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Monolithic CAD/CAM restorations-Esthetic zone applications

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Abstract

Computer-aided design and manufacturing technology has been closely associated with implant-supported restoration. The digital systems which are used for restorative purposes comprise data acquisition, processing, and manufacturing using subtractive or additive methods. Advancements in digital dentistry are closely related to developments in optical scanning, computer-based digital algorithms and fabricating techniques in terms of accuracy and reliability which helped the development of novel ceramic materials with high esthetics and strength for versatile clinical applications. Time efficiency, cost effectivity, durability and biomimetic properties of machine-made restorations necessitate monolithic materials to serve this purpose. Contemporary ceramic materials are being widely used for rehabilitation of dentition from a single unit to full arch cases. This review aims to give an insight about optical properties and clinical use of monolithic materials.

Keywords: cadcam, dental, dentistry, digital, monolithic

1. Introduction

Porcelain use in dental restorations started in 1950s by applying porcelain bonded to metal (Asgar, 1998). The castable Dicor® crown system was also developed in the 1950s by Corning Glass Works. Glass was strengthened with mica by using the lost-wax casting technique. The 'casted restoration' was heat-treated or cerammed to provide a controlled crystallization of the glass. The type of crystal formation examples is leucite, fluoromica glass, lithium disilicate, and apatite glass ceramics (Krishna et al., 2009).

To solve the thermal expansion mismatch problem between metals and feldspathic porcelains Leucite was added. Aim was to raise the coefficient of thermal expansion. The crystalline leucite phases tend to slow down crack propagation of feldspathic porcelain. High leucite-containing ceramics Empress® 1 and optimal pressable glass ceramics were introduced to the market in the late 1980s to be the first examples of pressable ceramic materials and that was a major step towards contemporary CAD CAM materials like Empress CAD.

The first computer-aided design/computer-aided manufactured (CAD/CAM) substructure material, Procera® AllCeram core, was produced by Nobel Biocare in the mid-1990s and consisted of 99.9% alumina core to which a feldspathic ceramic was layered. In 1998 IPS Empress II, a lithium disilicate ceramic material used as a single and multiple-unit framework indicated for the anterior region, was introduced by Ivoclar. The core required a layering with a veneer porcelain specially designed for the material. A five-year study revealed a 70% success rate was shown for five years as a fixed partial denture framework (Marquardt and Strub, 2006).

Lithium disilicate was re-introduced to the market in 2006 as a partially crystalized milling block (Cerec® for chairside and inLab® milling units for laboratories). The flexural strength of the material was very high compared to other all ceramic systems. Block option enabled CAD/CAM milling of a framework which allowed for cut-back and layering with porcelain or produce an implant abutment with a titanium base allowed many opportunities for digital dentistry. Monolithic dental restorations are the essence of high technology dental treatments with full digital workflow. They combine the strength and durability with natural optical properties. Choice for a monolithic dental restoration material is based on several factors; translucency of teeth, parafunctional habits, occlusal relations, opposing dentition and extent of restoration.

A full digital workflow in restorative procedures is defined as the production and delivery of a restoration without a physical model. Intraoral scanners are used for impression procedures. Design and planning are made virtually on a design software. CAD design is transferred to the milling machine. And the final product should not necessitate any manual material add-ons or model transfers. Final design and form of the restoration is milled or 3D printed. Only minor corrections and occlusal adjustments are performed. Following a mechanical polishing the restoration may or may not require a glaze and make-up procedure depending on the material choice

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and indication. After finalization of the restoration, the definitive restoration is delivered to the patient. Monolithic restorations' treatment range covers single veneers to full arch rehabilitations including implant supported restorations.

2.1. Advantages of monolithic restorations

Less preparation is needed due to lack of layering depending on the case. Even 0.1 mm thickness (contact lens) laminate veneers can be produced by combining CAD/CAM technologies with manual applications.

- Less prone to chipping and fractures
- Demonstrate adequate strength to withstand chewing forces
- Broad range of trancluceny and polychromatic properties help to cover esthetic cases.
- Cost-effectiveness
- Reproducibility. In case of debonding or documentation, virtual files allow to produce the exact replica of missing restoration regardless of the time and location for multiple occasions.
- Ability to produce the exact form created in a digital design software allows clinicians to achieve mock-up proposal in final restorations. This is very helpful for the acceptance of the case by the patients and increases patient satisfaction.
- Enables mirroring and copying existing restorations and dentition to increase acceptance of the patients.
- Digital workflows create the sensation of contribution to the treatment process by patients, this mutual cooperation increases patient satisfaction. Also helps to enhance the individual experience.
- Enable single-visit dentistry and chair-side applications. Permanent restorations can be produced and delivered to the patient when indicated in one appointment. It reduces the total chair-time and increases cost efficiency of dental practice.
- Chairside applications are also extremely useful in terms of preventing cross contamination as they do not require any transfer of the impressions to the dental laboratory. This feature will be more important and beneficial after Covid-19 pandemic.

2.2. Disadvantages and limitations

Inadequate for highly demanding esthetic cases when layering is obligatory to achieve harmony and individual characteristics. However, most of the monolithic restoration materials allow material add-ons to overcome this issue.

- Lithium disilicate monolithic restorations and most of the monolithic zirconia restorations with super-high transcluceny are limited to three-unit bridges.
- Translucent monolithic restorations cannot mask heavily coloured devital teeth and metal post-cores. Opaque core and layering are required
- The main objective of restoring a tooth or a dentition is creating function, esthetics, form and phonetic rehabilitation with long-standing, predictable reconstructions.

Today's state-of-the-art technology available in both realms is capable of yielding from above average to excellent esthetic results. Clinical choice between veneered restorations and monolithic restorations depends on:

- Location of the restoration
- Occlusal considerations
- Need for strength
- Esthetics
- Number of restorations
- Underlying tooth or implant

For veneered restorations, porcelain layer upon core material has a low flexural strength and may show porcelain chipping or fractures (Poggio et al., 2017). Monolithic restorations have a higher flexural strength (380-1000 MPa) and are indicated for almost every situation. Monolithic restorations are produced by CAD/CAM technology and less prone to complications when properly designed considering material requirements. Conventional powder/liquid layering porcelains show high level color and optical properties to match that of natural dentin and enamel very closely and this is a major advantage compared to monolithic restorations. The most challenging part of monolithic rehabilitations is undoubtedly achieving optimal esthetics, especially for demanding cases. But the esthetic paradigm for matching the shade and creating micro-detailed characterization shifted to form and optic properties, translucency in particular. Every year new materials are being introduced to the dental market to be compatible for CAD/CAM Technologies. Monolithic blocks and discs present improved shade and optical properties to eliminate veneering porcelain and minimize the use of surface stains. Success of any monolithic restoration in terms of shade and harmony relies on the correct determination of the degree of translucency. Translucency is defined as: allowing the fraction of light that is not reflected to penetrate its surface where it is mainly scattered and transmitted. Monolithic materials can represent various degrees of translucency as high translucency, medium translucency, low translucency, medium opacity, multi translucency, full opacity, bleach properties.

2.3. High translucency

Indicated when minimal preparation is required and there will be no change in the colour of underlying tooth. Requires up to 0.3 mm of reduction for laminate veneers to achieve adhesive bonding to enamel surface.

2.4. Medium translucency

Suitable for multidiastemata and almost every anterior case that requires partial change of colour. When the thickness of the restoration is below 0.8 mm material shows high translucency and has a complete masking capacity with a minimum of 1.0 mm thickness.

2.5. Low translucency

Indications are limited when low translucent monolithic materials have been chosen. Lack of incisal translucency for lithium disilicate restorations reduces natural mimicry. Low translucent materials are suitable for posterior area especially for TiBase implant crowns.

2.6. Polychromatic blocks

Polychromatic feldspathic blocks help to achieve optimal esthetic outcomes for single veneers or crowns in the anterior zone. Vita Triluxe, Cerec PC, IPS Empress CAD Multi are materials of choice when high strength of oxide ceramics is not required. Due to their low flexural strength minimal thickness should be 0.3 mm for laminate veneers. No need for crystallization firing facilitates use with manual polishing only. Not subject to dimensional change after firing. More durable than powder/liquid porcelains as the product is fully sintered and dense. Glaze firing increases flexural strength approximately 30 MPa. Indicated for veneers, full crowns, inlays and onlays.

2.7. Classification of monolithic restorative materials

Full ceramic restorations have been widely used for their high biocompatibility and esthetic superiorisities. However, until introduction of monolithic restorations combining strength and esthetics, their use was almost limited to anterior zone. Recent developments in materials extend the use of monolithic restorations in dental practice to a very broad range like one-piece implant supported full arch bridges. Another important advantage of monolithic restorations is the ability to create the same design in a reproducible manner. Monolithic CAD CAM restorations can be classified according to their processing routes or their composition. A brief information about most popular monolithic CAD/CAM materials can be found on Table 1. Regarding composition, contemporary CAD CAM monolithic materials are classified to three main groups; glass ceramics, resin-matrix ceramics and oxide ceramics.

2.8. Glass ceramics

Silica: VITA Mark II is the first CAD/CAM fine structure feldspar ceramic. Silica ceramics can represent two crystallization patterns; with a sodium potassium aluminum silicate peak. It has low characteristic strength of 118.65 MPa (Wendler et al., 2017). Feldspathic ceramics are considered as the best biomimetic materials. CAD/CAM feldspathic blocks are being used for single crowns, porcelain veneers, inlays, onlays and endocrowns with a high survival rate (Wiedhahn et al., 2005; Otto and Schneider, 2008; Otto and Mormann, 2015). They offer high translucency and good esthetics but their low flexural strength and brittleness require adhesive bonding (Beier and Dumfahrt, 2014).

There are different types of feldspathic ceramic blocks according to their optical properties as monochromatic, dichromatic and polychromatic. Different thicknesses of porcelain laminate veneers produced from monolithic feldspathic blocks are significantly effective on shade and masking underlying substrate. Veneers with a thickness less than 0.7 mm cannot mask the underlying tooth colour. Conventional feldspathic ceramics belong to this material group and considered as the most esthetic materials to achieve a natural enamel look thanks to their translucency and opalescence.

Leucite reinforced glass ceramic: Empress CAD (Ivoclar Vivadent) is the most popular example of this material group. This material is an early generation CAD/CAM block containing leucite crystals up to 40% embedded in a feldspathic glass ceramic. Leucite reveals a dentritical growth through surface crystallization of glass particles in powdered glass by bulky crystallization of monolithic glasses having TiO_2 and CeO_2 as nucleating agents. Flexural strength of leucite reinforced glass ceramics is 185 MPa and they show a low characteristic strength of 187.7 MPa (Wendler et al., 2017). LRGCs exist in high translucent (HT), low transclucent (LT) and polychromatic (PC) forms in terms of light transmitting properties. LRGCs are indicated for anterior veneers, crowns and posterior inlays/onlays due to their increased strength compared to feldspathic ceramics and their translucency. They reveal a 96.4% survival rate for five years according to Nejatidanesh et al. (2018) (Fig. 1).

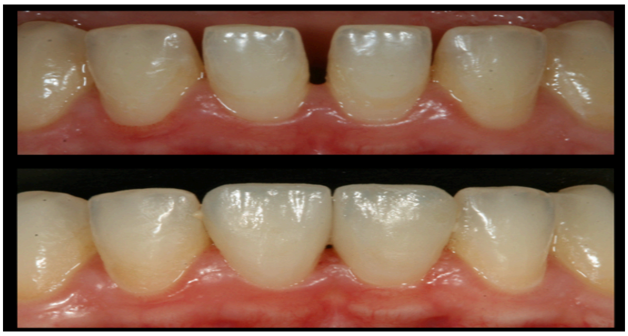

Fig. 1. IPS Empress CAD PLVs on teeth 31 and 41

Lithium disilicate ceramic: IPS E.max CAD. They reveal needle like particles (0.5 to 4 μm) with different orientations. Milled LiDiSil is exposed to a 2 stage crystallization. After sinterization, the final flexural strength is 530 MPa and also shows a high characteristic strength of 609.80 MPa according to Wendler et al. (2017). Shade and transclucency variety accompanying high strength makes this material indicated for anterior and posterior single crowns, inlays, onlays, veneers and 3 unit bridges terminating at 2nd premolar. LDSCs exist in various translucencies like HT, LT, MT (medium translucency), MO (medium opacity) and HO (high opacity) (Fig. 2).

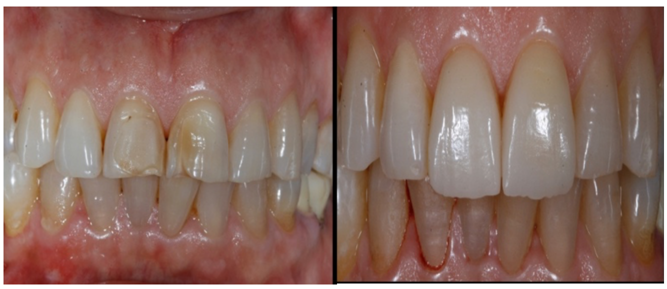

Fig. 2. Lithium Disilicate MT PLVs on teeth 11-21

Table 1. CAD CAM monolithic materials

Material Group	Material	Brand	Strength (MPa)	Indications	Milling Condition	Block/Disc	Crsytallization Firing	Glaze Firing Option	Shade Range	Transclucency	Add-on	Documentation
Glass Ceramic	Silica / Feldspar Ceramic	CEREC Blocs C Dentsply Sirona	120	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block	N	Y	A1, A2, A3.5, A4, B1, B2, B3, C2, C3, D3 (VITA) BL2 (IVOCLAR)	HT with chameleon effect	Possible	
Glass Ceramic	Silica / Feldspar Ceramic	CEREC Blocs C PC Dentsply Sirona	120	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block	N	Y	A1, A2, A3.5, A4, B1, B2, B3, C2, C3, D3 (VITA) BL2 (IVOCLAR)	Polychromatic	Possible	
Glass Ceramic	Silica / Feldspar Ceramic	CEREC Blocs C IN Dentsply Sirona	120	Veneer, Anterior Crown, Posterior Crown	Wet	Block	N	Y	A1, A2, A3.5, A4, B2, B3, BL2, C2, C3, D3	Polychromatic with dentin core	Possible	
Glass Ceramic	Silica / Feldspar Ceramic	VITABLOC S Mark II VITA	140-160	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block	N	Y	All Classic and 3D Master VITA Shades	Monochromatic translucent	Possible	
Glass Ceramic	Silica / Feldspar Ceramic	VITABLOC S Triluxe VITA	140-160	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block	N	Y	A1, A2, A3, 1M2C, 2M2C, 3M2C	Polychromatic 3 shade intensity layers	Possible	
Glass Ceramic	Silica / Feldspar Ceramic	VITABLOC S Triluxe Forte VITA	140-160	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block	N	Y	A1, A2, A3, A3.5 1M2C, 2M2C, 3M2C	Polychromatic 4 shade intensity layers	Possible	
Glass Ceramic	Silica / Feldspar Ceramic	VITABLOC S RealLife	140-160	Veneer, Anterior Crown	Wet	Block	N	Y	0M1, 1M1, 1M2, 2M1, 2M2, 3M2	Polychromatic with dentin core	Possible	
Glass Ceramic	Leucite reinforced Glass-Ceramic	IPS Empress CAD	185	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block	N	Y	All Classic VITA Shades BL1, BL2, BL3, BL4 (Ivoclar)	HT-LT-Multichromatic	Possible	
Glass Ceramic	Leucite reinforced feldspar ceramic	GC Initial LRF GC	250	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block	N	Y	A1, A2, A3, A3.5, B1, Bleach	HT-LT	Possible	
Glass Ceramic	Lithium disilicate Glass-Ceramic	IPS e.max CAD Ivoclar Vivadent	530	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown, 3- unit bridges, TiBase abutment	Wet	Block	Y	Y	A1, A2, A3, A3.5, A4, B1, B2, B3, B4, C1, C2, C3, C4, D2, D3, D4 ((VITA) BL1, BL2, BL3, BL4 (IVOCLAR)	HT-LT-MT-MO	Possible	
Glass Ceramic	Lithium disilicate Glass-Ceramic	Obsidian Glidewell	385	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block	Y	Y	A1, A2, A3, A3.5, B1, B2, B3, C1, C2, C3, D2, D3, (VITA BL1, BL4 (IVOCLAR)	Not specified (MT)	Possible	
Glass Ceramic	Lithium aluminosilicate	n!ce Straumann	350	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown, TiBase abutment	Wet	Block	Optional	Y	A1, A2, A3, A3.5, B1, B2, B4, Bleach	LT-HT	Not possible	
Glass Ceramic	Lithium disilicate Glass-Ceramic	Amber Mill Haas	450	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown, 3- unit bridges	Wet	Block /Disc	Y	Y	All VITA Classic Shades W1, W2, W3, W4	HT-LT-MT-MO	Possible	
Glass Ceramic	Zirconia reinforced lithium silicate	CELTRA DUO Dentsply Sirona	210 (370 after firing)	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block	Optional	Y	A1, A2, A3, A3.5, B1, B2, C1, C2, D2, D3, BL2, BL3	LT-HT	Possible	
Glass Ceramic	Zirconia reinforced lithium silicate	VITA Suprinity PC VITA	360	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block	Y	Y	A1, A2, A3, A3.5, B2, C2, D2 0M1, 1M1, 1M2, 2M2, 3M2, 4M2	HT-T	Possible	
Resin-Matrix Ceramic	Resin-nanoceramic	Lava Ultimate 3M	200	Veneer, Inlay, Onlay (limited use)	Wet	Block	N	N	A1, A2, A3, B1 (HT) A1, A2, A3, A3.5, B1, C2, D2, BL (LT)	HT-LT	Possible (only composite)	
Resin-Matrix Ceramic	Hybrid ceramic resin	Tetric CAD Ivoclar Vivadent	272	Inlay, Onlay, Veneer	Wet	Block	N	N	A1, A2, A3, A3.5 Bleach	HT-MT	Possible (only composite)	

Resin-Matrix Ceramic	Dual-network Hybrid Ceramic	VITA ENAMIC VITA	150-160	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown, TiBase abutment	Wet	Block /Disc	N	N	0M1, 1M1, 1M2, 2M2, 3M2	HT-T	Possible (only composite)	
Resin-Matrix Ceramic	Hybrid Ceramic Polymer Structure	VITA ENAMIC multiColor VITA	150-160	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown, TiBase abutment	Wet	Block	N	N	1M1, 1M2, 2M2, 3M2, 4M2	6 layer gradient HT	Possible (only composite)	
Resin-Matrix Ceramic	Nano-particle filled Resin Ceramic	CERASMART Blocks GC	238	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block	N	N	A1, A2, A3, A3.5, B1	HT-LT	Possible (only composite)	
Resin-Matrix Ceramic	Ceramic-Based hybrid	HC Blocks Shofu	191	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block /Disc	N	N	A1, A2, A3, A3.5, B3, W2	HT-LT	Possible (only composite)	
Resin-Matrix Ceramic	Reinforced hybrid composite	Brilliant CRIOS Coltene	262	Veneer, Inlay, Onlay, Anterior Crown, Posterior Crown	Wet	Block /Disc	N	N	LT Bleach, A1, A2, A3, A3,5, B1, B2, B3, C2, HTA1, A2, A3, B1	HT-LT	Possible (only composite)	
Composite	Composite	Paradigm MZ 100 3M	146	Inlay, Onlay, Veneer	Wet	Block	N	N	A1, A2, A3, A3.5, B3, Enamel	T Chameleon effect	Possible (only composite)	
Oxide Ceramic	Monolithic Zirconia	inCoris TZI	900	Anterior Crown, Posterior Crown, Bridge, TiBase abutment	Wet or Dry	Block /Disc	Y	Y	A1, A2, A3, A4, B2, B3, C2, C3, D3	Translucent	Possible	
Oxide Ceramic	Super-Translucent Multilayered Zirconia	KATANA Kuraray	763	Anterior Crown, Posterior Crown, Bridge, TiBase abutment	Wet or Dry	Block /Disc	Y	Y	A1, A2, A3, A3.5, B1, B2, B3, C1, C2, C3, D2, D3, NW	HT-Polychromatic	Possible	
Oxide Ceramic	Multilayered Monolithic Zirconia	IPS e. max Multi ZirCaD Ivoclar	850	Anterior Crown, Posterior Crown, Bridge, TiBase abutment	Wet or Dry	Block /Disc	Y	Y	A1, A2, A3, B1, B2, C2, D2, Bleach	MT	Possible	
Oxide Ceramic	Monolithic Zirconia	BruxZir Glidewell	870	Anterior Crown, Bridge	Wet or Dry	Disc	Y	Y	All Classic and 3D Master VITA Shades	Polychromatic	Possible	
Oxide Ceramic	Super High Translucent Zirconia	Zolid fx White Amann Girrbach	700	Anterior crown, bridges Up to 3-unit bridges in molar area	Wet or Dry	Block /Disc	Y	Y	W	HT	Possible	
Oxide Ceramic	Super High Translucent Zirconia	Zolid fx White Amann Girrbach	700	Anterior crown, bridges Up to 3-unit bridges in molar area	Wet or Dry	Block /Disc	Y	Y	All Classic and 3D Master VITA Shades	HT-Polychromatic	Possible	
Oxide Ceramic	Monolithic Zirconia	Prettau Zirkonzahn	1200	Up to 14 unit bridges	Wet or Dry	Disc	Y	Y	All Classic and 3D Master VITA Shades	Translucent	Possible	

Material Group	Crystallization Firing	Glaze Firing Option	Shade Range	Translucency	Add-on	Documentation
Glass Ceramic	N	Y	A1, A2, A3, A3.5, A4, B1, B2, B3, C2, C3, D3 (VITA) BL2 (IVOCLAR)	HT with chameleon effect	Possible	
Glass Ceramic	N	Y	A1, A2, A3, A3.5, A4, B1, B2, B3, C2, C3, D3 (VITA) BL2 (IVOCLAR)	Polychromatic	Possible	
Glass Ceramic	N	Y	A1, A2, A3, A3.5, A4, B2, B3, BL2, C2, C3, D3	Polychromatic with dentin core	Possible	
Glass Ceramic	N	Y	All Classic and 3D Master VITA Shades	Monochromatic translucent	Possible	
Glass Ceramic	N	Y	A1, A2, A3, 1M2C, 2M2C, 3M2C	Polychromatic 3 shade intensity layers	Possible	
Glass Ceramic	N	Y	A1, A2, A3, A3.5 1M2C, 2M2C, 3M2C	Polychromatic 4 shade intensity layers	Possible	

Glass Ceramic	N	Y	0M1, 1M1, 1M2, 2M1, 2M2, 3M2	Polychromatic with dentin core	Possible	
Glass Ceramic	N	Y	All Classic VITA Shades BL1, BL2, BL3, BL4 (Ivoclar)	HT - LT - Multichromatic	Possible	
Glass Ceramic	N	Y	A1, A2, A3, A3.5, B1, Bleach	HT - LT	Possible	
Glass Ceramic	Y	Y	A1, A2, A3, A3.5, A4, B1, B2, B3, B4, C1, C2, C3,C4, D2, D3, D4 ((VITA) BL1,BL2, BL3, BL4 (IVOCLAR)	HT - LT - MT - MO	Possible	
Glass Ceramic	Y	Y	A1, A2, A3, A3.5, B1, B2, B3, C1, C2, C3, D2, D3 (VITA BL1,BL4 (IVOCLAR)	Not specified (MT)	Possible	
Glass Ceramic	Optional	Y	A1, A2, A3, A3.5 B1, B2, B4, Bleach	LT - HT	Not possible	
Glass Ceramic	Y	Y	All VITA Classic Shades W1, W2, W3, W4	HT - LT - MT - MO	Possible	
Glass Ceramic	Optional	Y	A1, A2, A3, A3.5 B1, B2, C1, C2, D2, D3, BL2, BL3	LT - HT	Possible	
Glass Ceramic	Y	Y	A1, A2, A3, A3.5, B2, C2, D2 0M1, 1M1, 1M2, 2M2, 3M2, 4M2	HT - T	Possible	
Resin-Matrix Ceramic	N	N	A1, A2, A3, B1 (HT) A1, A2, A3, A3.5, B1, C2, D2, BL (LT)	HT - LT	Possible (only composite)	
Resin-Matrix Ceramic	N	N	A1, A2, A3, A3.5 Bleach	HT - MT	Possible (only composite)	
Resin-Matrix Ceramic	N	N	0M1, 1M1, 1M2, 2M2, 3M2	HT - T	Possible (only composite)	
Resin-Matrix Ceramic	N	N	1M1, 1M2, 2M2, 3M2, 4M2	6 layer gradient HT	Possible (only composite)	
Resin-Matrix Ceramic	N	N	A1, A2, A3, A3.5, B1	HT - LT	Possible (only composite)	
Resin-Matrix Ceramic	N	N	A1, A2, A3, A3.5, B3, W2	HT - LT	Possible (only composite)	
Resin-Matrix Ceramic	N	N	LT Bleach, A1, A2, A3, A3.5, B1, B2, B3, C2 HT A1, A2, A3, B1	HT - LT	Possible (only composite)	
Composite	N	N	A1, A2, A3, A3.5, B3, Enamel	T Chameleon effect	Possible (only composite)	
Oxide Ceramic	Y	Y	A1, A2, A3, A4, B2, B3, C2, C3, D3	Translucent	Possible	
Oxide Ceramic	Y	Y	A1, A2, A3, A3.5 B1, B2, B3, C1, C2, C3, D2, D3, NW	HT - Polychromatic	Possible	

Oxide Ceramic	Y	Y	A1, A2, A3, B1, B2, C2, D2, Bleach	MT	Possible	
Oxide Ceramic	Y	Y	All Classic and 3D Master VITA Shades	Polychromatic	Possible	
Oxide Ceramic	Y	Y	W	HT	Possible	
Oxide Ceramic	Y	Y	All Classic and 3D Master VITA Shades	HT - Polychromatic	Possible	
Oxide Ceramic	Y	Y	All Classic and 3D Master VITA Shades	Translucent	Possible	

Lithium silicate/phosphate glass ceramic: It is also known as zirconia reinforced lithium silicate. Vita Suprinity, Celtra and Celtra Duo belong to that material group. VITA Suprinity blocks are in a metasintered stage to facilitate grinding and later requires a final crystallization. Celtra Duo is in a fully sintered form and can be delivered to patient after mechanical polishing following milling. Flexural strength of LSPGCs averages 360 MPa. Characteristic strength reveals an intermediate range in comparison with silicate ceramics and zirconia (Celtra Duo: 565.87 MPa; VITA Suprinity: 573.03 MPa) (Wendler 2017).

The addition of ZrO_2 to lithium metasilicate and disilicate did not result in an increased strength or higher resistance to crack propagation as compared with LiDiSil. Multiple cracking and surface pitting were observed in SEM evaluation.

Thermal incompatibility between phases and related high local residual stresses that are relieved upon cooling by means of microcracking are possible reasons. (Wendler et al., 2017). In addition, damage induced to the presintered block by diamond coated grinding instruments during machining is another source of concern (Chavali et al., 2017).

Lithium aluminosilicate ceramic: Straumann Nice blocks. n!ce® is a lithium aluminosilicate ceramic reinforced with lithium disilicate and available in two levels of translucency: High Translucency and Low Translucency. LAC restorations can be seated using either adhesive or self-adhesive cementation. They can simply be polished, or stain and glaze can be applied if more pronounced characterization is wished. Layering or porcelain add-ons are not possible for this material. The flexural strength is 350 MPa according to the manufacturer. Immediate applications with titanium base abutments are the main indication for this type of material.

2.9. Resin-matrix ceramics

Resin based composites: (Predominant organic phase with fillers). Lava Ultimate contains dispersed nanometric colloidal silica and ZrO_2 spherical particles in agglomerated and non-agglomerated form (80% weight, 65% volume) embedded in a dimethacrylate resin. Flexural strength is 200 MPa.

Cerasmart, Brilliant Crios and Shofu Blocks are novel RBCs with a homogenous and evenly distributed ceramic network. RBCs should be pretreated through air-particle abrasion and application of a universal bonding agent.

Polymer-infiltrated ceramic network: (Predominant inorganic phase with high temperature/high pressure polymer infiltration). VITA Enamic is an amorphous structured material with no evidence of crystallization. Flexural strength is 160 MPa. Due to the dual network structure, crack propagation is mitigated by the interlinked polymer network. Hydrofluoric acid etching in combination with silane is recommended as a surface treatment prior to bonding.

2.10. Oxide ceramics

Zirconia is first introduced in early 1990s by CAD/CAM technology. It has a very high flexural strength (1200 MPa) and used as a framework material for fixed restorations for years. However the high opacity of the material required veneering and layering process for esthetics and complications like porcelain chipping and fractures are frequent. To overcome this problem and make use monolithic zirconia as a restoration translucent zirconia was developed. Translucent monolithic zirconia is produced by reducing particle dimensions of zirconium dioxide and binding with an agent through colloidal process to minimize the pores within the structure. Translucent zirconia can be used for anterior restorations up to 3 unit bridges as the flexural strength is significantly lower compared to conventional zirconia. The latest progress to increase the translucency is to stabilize the zirconia with a cubic crystalline phase. Increasing the yttria content to more than 8 mol% will stabilize the cubic phase (Zhang, 2014). There are different versions of “high-translucent” or “cubic-containing” zirconia on the market. These cubic zirconia samples are produced to have approximately 8 mol% yttria to 10 mol% yttria. (Lava™ Esthetic (3M ESPE); Katana™ Zirconia (UTML/STML) (Kuraray Noritake Dental Inc., kuraraynoritake.com); BruxZir® Anterior (Glidewell Laboratories); ArgenZ™ Anterior (Argen Corp., argen.com); and Imagine® (Jensen Corp.)).

2.11. Clinical performance and design requirements for monolithic restorations

As all monolithic restorations are being produced by CAD/CAM Technologies, the preparation design and parameters should be considered accordingly. Monolithic restorations use subtractive method for production which means that a block or a disc is milled by a 3-, 4- or 5-axis milling machine with appropriate burs. The axis content and bur design and diameter necessitates to apply adjusted principles for tooth preparation. Milling parameters affect the internal fit of the final restoration. Tooth preparations must be rounded to prevent stress and also should provide enough space for cementation and fit. Sharp corners and edges should be avoided. Preparation has a significant effect on the marginal fit of monolithic CAD/CAM crowns and finish line of choice is a chamfer or rounded shoulder for the best fit (Renne et al., 2012). Another important issue for success of monolithic materials is the thickness of the restoration. Material properties define the minimal thickness for strength and determine the thickness of the restorative material needed for change in the colour of underlying tooth structure. Masking with monolithic zirconia require a minimal thickness of 0.9 mm (Tabatabian et al., 2018) (Fig. 3).

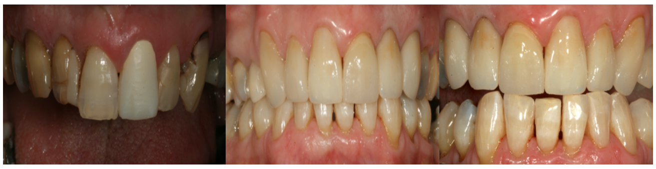

Fig. 3. Masking effect of low translucent monolithic lithium disilicate restorations

Lithium disilicate restorations are shown to be a safe alternative to metal-ceramic 3-unit FDPs when manufacturer's recommendations are followed. Kern et al. (2012) demonstrated 100% survival rate for five years and 87.9% survival rate for ten years. The success rate of lithium disilicate FDPs was found to be 91.1% for five years and 69.8% for ten years. Sailer et al. (2015) showed all-ceramic single crowns to exhibit comparable survival rates to metal-ceramic single crowns after a mean observation period of at least 3 years. While leucite or lithium-disilicate reinforced glass-ceramic or oxide ceramic materials perform similarly well in anterior and posterior regions the mechanically weaker ceramics like the feldspathic or silica glass-ceramics can only be recommended for anterior with low functional loads (Sailer et al. 2015) (Fig. 4).

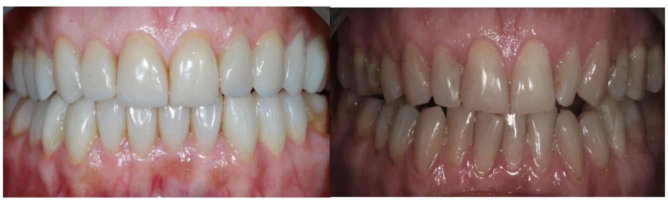

Fig. 4. VOD increased by monolithic restorations with a full digital workflow

3. Conclusion

Monolithic restorations are considered to be reliable and predictable for the rehabilitation of esthetic cases. Due to advances in technology and material developments, scientific documentation and evidence are limited for novel products. However, most of the products in the dental market have long term success and are being used with great confidence for daily practice.

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