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Achieving the Desired Esthetic with Current CAD-CAM Ceramics

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Abstract

The demand for tooth-colored restorations has grown considerably during the last decades. Restoration of anterior teeth is a difficult task, even for an experienced operator. Color is the most important determinant of esthetics. The esthetic appearance of a restoration should match the surrounding dental tissue. This requires that the optical properties of the restorative material be similar to that of the natural teeth. Thus, for an acceptable esthetic result, favorable shade matching of the all-ceramic restoration should be achieved by controlling light absorption, reflection and transmission of the ceramic material. There are many different ceramic systems that can be used to achieve highly esthetic results. These ceramic systems include In-Ceram, Hi-Ceram, IPS-Empress, Optec, and CAD-CAM ceramics. All ceramic systems have different composition, microstructure, crystalline content and phases. Direct transmission, translucency, opacity and opalescence, all influence the optical properties of the ceramic restoration. Other factors include the thickness of porcelain, number of porcelain firing, glazing, porcelain powder/liquid ratio, surface texture and even the resin shade. This article focuses on controlling these variables to achieve the best possible esthetic result with an all ceramic system with the emphasis on CAD-CAM systems.

Keywords: CAD-CAM, Esthetics, Dental Ceramics.

Introduction

Color is the most important determinant of esthetics. The esthetic appearance of a restoration should match the surrounding dental tissue [1,2]. In natural teeth, optical properties are influenced by the dentin shade, enamel structure (thickness and translucency), tooth dimension and surface texture. The optical properties of teeth and porcelains include color and translucency in addition to hue, value and chroma and need to be similar to that of the natural teeth. A tooth, as most biological tissues, reflects, diffuses, absorbs and transmits light reaching its surface. Thus, for acceptable aesthetic results, favorable shade matching of the all-ceramic restorations should be achieved by controlling light absorption, reflection and transmission of dental ceramic materials [1]. The optical behavior of a ceramic restoration is also determined by luting cement (thickness and shade), underlying tooth structure and the ceramic veneer. If a ceramic restoration is placed on a colored underlying tooth structure, this color beneath the restoration might result in discoloration and shadowing, particularly in the cervical areas of the restoration. Due to the complex optical characteristics of tooth color, achieving successful aesthetics with a restoration is a difficult process for dental clinicians.

In order to achieve highly esthetic results, different ceramic systems are available [2-4]. The perceived color of a ceramic restoration is known to be affected by; the type of ceramic substructure, shade of ceramic material, translucency, thickness, surface texture, porcelain powder liquid ratio, ceramic firing temperature, surface glaze and layering extrinsic colorants. Although, the chemical structure of the ceramic system is more important for determining the optical parameters than the fabrication techniques, different heat temperatures, pressing pressure or sintering techniques can also influence the porcelain texture [1-5].

The microstructure of CAD-CAM ceramic systems influences the optical properties [5]. There are important relationships between chemical composition, atomic structure, fabrication process, microstructure and properties of dental ceramics [5,6]. The relative amount, nature, shape, distribution and particle size of the crystalline phase (s) and porosity directly influences the mechanical and optical properties of ceramics. A material composed of small particles (approximately 0.1 mm in diameter) is less opaque, causes surface reflection as light strikes, refracts as light passes through, and absorption. Ceramics containing less crystalline phase are generally considered to be more translucent [2,4-6].

CAD-CAM Ceramics

CAD-CAM has become a very common technology in dental practice. Taking the time to choose the best material for each case will ensure production of a strong, esthetic restoration, patients will not only love, but that will last them for years to come [7,8]. There are a variety of CAD-CAM materials to choose from. In one classification dental CAD-CAM materials are categorized into:
1) CAD-CAM Blocks (block form); including glass ceramics, resin nano ceramics, zirconia, ceramic composites, ceramics and resin composites.

2) CAD-CAM Powder Systems (Sprays); offer high contrast detail for optimal imaging and accurate digital impressions.
3) CAD-CAM Cutback Porcelains; provide lifelike esthetics.

The following criteria must be taken into account while selecting the proper CAD-CAM block; desired tooth shade, preparation shade or abutment shade, type of restoration, restoration thickness and/or preparation depth, processing technique (staining vs. cut-back technique) and the cementation material.

CAD-CAM all-ceramic biomaterials are divided into two categories which are CAD-CAM glass ceramics and CAD-CAM compatible polycrystalline alumina and zirconia. Each have unique characteristics and different clinical usages (**Table 1**).

Table 1: CAD-CAM all-ceramic biomaterials with different clinical usages.

CAD-CAM all-ceramic biomaterials		Clinical/laboratory recommendation
CAD-CAM-compatible feldspathic ceramics	CAD-CAM-compatible feldspathic ceramics	fabricating veneers inlays/onlays and single anterior and posterior crown
	CAD-CAM and mica-based ceramics	Low clinical performance
	CAD-CAM with leucite-reinforced ceramics	single tooth restorations
	CAD-CAM milling lithium disilicate reinforced ceramics	Veneers, Inlays, Onlays, Partial crowns, Crowns for anterior and posterior restorations, Implant superstructures for single-tooth restorations (anterior and posterior region)
	CAD-CAM and glass infiltrated alumina and zirconia ceramics	Substructure for anterior and posterior crowns and multi-unit bridgesand 3-unit bridges and posterior crowns (no more than one pontic unit)
CAD-CAM compatible polycrystalline alumina and zirconia	Alumina based polycrystalline ceramics	substructures for anterior single crowns and short span bridges and posterior single crowns,-super -structures on implant abutments
	Stabilized zirconia based polycrystalline ceraics	inlay bridges, implant abutments and telescopic crowns Opaque core framework
	Yttria partially stabilized tetragonal zirconia	framework material for FPDs
	Magnesium partially stabilized zirconia	porcelain laminate veneers
	Ceria stabilized zirconia/alumina nanocompoite (Ce-TZP/A).	ceramic restorations, such as laminates

Typically CAD-CAM dental restorations are milled from solid blocks of ceramic or composite resin that closely match the basic shade of the restored tooth. An image (scan) is taken of the prepared tooth and the surrounding teeth [1,8,9]. Digital impression, draws the data into a computer. Proprietary software then creates a replacement part for the missing areas of the tooth, creates a virtual restoration and the virtual data is sent to a milling machine [9].

CAD-CAM-compatible feldspathic ceramics

These feldspathic ceramic materials have excellent aesthetic properties are bonded to tooth tissue by using airborne particle abrasion (50 mm Al_2O_3), followed by etching with hydrofluoric acid (HF) and the use of a silane coupling agent which is used to bond dissimilar materials. Their characteristics make them useful in fabricating veneers inlays/onlays and single anterior and posterior crowns; however, they are not considered strong enough for posterior load bearing areas. Originally they used to be monochromatic (Only single-colored blocks were available) but natural tooth is consisted of different layers with different translucencies and different color saturations [9-11]. The newer Vitablocs™ TriLuxe™, Triluxe™ Forte and RealLife™ blocks (Vita Zahnfabrik, Bad Sackingen, Germany) contain multi-shade layers and offer a gradient of colour and translucency.

CAD-CAM and mica-based ceramics

Dicor™ (Dentsply, York, USA) and Dicor™ MGC (Dentsply, York, USA) are a mica based glass ceramic marketed for both laboratory ceramming and machining. Similar in clinical performance to Vita™ Blocs but cumulative breakage at 2 years was found to be higher than for Vita™ Mark II and have Low clinical performance [10].

CAD-CAM with leucite-reinforced ceramics

A leucite reinforced ceramic is similar in structure to heat pressed ceramics. The marginal gap, internal fit and fracture load also compares favorably with Empress™. It was developed for chair-side single unit restorations. CAD-CAM with leucite-reinforced ceramics are available in high and low translucency (Empress™ CAD HT, LT) and polychromatic blocks (Empress™ CAD Multi). The milled restoration can in the next step be stained and glazed. Value of the leucite-based IPS Esthetic is the highest, relative to other full ceramics. Although this property may promote the optical parameters of the restoration in many cases, it may cause an unexpected aesthetic appearance of the restoration, especially when there is severe background discoloration [2,3,8-10].

CAD-CAM milling lithium disilicate reinforced ceramics

These blocks are manufactured by pressure-casting procedure and can be easily milled after which the restoration is re-crystallized in a chair-side ceramic oven [11]. IPS™ e.max CAD (Ivoclar-Vivadent) was introduced in 2006 and is a chair-side monolithic restorative material. It is available in A-D and bleach shades as well as in 3 translucencies (one of which is of medium opacity). It is supplied in a pre-crystallized so-called blue state. After heat treatment, the block changes from blue to the chosen shade and translucency. The material has been recommended for use in fabricating inlays, onlays, veneers, anterior and posterior crowns and implant supported crowns. It is interesting to note that pressing or machining procedures do not appear to affect the color of these ceramic materials, and it is the crystalline composition of the material rather than the construction techniques, that determines their optical properties.

High strength ceramics used for core/framework materials of all ceramic restoration

Fractures of ceramic FPDs usually occur in connector areas because of the concentrated stress. The connector design partly depends on the type of ceramic material used for the framework. High strength ceramics have been developed as the core/framework material to enhance esthetics and the biological incompatibility risks of metals used for conventional porcelain-fused to metal restorations [11,12].

CAD-CAM and glass infiltrated alumina and zirconia ceramics

These blocks are manufactured by dry pressing the ceramic powder into a mold and compacted until the open pore microstructure is reached. Then, the material is sintered and infiltrated by La-glass. Veneering composite is applied for characterization after the substructure is milled. Classic examples of slip cast, glass infiltrated ceramics are InCeram^{TM} Alumina, Spinell and Zirconia. CAD-CAM InCeram Spinell is the most translucent material of the group and is recommended especially for anterior crowns. The opacity of zirconia has limited its use to the posterior region and mostly as substructures for crowns or bridges [11,13].

Stabilized zirconia based polycrystalline ceramics

The advent of polycrystalline ceramics such as stabilized zirconium dioxide is a direct result of CAD-CAM technology without which the fabrication would not have been possible [13]. The marginal fit of zirconia restorations is dependent on; configuration and design of the teeth preparations, the accuracy of the scanning system, type of machining and the veneering procedures [13]. There are two types of zirconia blocks currently available for distinct CAD-CAM applications (**Table 2**).

Table2: Types of zirconia block currently available for distinct CAD-CAM applications.

Types of zirconia blocksfor distinct CAD-CAM applications	
Hard machining of the densely sintered ceramic blocks	Fully sintered dense blocks for direct machining using a dental CAD-CAM system with a grinding machine with higher stiffness
Green machining of the presintered ceramic blocks	The use of partially sintered blocks for CAD-CAM fabrication followed by post-sintering to obtain a final product with sufficient strength.

Common examples of CAD-CAM systems for fabrication of 3Y-TZP restorations are; LAVA (3M ESPE), Cercon (Dentsply), IPS e.max ZirCAD ZirCAD (Ivoclar-Viva- dent), Procera Zirconia (Nobel Biocare), and Vita YZ blocks (Vita Zahnfabrik) [14]. Currently Yttria-stabilized tetragonal zirconia polycrystals have greater fracture resistance than conventional ceramics and are gaining increasing attention as a framework material for FPDs, especially posterior ones [13,14]. Natural zirconia is dull white, X-ray opaque and its opacity is comparable to metal; however, the translucency decreases with an increase in crystalline content [14-16]. In this aspect, it is useful in masking discolored teeth or metal substructures such as metal posts and cores. Feldspathic porcelain in contrast, requires more tooth reduction to become sufficiently opaque to mask stains, and this increase in thickness may impede light polymerization of the luting cement and compromise bonding to dentin [15,16]. The esthetics of dental zirconia have been improved through various procedures such as infiltration, use of precolored blocks, thinner coping thickness, different colors of the liners and choosing zirconia blocks with different grain size and veneering techniques [13-17]. Insufficient framework thickness has been cited as the major factors causing catastrophic fracture within the zirconia core [18]. and contributing reasons for veneer fracture may include, weakness of the veneer material the core/veneer bond stresses, distortion due to the veneering process, unsupported veneering porcelain, configuration of the core and veneer, residual stresses arising from coefficient of thermal expansion mismatch, and rapid cooling rates after heat treatment [18]. For this reason, zirconia restorations are not considered chair side restorations [18].

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