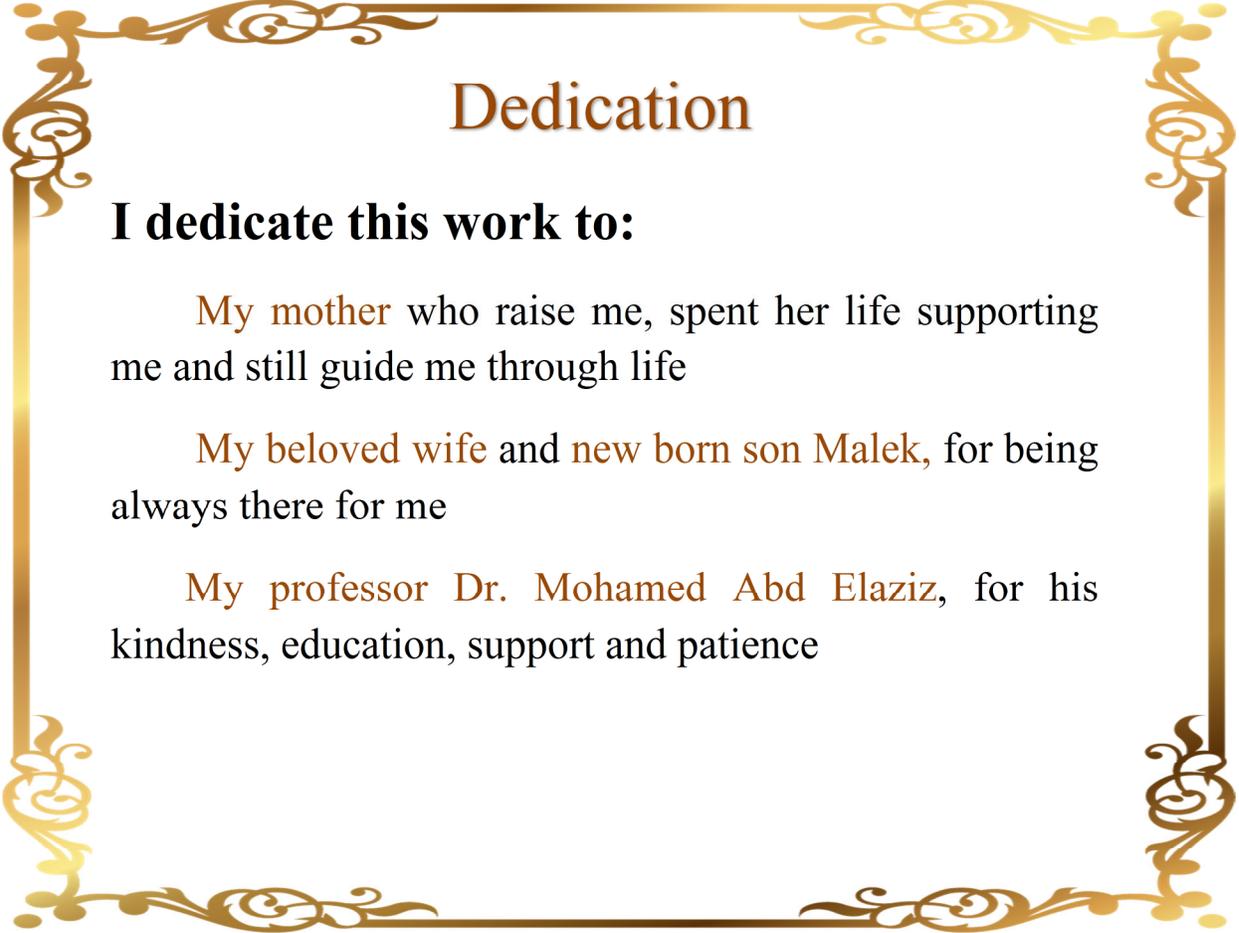
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Dedication

I dedicate this work to:

My mother who raise me, spent her life supporting me and still guide me through life

My beloved wife and new born son Malek, for being always there for me

My professor Dr. Mohamed Abd Elaziz, for his kindness, education, support and patience

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INTRODUCTION

Many different types of ceramic systems have been introduced in recent years for all types of indirect restorations, from very conservative non preparation veneers, to multi-unit posterior fixed partial dentures a. Although ceramics can be very strong, they are also extremely brittle and will catastrophically fail after minor flexure. Thus, these materials are strong in compression but weak in tension.

Zirconia or zirconium dioxide (ZrO₂) is a highly attractive ceramic material in prosthodontics due to its excellent mechanical properties related to transformation toughening, which are the highest ever reported for any dental ceramic and enhanced natural appearance compared to metal-ceramics.¹ Zirconia shows similar mechanical properties to stainless steel² and the highest ones among ceramics used in dentistry. As the strongest and toughest of all dental ceramics.³

Although zirconia has superior mechanical properties, its opaque white color and insufficient translucency require glassy porcelain veneering on the framework to achieve a natural appearance and acceptable esthetics.⁴ However, cracking or chipping of the porcelain veneer has been reported to be a major complication of these restorations.⁵

Another alternative solution was to use non-veneered zirconia restorations. The translucency of zirconia was increased and full-contoured, monolithic zirconia restorations without veneering porcelain have become increasingly popular as a result of advances in CAD/CAM technology^{4,6} The monolithic zirconia has been used in posterior region, especially for single crowns, in order to eliminate the veneer cracking^{7,8}

Monolithic zirconia also possesses acceptable esthetic properties comparable to those of natural teeth. An advantage of using this monolithic zirconia restoration is its straightforward preparation because framework thickness adjustment is not required for veneer layering⁹

A strong and solid bond between cement and zirconia is extremely important for patients' satisfaction. Marginal seal, proper retention and sufficient aesthetics are improved characteristics of resin cements over conventional cements. However, for sufficient bonding one of the vital components is micromechanical attachment^{10, 11}

Roughening zirconia restorations inner surfaces causes increases in the area convenient for penetration and in situ polymerization of resin based materials, which in turn enhance the mechanical bond.

There are many surface treatment methods to improve a successful bonding. Hydrofluoric acid etching, which is one of the most effective methods to increase the bonding mechanism, is not a useful technique due to the fact that the zirconia is not glassy and is densely-sintered. Studies to ensure a good bonding in zirconia have been shown for many years that the surface should be cleaned first and then roughened. Then chemical activations such as airborne particle abrasion using pure alumina or silica coating using silica-coated alumina particles can be carried out.

Due to the improvement of lasers in dentistry laser irradiation is thought to be an alternative method to increase surface roughness and improve adhesion between ceramics and resin cements^{12, 13, 14}

Recently, several new ceramic primers have been introduced to the dental market to increase chemical bonding to zirconia ceramics.

The application of MDP containing bonding agents can increase bond strength to zirconia¹⁵ because of an interaction between the hydroxyl groups of MDP and the cationic surface of zirconia.¹⁶

Although surface treatments of zirconia improve the bonding mechanism to tooth structure, it might affect the surface texture and surface roughness of zirconia.

The roughness, smoothness and surface quality of a restoration material is important for ensuring a desired esthetic appearance and long-term clinical success¹⁷ because rough surfaces have an impact on discoloration in addition the light reflects and diffuses from an irregular and rough surface, which alters the restoration color.¹⁸

Optical characteristics like color stability, translucency, and opalescence must be considered during the selection of materials for maintaining esthetics.¹⁹ The optical characteristics of restorative materials were reported to be affected by the material structure and surface texture and aging.²⁰

Despite the many advantages of monolithic zirconia, surface treatments required for bonding might affect the optical properties and surface roughness of zirconia

REVIEW OF LITERATURE

Dental ceramics are appreciated as a highly esthetic restorative material with an optimal esthetic property that simulates the natural dentition appearance. Other desirable characteristics include translucency, fluorescence, chemical stability, biocompatibility, high compressive strength, and a coefficient of thermal expansion similar to tooth structure.²¹ In spite of their many advantages, ceramics are fragile under tensile strength.²²

Many different ceramic systems have been introduced in recent years for all types of indirect restorations. Ceramics fall into three main composition categories: predominantly glass; particle-filled glass; and polycrystalline. Zirconia is a polycrystalline ceramic without a glassy phase and exists in several forms.

Zirconia (zirconium oxide) was introduced by Martin Heinrich in 1789.²³ Which is a highly attractive ceramic material in prosthodontics due to its excellent mechanical properties related to transformation toughening, which are the highest ever reported for any dental ceramic and enhanced natural appearance compared to metal-ceramics.^{24,25}

This material is a noncytotoxic metal oxide, which is insoluble in water and has no potential of bacterial adhesion. In addition, it has radio-opacity properties and exhibits low corrosion.²⁶

Unalloyed zirconia (pure form) can exist in three crystallographic forms. At room temperature and upon heating up to 1170 °C, the structure is monoclinic. Then it is tetragonal between 1170 and 2370 °C and cubic above 2370 °C and up to the melting point.²⁷

Upon cooling, transformation from the tetragonal (t) phase to the monoclinic (m) phase will induce a substantial increase in volume (~4.5%). This will lead to catastrophic failure.

Adding CaO, MgO, Y₂O₃ or CeO₂ to zirconia-alloys allows the retention of the tetragonal structure at room temperature. This will control the stress-inducing t→m transformation. Compressive stresses developed in the vicinity of a crack tip, arrest crack propagation and lead to high fracture toughness^{28, 29}

HEUER, A. (1987)³⁰ and Hannink, R. et al. (2004)³¹ reported that the Zirconia has unique physical characteristics and high strength. The high strength of zirconia is derived from a stress-induced transformation from the metastable tetragonal form to the stable monoclinic form (t→m). The stress-induced transformation greatly enhances the mechanical properties of transformation-toughened ZrO₂ ceramics, where the crack resistance increases during the course of cracking propagation.³⁰

I- Classification of zirconia

A. According to manufacturing

The zirconia was divided to three main types which are available for use in clinical dentistry, although they are chemically identical; they have slightly different physical properties. The first type is supplied as a fully sintered zirconia. The second type is supplied as a partially sintered zirconia, while the third type is supplied as a non sintered or "green state" zirconia. This process utilizes slurry of zirconia oxide that is applied to an oversized die and then sintered