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Dental Application of IPS e.Max Ceramic - A Review Article

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Abstract: ***The aim of this review study is to report the state of current literature and recommendationsfor the lithium disilicate glass-ceramic IPS e.Max. Science, mechanical andoptical properties of the material were reviewed as well as, the material performance and indications of use. This paper provides a brief historical overview,summary of current literature, and clinical recommendationfor the use of IPS e.Max CAD in dental practice.***

Keywords: lithium disilicate glass-ceramic, IPS e.Max, material properties, clinical recommendation

1. Introduction

Over the last 30 years, many types of all ceramic systems have been developed in a need to shift toward metal-free restorations to meet the increased demands for highly aesthetic, biocompatible, and long-lasting restorations of both patients and dentists [1,2]. Various and countless studies were performed where many dental materials struggle to survive, while many others showed their proficiency in both function and aesthetic [2]. Hence, the dental field has evolved rapidly producing different recent types of ceramics among them is e IPS e.Max line (IvoclarVivadent, Schaan, Liechtenstein), which is a well known type of glass ceramics.

The aim of this study is focusing on reviewing literature related IPS e.Max CAD to provide background on the material, the material science, mechanical properties, optical and esthetic properties, clinical findings, recommendations as well as, the material applications.

Material history

IPS Empress was first introduced as a high leucite-containing glass-ceramic in 1986 [3]. Lucite-based glass-ceramic derived from the ternary phase system (SiO_2–Al_2O_3–K_2O system) but, with higher content of K_2O. In 2004, the system was further expanded and optimized with the introduction of the new high translucent IPS Empress, this was followed by the release of IPS Empress CAD in 2006 a chair-side monolithic restorative material, creating an opportunity for this material to be milled using CAD-CAM technology [4,5]. Being a glass-ceramic material, lithium disilicate ceramic permits, although does not require, adhesive luting for retention [6] as well as, offering maximum esthetics [7] and high fracture resistance [8]. Thanks to these beneficial properties, it is a material widely used in clinical practice.

Microstructure properties

The blocks are manufactured in a process based on what is known as“pressure-casting procedure”[9]. IPS e.Max CAD is supplied in a pre-crystallized state called “blue state”. The blue ceramic is composed primarily of lithium meta-silicate (Li_2SiO_3), which is easier to mill and results in lower bur wear [9,10]. At this state, the block can be easily milled after which the restoration is re-crystallized in a chair-side ceramic oven at 850 8C in vacuum for 20–25 min(following manufactures instructions). During this heat treatment, the metasilicates are dissolved, lithium disilicate crystallizes and the ceramic is glazed at the same time [9,10,11]. The block also changes from blue to the chosen shade and translucency [9]. This glass ceramic in a pre-crystalline phase “blue state” is composed of 40% lithium metasilicate crystals (Li_2SiO_3), 0.2e1.0 mm in size and platelet shaped, set in a glassy phase along with lithium disilicate nuclei [10]. A study analyzed the various phases present in the ceramic materialduring different firing temperatures confirmed the persistence of a glassy phase through X-ray diffraction (XRD) [12]. The partially crystalized state is more easily mill, as mentioned previously, and results in less bur wear and high edge stability [10,9,13]. After complete crystallization the material will the material will transform into lithium-disilicate which microstructure is composed of 70% prismatic crystals (0.5–5 μm long) dispersed in a glassy matrix. Lithium-disilicate microstructure has numerous small interlocking plate-like randomly oriented crystals [14]. This change of the material is known as "phase transformation of lithium-disilicate ceramics" which has been a focus of many research and studies for many years attempting to explain the crystalline phase transformation process for lithium disilicate ceramics [12,15]. A study by Lien W. 2015, stated that; during the phase transformation processshown via XRD analysis that in addition to lithium metasilicate, lithium orthophosphate (Li_3PO_4) and cristobalite (SiO_2) forms [16,17]. The previous study showed that at low temperatures (below 590 C) lithium disilicate precipitation was not seen, while at temperatures between 590 C and 780 C spherical precipitations of lithium orthophosphate and lithium disilicate were formed [12]. Another study by Almansour F. 2015, concluded that by increasing the pressure during firing, it was possible to achieve crystal transformation without residual lithium metasilicate at 800 C (with a 2 min hold) when utilizing plasma spark sintering [18]. The aim of both mentioned studies was to improve the properties of the evolved crystalline phase. IPS e.Max CAD has seen increasing demand in use over the several years because of its esthetic nature, impressive strength, and ease of use.

Mechanical properties

IPS e.Max CAD has seen an increasing demand and use since its introduction in the dental field due to its high mechanical properties compared to other ceramics in the field. There is a dramatically huge difference in all properties between the initial pre-crystalline material (Lithium-metasilicate) and the final tempered material (Lithium-disilicate). The aim of this current study is to understand and highlight the mechanical properties of the final ceramic material. Manufacturer literature states that the material experiences 0.2% linear shrinkage [10]. This shrinkage was related as a possible cause of gaps at the margins of restorations and compromise internal fit, although this shrinkage does not result in discrepancies significantly different than other CAD/CAM materials [19,20]. Many studies stated that IPS e.Max CAD possesses a recorded flexural strength of 262e360 MPa which shown to be above other leucite reinforced dental ceramics and a fracture toughness of 2.0e2.5 MPa [10,11,12,20,21,9,17]. A study by Goujat et al 2017, concluded that mechanical properties are dependent on structural composition of material not their chemical formulation [20].

Color and optical properties

Successful dental restoration and complete patient satisfaction are the main objectives in dental practice regarding that; Color and optical properties play the major role to achieve these goals.IPS e.Max CAD is available in the standard A to D shades and also includes a line of bleach shades as well [9,10]. As mentioned previously, the pre crystalline state of the material blocks is available only in "blue state". The final desired shade and translucency is obtained after firing the material. Keeping in mind that additional refinement of the final color of a delivered ceramic can be performed by adding stain and glaze to the surface of the restoration before the final tempering process. IPS e.Max CAD comes in wide colors variety. It is also available in three levels of translucency, medium opacity (MO), high translucency (HT), and low translucency (LT) [10]. This variation is accomplished through differences in the microstructure of the material. All three formulations have identical crystal content, but the difference is in crystal sizes, with HT ceramic exhibiting crystals of 1.5 0.8 mm dispersed in a glassy matrix, whereas LT ceramic exhibits smaller crystals (0.8 0.2 mm) in a higher density matrix [16].

Clinical performance and indications

Since IPS e.Max CAD material material was introduced in the dental field the manufacturer has released recommendations and clinical guidelines to take into consideration when utilizing the material as it was recommended for use as an esthetic framework, an inlay and onlay material, as an anterior veneering matrial only [10]. In 2016 an updated was released by the manufacture with a list of indications that suggested IPS e.Max CAD could be implemented as a veneering material, for inlays and onlays, partial and full crowns, three-unit fixed partial dentures (FPD) in the anterior, premolar and posterior region [22]. In this section of the current study, failure and fatigue testing will be discussed as a reflection of the material clinical performance. A study in 2013 found that monolithic posterior three-unit FPDs were susceptible to high load (1900 N) in the oral posterior region leading to failure at the connectors yet, it could be recommended for posterior. The same study showed that bi-layered FPDs on the other hand were susceptible to low-load (699 N) failure and should be avoided [23]. A study performed by Silvia et al 2019, concluded that Caution should be exercised in restoring non-vital teeth and in selecting luting techniques when using IPS e.Max CAD ceramics. High survival rates were obtained even for non-recommended uses of IPS e.max prompted by patient-specific considerations [24]. might be reached in forces as low as 1,100 to 1,200 N [20]. One point of interest is that the 2016 manufacturer indications recommend the use of IPS e.Max CAD for minimally invasive crowns (1 mm material thickness). Several studies on properties at 1 mm suggest a possible risk of complications when utilizing such a thin restoration. One study suggested that an increase in material thickness from 1.6 mm to 1.8 mm could lead to an increase in predicted failure loads from 1,400 N to over 2,000 N [21]. One six-year study showed 87.6% of monolithic single unit crowns remained clinically acceptable and 70.1% without any complications whatsoever [25]. Due to the relatively recent introduction of IPS e.Max CAD there are few clinical studies that exist that look restoration longevity and unfortunately there is a lack of literature that provides a more comprehensive look at short term studies, reporting further difficulties [9]. There is a lack of clinical studies that assess the survival of IPS e.Max CAD ceramic restorations when used in multiple unit FPD. In another hand, many studies were performed in single anterior teeth using IPS e.MAX CAD that clinically proven to have acceptable longevity and wear characteristics in clinical trials. For single-unit crowns esthetics can be a primary consideration [21]. The translucency properties of IPS e.Max CAD (HT and LT formulation), make it possible to place margins that blend with adjacent dentition, effectively masking the edges of the restoration [10]. Discoloration of the edges is another concern when it comes to margin placement. Fasbinder et al 2010, study found a 3 of 23 (alfa score of 87.0%) IPS e.Max CAD crowns cemented with dual-cure self-etching cement (Multilink Automix [MA], IvoclarVivadent) exhibited localized marginal staining after two years [13, 26]. Unfortunately, much like clinical failure rates of posterior restorations, there is few clinical evidence of failure for anterior restorations due to fracture or undesirable esthetic complications.

2. Conclusion

Clinical studies of IPS e.Max CAD have been limited, that's related to the limited time the material has been available on the market. Several studies have shown promising short and medium-terms survivability for single unit crowns and initial results for implementation of inlays and onlays is promising as well. Some in vitro studies have questioned the use of the material in layered posterior multi-unit FPDs and veneers that could experience heavy occlusal forces, however there is a lack of clinical data to determine the significance of these results. Lack of data on IPS e.Max CAD provides a unique opportunity for more researches as there is much more to learn about the material.

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