Marginal fit and fracture resistance of different yttrium zirconia posterior framework designs

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Introduction

During the past 40 years, porcelain fused to metal technique has been extensively used in fixed partial dentures. Although this technique has improved the demand for more aesthetic materials with high strength properties for fabricating FPDs. However; the public scare about allergic adverse side effects of dental alloys has accelerated the development of alternatives to metallic dental restoration, therefore numerous attempt have been made to develop all ceramic systems which eliminate metal infrastructure.(1)

However; dental ceramics are brittle and their low fracture resistance and relatively low flexural strength still limit the possibility of manufacturing FPDs using all-ceramic frameworks. Recently, yttrium oxide partially-stabilized zirconia (Y-TZP), has been made available to dentistry through the CAD/CAM-technique. Yttrium-Zirconia ceramics have been shown to have excellent mechanical performance, and superior strength and fracture resistance compared to other ceramics . Since Y-TZP has attractive mechanical properties, it could be of interest in the manufacturing of all-ceramic bridges intended for placement in premolar and molar regions. (1)

The idea of using CAD/CAM techniques for the fabrication of tooth restorations was originated with Duret in the 1970s. Ten years later, Mormann developed the CEREC-system, first marketed by Siemens, which enable the first chair side fabrication of restorations with this technology. There has been a marked acceleration in the development of other CAD/CAM laboratory systems in recent years until reaching the

Cerec 3 system, and finally the Cerec-inLab system, which is designed for indirect fabrication of all ceramic restorations.[2]

The combination of newly introduced In-ceram yttrium partially stabilized zirconia cubes with the Cerec-inLab system may offers a viable alternative to metal-ceramic bridges in posterior area.

Currently, dental prosthetic treatment follow principles based on conserving sound tissue, concerning the removal of limited amount of sound tooth structure, including axial reduction and the finish line configuration. Modern adhesive technology and high strength ceramic materials with enhanced fracture toughness may facilitate the development of minimally invasive preparation technique. [3]

Moreover; since connectors represent the region of least cross section across fixed partial denture, therefore; are at greater risk during flexural caused by stress concentration. Thus; the dimensions and designs of the connectors are important factor in increasing survival rate of all ceramic bridge. Fortunately, the newly introduced Cerec-inLab three dimensional software enables the operators to control the connector design, direction and dimension in a simple and fast way.

Review of literature

Ceramics have been used in dentistry for many years. Dental porcelains were first introduced in the eighteenth century and were attractive for dental restorations due to their excellent aesthetics. Their use increased after Land introduced a foil technique for fabrication of high-fusing feldspathic porcelains in 1903 [4] .

Dental porcelains have relatively low strength , and therefore limited longevity, despite some improvements having been made with the development of modern synthetic porcelains. Several techniques have been developed to increase the strength of ceramics, the principle behind them being to reinforce the material in such a way that it can withstand or deflect the energy at a crack tip.

The alumina-reinforced feldspathic core was developed by Hughes and McLean in 1965 [5] . The material consists of a feldspathic glass containing 45-50% alumina. The alumina ceramic is strengthened by dispersion of a crystalline phase in the glassy matrix . Traditionally, the core was baked on a platinum foil and later veneered with matched-expansion porcelain; however, it is now more commonly baked directly on a refractory die.[6] The alumina particles are stronger than the glass and more effective at preventing crack propagation .The flexural strength of feldspathic porcelain is at best 60 MPa, which is raised to 120-150 MPa for the aluminous core porcelain. This strength is insufficient in posterior sites and is suitable only in anterior sites [7] .

In the early 1990 s IPS Empress 1 which is a leucite-reinforced glass ceramic was produced [8] . It obtains its strength from the finely dispersed leucite crystal reinforcement and is recommended for restoring single units including veneers, inlays, onlays, and anterior crowns . The strength values of IPS Empress 1 range from 95 to 180 MPa and the fracture toughness is approximately 1.3 $MPa.m^{1/2}$ [9] . In 1998, Ivoclar released IPS Empress 2, which is lithium disilicate-reinforced glass ceramic processed with the same procedure and equipment used for IPS Empress 1. IPS Empress 2 has been recommended for core material suitable for 3 unit-fixed partial dentures up to second premolar [9] [10] . The chemical composition of IPS Empress 2 is 60 % by weight lithium disilicate, which represents the main crystalline content. The improved mechanical properties of this material compared to most other pressable ceramics are attributed to its chemical composition, which comprises dense multi-elongated lithium disilicate crystals within the glass matrix. In such a structure, a crack would be trapped by these distributed crystals, resulting in improved strength and fracture toughness [11] . The strength and fracture toughness values of IPS Empress 2 has been reported to range from 340-400 MPa and 2 to 3.3 $MPa.m^{1/2}$, respectively . [9] .

Another method of strengthening ceramic materials was introduced in 1989 with the slip-cast technique where a slurry of aluminum oxide forms a green state core which is partly sintered and later infiltrated by glass. The strength of this material is higher than that of porcelains and glass-ceramics, and is further increased when the slurry contains a mixture of aluminum oxide and zirconium dioxide, creating a zirconia-toughened alumina material (ZTA). Another high-strength oxide ceramic material was developed in 1994 with the introduction of a material system that densely sinters high-purity aluminum oxide, reaching 99,9% alumina content.[6]