Comparative analysis of the effect of aging on recent esthetic CAD/CAM materials

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Dedication

This work is dedicated to

My dear parents,

Precious sister,

Beloved fiancée

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Introduction

Advancements are inevitable in all fields of science. The continuous search for better qualities and properties will never stop. As the advancements in dentistry continue, new materials and techniques are being introduced to the field to meet the increasing demand for superior esthetics and best physical properties [1, 2]. The integration of the restoration with the biological tissues and the achievement of normal function are the goals that clinicians and technicians aspire to achieve in everyday dental practice [3].

Dental porcelain is the preferred material to replace natural tooth tissue in prosthetic dentistry owing to its properties of wear resistance, high strength, toughness and excellent esthetics are considered [2].

All ceramic restorations are being considered by dentists and patients to the point where these types of restorations are becoming the standard of care [4].

Several types of all ceramic systems have been developed to meet the increased demands of patients and dentists for highly esthetic, biocompatible, and long-lasting restorations [5]. The development of high strength ceramics has led to the increased use of metal free restorations with higher mechanical characteristics compared to the early ceramic materials [6].

Parallel to the improvements in the material is the evolution of dental technologies such as Computer Aided Design / Computer Aided Manufacture (CAD/CAM). It serves to expand the restorative choices available for the dental patient. The strength, durability and biocompatibility of indirect restorations fabricated via CAD/CAM make them favorable for anterior and posterior indications.

With all improvements accomplished in the physical properties of ceramic blocks used, two main drawbacks of ceramics still exist. The chipping of the material in thin sections, either during the milling process or during checking and verification, caused by intrinsic brittleness of ceramic materials, and the high hardness relative to enamel resulting in wear of the opposing natural dentition. So there is a great need in determining which material is best in every clinical situation.

This has been a strong motivation for manufacturers to develop a new category of materials, called the hybrid ceramics, which combines strength and esthetics of ceramics and resilience and elasticity of composites.

Review of literature

Dental ceramics may be classified according to their application, fusion temperature, manufacture technique and crystalline phase [7]. According to Kelly [8], there are two concepts behind the science of ceramics used in dentistry; the first concept includes three main groups: glass ceramic materials, particle-filled glasses and polycrystalline ceramics, and the second concept includes any combination of two or more of those groups

Glass ceramics:

Glass ceramics were introduced in the late 1950s. They are prepared by controlled crystallization of glasses [9]. Crystallization was done by controlled heat treatment of glass to form nuclei of crystallization and crystal growth occurs. Various crystalline phases can nucleate and grow depending on the composition of glass [10].

Types of glass ceramics:

- **Mica-based:**

Dicor (Dentsply Intc., York, PA) has tetrasilicic flouromica as the major crystalline phase. Lost wax technique or CAD/CAM milling out of pre-fabricated blanks can be used to fabricate restorations [11, 12].

- **Hydroxyapatite based:**

Cerapearl (Kyocera, San Diego, CA) is a castable glass ceramic in which oxyapatite is the crystalline phase [13].

- **Leucite-based:**

Leucite reinforced glass ceramic is highly translucent and has a flexural strength of 100-150 MPa. Restorations are fabricated by lost wax technique or CAD/CAM milling from prefabricated blanks. IPS Empress (Ivoclar Vivadent, Liechtenstein) was introduced to the market and is indicated for veneers and single crowns in the anterior region [14-17].

- **Lithium disilicate:**

A glass ceramic with a higher flexural strength (350 - 440 MPa), higher fracture toughness (2-3 MPa) and high thermal shock resistance due to the low thermal expansion was achieved by precipitating lithium disilicate ($LiSi_2O_5$), forming around 70% volume of the crystal content, which is higher than that of leucite materials. High temperature x-ray diffraction studies showed that before the growth of lithium disilicate crystals ($LiSi_2O_5$), both lithium meta-silicate ($LiSiO_3$) and crystobalite are formed during the crystallization process. The final microstructure comprises of highly interlocked lithium disilicate crystals of dimensions 5 mm length and 0.8 diameter. The presence of a thermal expansion mismatch between lithium disilicate crystals and the glass matrix result in indirect compressive stresses around the crystals, which helps in crack deflection and provides higher strength [18-21].

Lithium disilicate is a highly translucent material with a refractive index of 1.55 which is very close to that of the glass matrix which is 1.5 causing less light scattering and higher translucency [22, 23].

Lithium disilicate was announced in 1998 as IPS Empress II (Ivoclar Vivadent) a material that can be used in short fixed dental prostheses (FDPs) in the anterior region and short span FDP with the second premolar as the posterior abutment. The restoration is made by the lost wax technique which involves the use of a pre-colored ingot that is heated and pressed into an empty mold inside the phosphate-bonded. This technique produces a restoration with good marginal adaptation with a mean fitting accuracy of posterior crowns amounted to less than 50 µm [24]. In a 5-year prospective clinical study, the survival rate was found to be reaching 100% for posterior single crowns and 70% for 3-unit FDPs, in the anterior and premolar area [25]. For further esthetics it should be veneered with flouroapatite based veneering porcelain [19, 26-29].

IPS e.max was introduced in 2005 as an improved version of IPS Empress II for heat pressing (IPS e.max Press) and CAD/CAM machining (IPS e.max CAD).

The manufacturing process of IPS e.max CAD is based on glass technology (pressure casting technology) is used in the fabrication of the blocks. This novel method of manufacturing uses optimized processing parameters to prevent defects formation; like pores and pigment accumulation, in the bulk of the ceramic [30].

IPS e.max CAD blocks are produced with 40% platelet-shaped lithium metasilicate crystals in a glassy phase which is produced after an intermediate crystallization process to give a blue, translucent block. The color is controlled by the use of coloring ions but not fully oxidized (intermediate phase); thus a blue color is produced. The final crystallized state and desired tooth color is attained after milling by a final firing process in which lithium metasilicate transforms into lithium disilicate. The final state of IPS e.max CAD consists of 70% fine spindle shaped grains lithium disilicate crystals with a 360 MPa flexural strength [21, 30, 31].

Crystals of lithium meta-silicate, in the partially crystallized form, are responsible for good machining properties, moderate strength and good edge properties [31].

The two levels of translucency provided depend on the crystallization pretreatment. The low translucency (LT) blocks have a higher density of smaller crystals while the high translucency (HT) blocks contain fewer and larger crystals of lithium metasilicate in the pre-crystallized state [32].

- **Zirconia reinforced lithium silicate:**

It was introduced in 2013 as a new class of glass ceramic material produced with a novel manufacturing process. It is reinforced with zirconia (approximately 10 % by weight) which provides excellent material quality and consistent high load capacity [33].

The zirconia reinforced lithium silicate is produced in three stages; the first stage, which is the molding, the block is in a glass state, where it is very brittle and susceptible to fracture during machining. The second stage, the thermal pretreatment, is done to initiate crystal growth. At this stage the block exhibit ceramic properties, so it can be processed to form restorations. The third stage, final crystallization in a dental furnace, is done to give the material its final esthetic and physical properties [34].

The presence of 10% zirconia dissolved into the lithium silicate glass matrix results in 4 times smaller silicate crystals, implying a high glass content and higher translucency than conventional lithium disilicate ceramics, it also gives the material a higher compressive strength reaching 540 MPa, thus it is indicated for anterior and posterior crowns, supra-structure on implants, veneers, inlays and onlays [33-35]