The Effect Of Different Preparation Designs And Cement Type On The Fracture Resistance Of All-Ceramic Cantilever Anterior Fixed Partial Dentures

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Dedication

This work is dedicated to

My Dear Father, the one who always
supported me,

My Dear Mother, the one who is always
there for me,

My Adorable wife, to whom I owe a lot,

My daughter, the one who enlightened
my heart with joy

&

My Amazing Sister & Brother
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INTRODUCTION

Maxillary lateral incisors are among the most commonly congenitally missing teeth. The replacement of these teeth raises several important treatment planning concerns. Therefore, it is beneficial to use an interdisciplinary treatment approach to achieve the most predictable outcome.

Recently, yttrium oxide partially-stabilized zirconia (Y-TZP) ceramics have been introduced to dentistry because of their desirable esthetics, biocompatibility, superior fracture strength, and fracture toughness compared with other dental ceramic systems.

The development of these materials, coupled with the new computer-aided design/computer-aided manufacturing (CAD/CAM) fabrication techniques, has created a wide range of applications for dental restorations. Core substructures for dental restorations can be fabricated from fully or partially sintered ceramic blanks using manually controlled copy-milling or CAD/CAM technology.

After milling, zirconia has to be veneered with porcelain in layering or press technique; however, this veneering porcelain is directly exposed to chewing, clenching and moisture which might weaken the veneering and result in cracks or chipping.

The fracture resistance of all-ceramic restorations is one of the major concerns in clinical applications of these materials. Several factors influence the fracture resistance of all-ceramic restorations.

REVIEW OF LITERATURE

Dental ceramics may be defined as inorganic compounds with non-metallic properties consisting of oxygen and one or more metallic or semi-metallic elements, e.g. aluminum, magnesium, silicon, titanium and zirconium. [1, 2] They may exist as either crystalline or amorphous solids, being called glasses. [3]

Many different ceramics have been introduced in recent years for all types of indirect restorations.

Zirconia:

Zirconia is a polymorphic material that occurs in three temperature-dependant forms that are: monoclinic (room temperature to 1170 °C), tetragonal (1170 °C–2370°C) and cubic (2370°C – up to melting point). The tetragonal-to-monoclinic phase (t-m) transformation occurs below 1170°C and is accompanied by a 3-5% volume expansion which causes high internal stresses. This transformation is reversible and begins at 950°C on cooling, unless stabilizing oxides are added. [4, 5]

When stabilizing oxides such as magnesia, ceria, yttria and calcium oxides are added to zirconia, the tetragonal phase is retained in a metastable condition at room temperature, enabling a phenomenon called transformation toughening to occur. [6]

Yttrium-oxide (Y_2O_3 3% mol) is added to pure zirconia to control the volume expansion and to stabilize it in the tetragonal phase at room temperature. This Yttrium-oxide partially stabilized zirconia (Y-TZP) has high initial flexural strength (900 to 1200MPa) and fracture toughness (9 to $10MPa.m^{1/2}$). Tensile stresses at a crack tip will cause the tetragonal phase to transform into the monoclinic phase with an associated 3-5% localized expansion. The volume increase creates compressive stresses at the crack tip that counteracts the external tensile stresses and retards crack propagation. In the presence of higher stress, a crack can still propagate. The toughening mechanism does not prevent the progression of a crack it just makes it harder for the crack to propagate. [7, 8]

At room temperature, the transformation from tetragonal to monoclinic is a one-way process. This means that, once it takes place, the crack-hindering effect cannot be exploited for limiting further fractures. [9] when heating the material at a temperature between 900^{o}C and 1000^{o}C for a short time, the process can be reversed; [10, 11] in this case, the transformation from monoclinic back to tetragonal occurs, thus making crystals available again for further transformation and crack repair, and generates a relaxation of the compressive stress at the surface. From this point of view, the high temperature process of veneering zirconia with feldspathic ceramic should be taken into account as a possible risk of such a detrimental reverse transformation. [5]

The mechanical properties of 3Y-TZP strongly depend on its grain size. Above a critical grain size, 3Y-TZP is less stable and more susceptible to spontaneous *t→m* transformation, whereas smaller grain sizes (<1µm) are associated with a lower transformation rate. Moreover, below a certain grain size (~0.2µm), the transformation is not possible, leading to reduced fracture toughness. Consequently, the sintering conditions have a strong impact on both stability and mechanical properties of the final product as they dictate the grain size. Higher sintering temperatures and longer sintering times lead to larger grain sizes. [12]

Physical properties of zirconia

Zirconium (Zr) is a metal with the atomic number 40. The material has a density of 6.49 gm/cm^3, a melting point of 1852°C and a boiling point of 3580°C. Zirconia has a coefficient of thermal expansion (CTE~10.5-11x10^{-6}°C), and a low thermal conductivity, 2 Wm^{-1}k^{-1}, compared to 30 for alumina, so it prevents the sensitivity of the abutment tooth during temperature changes in mouth.

Zirconia is not soluble in water, [9]that was proved not to be cytotoxic, [13]and not to enhance the bacterial adhesion that is lower than on titanium. [14, 15] Moreover, it has a low corrosion potential, [5] and exhibits a favorable radio-opacity which is very useful in evaluation of marginal integrity. [16]

Mechanical properties of zirconia:

Y-TZP is a glass-free, high-strength polycrystalline ceramic that is indicated for anterior and posterior crown copings and FDP frameworks. [17, 18]

Zirconia has a flexural strength of (900-1200MP) [19] which is approximately equal to metal-ceramics (900-1000MPa), twice as strong as alumina oxide ceramics (500MPa) and 5 times greater than standard glass-ceramics. [20, 21]

Materials with high flexural strength (ability to bend before it breaks) provide restorations with less susceptibility to bulk fractures. [22]

Even more important is the fracture toughness of the material which measures the ability of a material to resist propagation of an internal crack. Fracture toughness of zirconia is (6-10MPa.m$^{1/2}$), [23] which is almost twice as high all that of alumina oxide ceramics (4MPa.m$^{1/2}$). This is due to transformational toughening, which gives zirconia its unique mechanical properties. [24, 25]

The modulus of elasticity (expression for stiffness) describes the resistance of the material against flexible deformation. For zirconium dioxide the young‘ s modulus amounts to approximately 200-300 GPa. Other all-ceramic systems reach approximately 100 GPa, while metal-ceramic