MONOLITHIC LITHIUM-DISILICATE GLASS-CERAMIC RESTORATIONS

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Abstract: In a pursuit for perfect esthetic and natural appearance of restorations in contemporary dentistry, porcelain fused to metal restorations are gradually being replaced by all-ceramics. All-ceramic restorative systems are not a new concept. They were first introduced with the so-called "porcelain jacket crown" in the 1900s by Charles H.Land, fabricated with high-fusing feldspathic porcelain on platinum foil matrix. Because of the low strength of this porcelain, the failure rate was very high and they were slowly abandoned. In the last 10 years with the introduction of lithium-disilicate class ceramics IPSe.max System (Ivoclar Vivadent) with a strength of 470 MPa monolithic restorations made a big comeback. Monolithic or full-contour lithium-disilicate restorations can be stained and glazed for more natural tooth colour look. The ideal restoration shade is optimally reproduced by means of the IPS e.max Shade Navigation App. It facilitates the material selection, leads to results that feature optimum shade match and thus provides efficiency and reliability. This material has two forms: a homogeneous ingot with various degrees of translucency and opacity used with hot-pressed technology Emax Press and a pre-crystallized block used with CAD/CAM technology Emax CAD. Regarding the strength of the material, pressed lithium disilicate is 11% stronger than the CAD/CAM lithium disilicate according to Ivoclar's 2011 scientific report. Pressable lithium disilicate restorations demonstrated a 98.4% survival rate. Machineable lithium disilicate restorations (IPS e.max CAD) demonstrated a 97.9% survival rate. The pressing technique demonstrated a significantly smaller marginal gap than the CAD/CAM technique. Some in vitro studies have pointed out that lithium disilicate monolithic crowns and FDPs, both CAD/CAM and hot-pressed, are more resistant to fatigue fracture compared to bilayered, hand veneered ones, showing higher fracture loads (1900 N), that are comparable to the metal-ceramic standard. Clinical outcomes of different IPS e.max lithium disilicate prostheses like single crowns, 3 unit bridges, veneers, inlays and onlays, both in the bilayered and monolithic forms, in a 4-year retrospective study reported: 0.91% for monolithic and 1.83% for bilayered single crowns (twice the rate of the monolithic); 4.55% for monolithic FDPs; 1.3% for monolithic and 1.53% for bilayered veneers; and 1.01% for monolithic inlays/onlays. This research supports the use of monolithic lithium disilicate restorations in everyday treatment of choice for high-strength and esthetic indirect treatments, whether for the anterior or posterior regions of the mouth. The material offers specific advantages to dentists such as the ability to provide strong and durable restorations with highly esthetic characteristics without metal. More clinical studies for the esthetic outcome of monolithic restorations are needed in the future.

Key words: all-ceramics, press ceramic, CAD/CAM, full contour restorations
Field: Medical sciences and Health

1. Introduction

Throughout the years, metal-ceramic restorations were the gold standard in crown and bridge procedures, but despite the material strength, their esthetic outcome was not fully satisfying. In a pursuit for perfect esthetic and natural appearance in contemporary dentistry, porcelain fused to metal restorations are gradually being replaced by all-ceramics. All-ceramic restorative systems are not new concept. They were first introduced with the so-called "porcelain jacket crown" in the 1900s by Charles H. Land, fabricated with high-fusing feldspathic porcelain on platinum foil matrix. But, because of the low strength of this porcelain, the failure rate was very high and they were slowly abandoned. Today technology of dental materials is very advanced and all-ceramic restorations become everyday practice. Generally, according to their structure, there are two types of all-ceramics bilayered and monolithic. In bilayered restorations, the core or the framework is made from high strength ceramic or zirconia veneered with layers of veneering ceramic for better esthetic. In, monolithic restorations the full construction is made of only one layer of ceramic or zirconia and the flexural strength remains the same throughout the entire restoration. With the monolithic concept, clinicians are able to overcome so many problems with bilayered restorations like fracture and chipping of low strength veneering layers (Fischer et al, 2007) and problems with bond strength between the core and veneer manifested with delamination (Von Steyern, et al. 2005) (Sailer et al. 2007). The shortcomings of high strength zirconia monolithic restorations like lack of translucency of zirconia, made a narrow span of indication and using this kind of constructions in the posterior region only. In the last 10 years with the introduction of lithium disilicate class-ceramics IPSe.max System (Ivoclar Vivadent) with strength of 470 MPa monolithic restorations made a big comeback. New dental products have always been a challenge to clinicians because, with little more than promotional information to guide them, they must judge between those that are new and those that are better and have proven success. The aim of this study was to elaborate on the information from literature for monolithic lithium disilicate class-ceramics restorations their indications and survival rate in comparison to other monolithic and bilayered constructions.

2. Material characteristics and technical procedures

Lithium disilicate glass-ceramic restorations show impressive results with excellent light-optical properties. Full-contour monolithic ceramic restorations could be stained and glazed for more natural tooth color look. The ideal restoration shade is optimally reproduced by means of the IPS E.max Shade Navigation App. It facilitates the material selection, leads to results that feature optimum shade match and thus provides efficiency and reliability. (Ivoclar Vivadent). This material has two forms and two manufacturing techniques: homogeneous ingots with various degrees of translucency and opacity used with hot-pressed technology E.max Press and a pre-crystallized block used with CAD/CAM technology E.max CAD. The wide range of available ingots with different shades for press technique (lost wax technique) gives us more options and wider indications for use. There are monochromatic and polychromatic multi ingots in three sizes. Monochromatic ingots have three levels of translucency, high translucency HT, medium translucency MT, low translucency LT, two levels of opacity ingots medium MO and high opacity HO and opal ingots with different levels of brightness (opal 1, opal 2). Polychromatic multi ingots are an ideal material for quickly and efficiently making of monolithic solutions. They have gradual transitions of color from dentin to enamel. E.max CAD pre-crystallized blocks have the same range of color as press ingots. In the initial condition, this bluish blocks show moderate hardness and strength (around 130MPa) because they are easier to mill, reducing wear of the machining devices at the same time, with evident advantages during chairside procedures (Denry and Holloway, 2010), but after the heat treatment, they get the needed toughness.

3. Indications and contraindications for monolithic restorations

There are a lot of indications for the production of monolithic lithium disilicate restorations, from veneers to 3-unit bridges. Given the high strength of ceramics, full and partial posterior and anterior crowns can be made with great esthetic, enhanced by the staining technique. Minimally invasive crowns with maximum tissue preservations, especially in a young patient with vital teeth 1mm thin can be made in the anterior and posterior region. Today very popular minimal preparation smile rehabilitation can be done with veneers also ultra-thin 0.3 mm. Inlays, onlays, occlusal veneers, and classical veneers are also perfect candidates for monolithic lithium disilicate ceramics. Fixed dental prosthesis up to 3-units are indicated in the anterior region and in the posterior region up to the second premolar. Implant superstructure up to-3unit also is limited in the premolar region. Because of the brittleness of glass ceramic patient with occlusal parafunction like bruxism are not good candidates for this type of restorations. Temporary seating of IPS E.max Press restorations is also not recommended. Sharp edge preparations and very deep subgingival preparations are contraindications for minimally invasive crowns.

4. Survival rate of monolithic restorations

Prosthetic therapy success with monolithic restorations depends mainly on the esthetic outcome of the restoration, its color and translucency, strength and fracture resistance of material, color stability, the relationship with the soft tissue and remaining teeth, cemented construction stability, the marginal closure and fitting, integrity of abutment teeth etc. One clinical chair side research showed that monolithic lithium disilicate posterior crowns has survival rate from 87,6% after 6 years evaluation. The main reasons for failure were crown fracture, abutment fracture, secondary caries below crown margin, loss of retention and severe endodontic problems.(Rauch, Reich & Schierz, 2016).Veneered lithium disilicate press ceramic restorations demonstrated greater survival rate 94,8% after 9 years of service.(Gehrt et al. 2013).Studies in literature are showing different survival rates because of the different years of follow-up but , survival rates for bouts monolithic and bilayer forms of press lithium disilicate ceramic are very high. Breemer et al. (2017) also evaluated high survival rate of press monolithic lithium disilicate posterior crowns after 5, 10, and 15 years check-up. The survival of the restoration was 92%, 85.5%, and 81.9% respectively. When this type of crowns are cemented on zirconia implants also promising survival rates 95.7% areb showed after an observation period of 3 years. (Spies et al., 2015) Machinable lithium disilicate crowns chair side CAD/CAM after

10 years showed survival rate of 83.5% (Rauch, at al., 2017). Reasons for failure were retention loss, carious lesions and a change in sensibility perception of abutment teeth. Similar survival rate Fasbinder et al. (2010) evaluated after two years of clinical service 86.9%. Monolithic lithium disilicate single crowns in the posterior region fabricated with feather-edge margins and adhesively cemented in one restrospective study showed survival rate 97.93% up to 12 years of service. (Schmitz et al. 2017). Secondary caries that occur on the crown's margins due to the bad marginal crown fit or cement dissolution is one of the main reasons for monolithic crown failure. (Baig, Tan & Nicholls, 2010) (Pak, Han, Lee, Kim & Yang,2010). Other complications associated with a big marginal gap are marginal discoloration or staining and microleakage. Therefore a smaller marginal gap increases chances for successful treatment. The different techniques lost wax and milling for making monolithic restorations may have discrepancies in the size of marginal gaps because of the distinguished series of steps for manufacturing. Also, big role in the marginal fit plays the expertise of the dental technician. Azar et al. (2018) in-vitro study demonstrated that pressing technique crowns have a significantly smaller marginal gap compare to those made with the CAD/CAM technique, but they are bought in the range of clinical recommendations. As far as the impact of the various impression techniques is concerned studies showed that pressed and CAD/CAM single crowns made with digital impressions had a better internal fit than pressed single crowns produced with polyvinylsiloxane impressions.(Alfaro et al. 2015). Clinical study for monolithic lithium disilicate fixed dental prosthetics showed survival rate of 100% after 5 years, and 87,9% after ten years follow-up, survival being defined as remaining in place either with or without complications (Kern, Sasse & Wolfart, 2012).

5. Strength and fracture resistance of monolithic restorations

Restoration fracture is not influenced only by the mechanical properties of the used material. Tooth preparation and restoration geometry, the material used for cementation of the restoration and progressive damage caused by occlusal function also effect on the fracture probability. Rekow et al. (2011) state that the crown material and crown thickness are the most significant factors that influence on the restoration fracture. The manufacturers' of the lithium disilicate ceramic says that the strength of any ceramic material is totally dependent on the thickness of the material and the preparation design. They recommend very specific tooth preparation protocols for their materials in order to guarantee greatest strength and predictable longevity of restorations. Needless to say, anything less than following these recommendations will result in a weaker final restoration. Ivoclar recommends tooth reduction for E.max posterior crowns at least 1.5 mm occlusal for cusp tips and the central groove, 1.5 mm on the axial walls and at least 1.0 mm deep flat shoulder margin, chamfer or feather edge. Nawafleh et al., (2017) said that tooth reduction required for lithium disilicate crowns is a crucial factor for a long-term successful application of this all-ceramic system. They found that bulk fracture of monolithic E.max CAD was the predominant failure observed and concluded that with reducing the tooth preparation by 0.5 mm on the occlusal and proximal/axial wall with a 0.8 mm chamfer significantly fracture load of the restoration is reduced. The mean fracture load for the crowns with 1,5 wall thickness were 2340N before and 2149N after aging and for 1mm wall thickness 1752N and 1054N. In contrary to this Seydler et al.,(2013) suggested that the wall thickness of posterior E.max CAD lithium disilicate crowns can be decreased to 1 mm wall thickness without cracking during artificial aging, thus reducing the invasiveness of the preparation, which is essential for young patients. Differences between crowns with d = 1.0 mm and d = 1.5 mm wall thickness were not significant, while crowns with d = 0.5 mm wall thickness were different and after aging they did crack. The loads to the failure of the crowns without aging (with aging) were 470.2N (369.2N) for d = 0.5 mm, 801.4N (889.1N) for d = 1.0 mm, and 1107.6N (980.8N) for d = 1.5 mm. According to other in vitro study CAD/CAM lithium disilicate single crowns should have a thickness of at least 1.5mm to withstand occlusal loads in posterior areas. (380 to 390 N)(Dhima et al., 2014)

In comparison with monolithic zirconia-based ceramic, lithium disilicate glass–ceramics have lower fracture resistance but much more esthetic. Monolithic ceramic restorations show markedly superior fracture resistance on their porcelain-veneered counterparts, from both chipping and radial cracking modes. (Zhang et al., 2013). A manufacturer's internal study comparing the difference in failure load for monolithic and bilayered crowns showed that adhesively retained monolithic lithium-disilicate restorations had the highest load to failure numbers. (Albakry, Guazzato & Swain, 2003). Zirconia crowns had highest fracture loads, lithium disilicate intermediate, and dental nanocomposite lowest. (Zhang et al., 2016)

Hamza & Sherif, 2017 in there in vitro research showed that monolithic lithium disilicate glass ceramic crowns had fracture resistance mean higher than bilayered zirconia-based crowns (after exposure in a chewing simulator and loaded until fracture in a universal testing machine), but lower than zirconia-reinforced lithium silicate. The mean fracture resistance for monolithic E.max CAD was 1565.2N. Similar to this in another study monolithic lithium disilicate crowns showed fracture strength of 1856 N, but lower than the monolithic zirconia crowns 2795 N and higher compared to the veneered high zirconia groups 1480 N (Johansson et al. 2013). Some in vitro studies have pointed out that lithium disilicate monolithic crowns and bridges, both CAD/CAM and hot-pressed, are more resistant to fatigue fracture compared to bilayered, hand veneered ones, showing higher fracture loads (1900 N), that are comparable to the metal-ceramic standard.(Mitsias et al, 2012)(Zhao et al., 2012).

Guess et al 2010 said that there is a threshold for damage/bulk fracture of the lithium disilicate ceramic and is in the range of 1,100 to 1,200 N. Regarding the strength of the material, it is considered that pressed lithium disilicate is 11% stronger than the CAD/CAM lithium disilicate according to Ivoclar's 2011 scientific report (IPS e.max Scientific Report Vol. 01/2001–2011) CAD-CAM monolithic lithium disilicate SCs showed an optimum in vitro stiffness and strength values when cemented onto both prefabricated titanium abutments and customized zirconia abutments (Joda et al.,2015)

One in vitro study of the fracture resistance of a different type of fixed dental prosthesis showed that monolithic lithium disilicate pressed bridges has significantly lowest fracture resistance followed by lithium disilicate glass ceramics pressed on zirconia-based and monolithic zirconia. (Choi et al. 2017)

Clinical outcomes of different IPS e.max lithium disilicate prostheses like single crowns, 3 unit bridges, veneers, inlays and onlays, both in the bilayered and monolithic forms, in a 4-year retrospective study reported low fracture rates: 0.91% for monolithic and 1.83% for bilayered single crowns (twice the rate of the monolithic); 4.55% for monolithic FDPs; 1.3% for monolithic and 1.53% for bilayered veneers; and 1.01% for monolithic inlays/onlays. (Sulaiman, Delgado & Donovan, 2015)When bonded to enamel (supported by dentin), the load-bearing capacity of lithium disilicate can approach 75% of that of zirconia, despite the flexural strength of lithium disilicate (400 MPa) being merely 40% of zirconia (1000 MPa). When bonded to dentin (with the enamel completely removed), the load-bearing capacity of lithium disilicate is about 57% of zirconia (Ma, Guess & Zhang, 2013)

6. Conclusions

This research supports the use of monolithic lithium disilicate restorations in everyday treatment for high-strength and esthetic indirect treatments, weather for the anterior or posterior regions of the mouth. The material offers specific advantages to dentists, such as the ability to provide strong and durable restorations with highly esthetic characteristics without metal. The fabrication processes and machinability affect the restorative quality of monolithic lithium disilicate glass ceramics. The light refraction gives the lithium disilicate material, a natural appearance and ability to be used in a monolithic form. In this state, the flexural strength remains the same throughout the entire restoration. Surface colorants are available to obtain the final shade and characterization. It's not the same as natural layered translucent teeth in terms, but it's certainly much closer than other available monolithic materials.They also are cost effective and very popular with many laboratories. The monolithic material structure of the glass-ceramic permits creation of very durable single tooth restorations with very high clinical reliability. Monolithic glass–ceramics are less vulnerable to chipping, but cannot match the zirconia for fracture resistance. Fully anatomical IPS e.max CAD crowns showed to be resistant against fatigue in cyclic fatigue tests. In comparison, crowns made of zirconium failed by fractures in the veneering material at clearly lower loads. Three-unit fixed dental prosthetics made from monolithic lithium disilicate ceramic may be a safe alternative to metal-ceramic bridges regardless of the cementation method used but only in the recommended indications. So far in literature there is no information about the fracture resistances and survival rates of monolithic veneers. More clinical studies for the overall esthetic outcome of monolithic restorations are needed in the future.

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