Dental biomaterials for chairside CAD/CAM: State of the art

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The wide use of chairside CAD/CAM restorations has increased the diversity of the restorative material. For the practitioner, the selection of the appropriate material is difficult amongst the variety offered by the market. Information on the characteristics of the products can be difficult to assess due to the lack of up-to-date classification and the lack of reliability of manufacturer's advertising. The purpose of this article is to structure the data on restorative materials provided by various sources in order for the practitioner to choose the product most suited to the clinical situation. The objective is to classify chairside CAD/CAM materials and to define their characteristics and indications. ***[J Adv Prosthodont 2017;9:486-95]***

KEYWORDS: CAD/CAM; Chairside; Ceramic; Resin; Block

INTRODUCTION

The first chairside CAD/CAM[1] produced inlay was made in 1985 using a ceramic block comprising fine grain feldspathic ceramic (Vita Mark I, Vita Zahnfabrik).[2] Since the 80's, different systems have been developed, such as known CEREC. Systems have evolved through a series of software and hardware.[3,4] The current systems offer a three-dimensional (3-D) design program and can fabricate inlays, onlays, veneers, crowns, as well as three unit bridges and custom lithium disilicate implant abutments.[5]

Initially, materials had to be mechanically strong but also easily machinable. Feldspathic ceramics were well adapted for small occlusal inlays (CEREC I).[2] Then, the desire to extend the indications of CAD/CAM restorations (onlays, crowns) has driven the practitioner to work with more mechanically resistant materials. Therefore, reinforced ceramic has been developed. To maintain rapid milling, some of them are offered at a pre-crystallized stage. A post-milling crystallization will be necessary to access the final shade and mechanical strength. The idea to propose softer materials less susceptible to brittle fracture was also developed. This is the resin class, much less mechanically resistant but which has the property of deforming before fracture, unlike ceramics.[6,7] The next step was to increase the mechanical properties of these resins with the incorporation of ceramic particles. Currently, manufacturers try to combine the advantages of these two families of materials by providing a ceramic network infiltrated with resin polymers. Metal blocks are also available, but their existence and their use are today almost anecdotal.

Nowadays, manufacturers propose more than 20 blocks for a chairside use. Blocks are available in different size, shade, and translucence and can require a post milling treatment, which would be different according to the type of material. Practitioners may encounter problems choosing the right material for the clinical situation among this large range of material and the related commercial communication.

The objective of this article is to classify chairside CAD/CAM materials and to define their characteristics and indications.

Metal

Presentation

Among the metals milled in fixed partial denture (FPDs), the main ones are cobalt-chromium alloys (CoCr) and titanium. For various reasons, including cost, precious

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metal alloys are not machined. Manufacturers are currently working on titanium blocks.

Blocks available are CoCr as pre-sintered form, which are very soft to enable rapid machining and low damages burs.

Information and science on these pre-sintered metals are currently limited.

These blocks are formed by metal powder compaction by isostatic pressure to obtain a solid but tender and soft material. To allow the required mechanical properties of the prosthetic piece, a post treatment is required. Sintering is a heat treatment with or without the application of external pressure, whereby a system of individual particles or a porous body modifies some of its properties in the sense of moving towards a state of maximum compactness.

Indications

Machined CoCr alloys have same indications than CoCr alloys formed by lost wax casting.

Its use is interesting in the case of thin reconstitution; however the lack of aesthetics of this material is a major flaw.

Manufacturers do not yet indicate achieving abutments.

The electrochemical corrosion phenomena between various metals must be taken into account when choosing the material, especially in case of metal restorations already present in the mouth. According to the literature, titanium is preferable for metal implant prosthesis.[8,9]

Metal frameworks and metal-ceramic restorations can be produced with these blocks. However, prosthetist intervention is required for the ceramic veneering. At this point, we are not within the framework of chairside CAD/CAM.

Manufacturers

Amann Girrbach markets a block named Sintron, made of pre-sintered CoCr shaped by dry milling. Machining the block with water spray is impossible as it disintegrates upon contact with water. The manufacturer guarantees that machining is safe for the operator.

Dentsply marketed not long ago a block named Crypton. Contrary to Sintron, its milling needs a water and oil spray in a closed circuit to avoid the toxicity of CoCr microparticles suspended in air. The manufacturer takes this precaution because inhaling microparticles can be detrimental to people nearby.

Nowadays, there is no communication from manufacturers or literature on the harmfulness of CoCr particles suspended during machining, neither on why the Amann Girrbach CoCr disintegrates during the spray milling.

Implementation

Blocks are not sintered during machining. The prosthetic piece obtained requires a post milling treatment. The sintering is carried out by thermal treatment under argon. Sintering causes shrinkage of the order of 10%, which must be anticipated by accurately designing slightly oversized parts, as with the pre-sintered zirconia.

Ceramics

Kelly proposes to consider ceramic as a "composite", meaning a composition of two or more distinct entities[10,11] formed from a matrix (glass or polycrystalline) in which are incorporated additive elements called fillers in various quantity. It is either particles (crystal or glassy high melting point) or modified atoms, called "doping" for polycrystalline ceramic.[10,12] They improve mechanical properties (fillers) or stabilize polycrystalline structure (doping).

The glassy matrix defines the aesthetic properties of the ceramic. The higher the glass rate is, the greater the importance of translucency is, which will work best to imitate the properties of enamel and dentin.[10] This glassy matrix permits the diffusion of light for translucency in depth. Mechanical properties decrease with the fragile glass phase but increase with the filler content. Inside the glassy matrix, the nature of filler would prevent the development of micro-fractures.

Many classifications of ceramics were proposed and used. Based on their microstructure, dental ceramics fall within three basic classes[11-16]:

- Predominantly glassy ceramics
- Particle-filled glasses
- Polycrystalline ceramics.

Today, predominantly glassy and particle-filled glasses represent almost all machinable ceramics for direct CAD/CAM. Recently, zirconia, under certain conditions, can also be machined chairside to realize monolithic restorations.

Therefore, an adjusted classification can be developed from Li & all most adapted to direct CAD/CAM:

- Direct CAD/CAM glass ceramics
    - Feldspathic
    - Leucite-reinforced
    - Lithium disilicate reinforced
    - Zirconium oxide and lithium silicate reinforced
- Direct CAD/CAM compatible polycristalline ceramics:
    - Zirconia

The two first sub-categories will be treated in the same paragraph because of their similar characteristics including their different microstructure (Fig. 1).

Fig. 1. Different types of ceramic blocks with different mandrels.

Direct CAD/CAM glass ceramics
Feldspathic and leucite-reinforced ceramics

Presentation

Feldspathic ceramics are obtained by simply mixing powder and water. A plasticized ceramic mixture is pressed and extruded through a nozzle to give its form. The blocks are then dried over several days before sintering.[2] Glasses in dental ceramics derive principally from a group of mined minerals called feldspar and are based on silica (silicon oxide) and alumina (aluminum oxide), hence feldspathic porcelains belong to a family called aluminosilicate glasses. Glasses based on feldspar are extremely biocompatible.[12]

Leucite-reinforced are particle-filled glasses. Their microstructures differ by the presence of fillers incorporated in the glassy matrix. The first fillers to be used in dental ceramics contained particles of a crystalline mineral called leucite.[12]

There are two major benefits to use leucite as a filler choice for dental ceramics; the first intended and the second probably serendipitous. First, leucite was chosen because its index of refraction is very close to feldspathic glasses; an important match for maintaining some translucency. Second, leucite etches at a much faster rate than the base glass and it is this 'selective etching' that creates a myriad of tiny features for resin cements to enter, creating a good micromechanical bond.[11,12]

Leucite-reinforced ceramics are formed in the glass state and then heat-treated to obtain a controlled and partial crystallization. This treatment allows the production of crystalline loads controlled devitrification of chemically homogeneous glass matrix and gives a fine grain structure, very homogeneous. This process is called "ceraming".[12]

Feldspathic and leucite-reinforced ceramics have a significant proportion of glassy phase (55 to 70%), which gives them an important translucency, and thus, the aesthetic qualities superior to other ceramic.[17] Dental ceramics that best mimic the optical properties of enamel and dentin are predominantly glassy materials.[11] However, these particularities do not allow proper hiding of a discoloration stump or a metal inlay-core.

Mechanical properties of these ceramics are insufficient to withstand occlusal stresses in theory. Reconstructions machined into this material will be bonded to increase this force.[18,19]

Indications

These ceramics, which have the most important aesthetic properties of chairside CAD/CAM blocks, are recommended for the realization of prosthetic restorations with high aesthetic impact. This material could be use to achieve veneers, crowns and partial crowns, and cavitary restorations.

Manufacturers

Different manufacturers propose this material, in one block shade, or in 3 or 4 stratified shades within the same block (Fig. 2). A three-dimensional structure block with a "dentin core" and "enamel" shade that surround it is also available. The restoration is milled in the curvilinear gradient color thanks to CAD software. This type of block has been specifically developed for aesthetic anterior restorations.

Fig. 2. Incisor crown milled in a 4 shades block.

Implementation and finish

There are different methods of finishing the milled ceramic reconstructions.

- Mechanical polishing: in SEM (Scanning Electron Microscopy), the polished surface is the smoothest surface compared with glazing and the natural tooth. Polishing can produce a smooth surface that can be more aesthetically similar to natural enamel than glazing.[12]
- Glazing: using glazure allows to bring a natural shine, sometimes superior to a simple mechanical polishing. The heat treatment process and glazing improve the mechanical properties of the workpiece by possible micro-cracks obliteration caused by machining.[20]
- Cut-back: the prosthetic piece is recessed on its vestibular portion and / or incisal, thanks to CAD software. This strategic area is then veneered to achieve personalization. This technique is recommended on anterior teeth with an important aesthetic expectation.

After glazing or polishing, there is a decrease of the abrading enamel facing ceramics. Enamel loss becomes almost equivalent to the material.[21]

Lithium disilicate, zirconium oxide and lithium silicate reinforced ceramics

Presentation

They have the same biphasic structure than leucite-reinforced ceramics. However, the proportion of crystalline phase is increased. The glass matrix is reduced to 30% of the volume. Filler particles are grown inside the glass object, after the object has been formed. After machining, the glass object is given a special heat treatment, causing the precipitation and growth of crystallites within the glass. Since these fillers are derived chemically from atoms of the glass itself, the consequence is that the composition of the remaining glass is altered as well during this process (termed 'ceraming'). Such particle-filled composites are called glass-ceramics.[11,12]

This type of ceramic could be filled by:

• Lithium disilicate

• Lithium silicate and zirconium dioxide.

These ceramics have an improved flexural strength, with good optical properties, and several levels of translucency and shades. Their strength and structure allow a good resistance, not avoiding an initial fracture but rather avoiding the spread of the fracture. Indeed, it will take a much larger load, twice more compared to a conventional ceramic, to achieve a complete fracture.[18]

Their mechanical resistance is considerably increased when they are bonded to enamel, reaching 70% of the resistance of zirconia.[22]

Lithium disilicate glass ceramics are actually only available chairside with e.max CAD (Ivoclar-Vivadent).[23] Blocks are milled in a pre-crystallized metasilicate phase. A final crystallization firing will dissolve metasilicate crystals, while disilicate crystals will undergo a reticulated growth, creating a kind of mesh arming the body of ceramics. This material has significant clinical experience.[24]

Zirconium oxide and lithium silicate glass ceramics (ZLS) are available in a pre-crystallized (easy to machine but with an intermediate color) or fully crystallized (more difficult machining but with the final shade). They contain 10% dissolved zirconium dioxide in a glassy phase of the ceramic and very fine lithium metasilicate and lithium disilicate crystals (average size: 0.5 - 0.7 μm).[25] The formed crystals are 4 to 8 times smaller than lithium disilicate crystallites.[25] This dual microstructure is achieved in a two-step process. The material is delivered in a pre-crystallized stage, containing only lithium metasilicate crystals. In its pre-crystallized phase, the material is easy to machine. After the water-cooled milling process and the finishing of the restoration, the final dual lithium silicate microstructure is reached during an 8-minute firing process at 840°C.[26] For the fully crystallized state, the firing process is not necessary. ZLS are more recent, but comparable with the clinically well-proven lithium disilicate glass ceramics.[23,25]

Indications

This type of ceramic has high optical properties, with multiple levels of shade and translucency according manufacturers, achieving aesthetic prosthetic reconstructions.

They can be used to make monolithic restorations such as veneers, inlays, onlays, endocrowns, anterior and posterior crowns. Bridges of small extent in anterior are only achievable with lithium disilicate.

These materials are available to achieve implant abutments, but there is not enough clinical evidence to confirm this indication. This type of material seems very promising.

The lithium disilicate cannot be considered as a bridge infrastructure ceramics, as well as zirconia, despite its mechanical properties because these indications are more limited. It can be used as an aesthetic ceramic on ceramic or metal frame.

Manufacturers

Different manufacturers offer this material (cf final tab), with a lot of shades and translucency.

Implementation and finish

According to the stage of crystallization of the block machined, the workpiece can require a post milling crystallization phase. Make-up and glazing can be realized before the heat treatment. Pre-crystallized can be bonded directly after machining, after a polishing step. If make-up is done, glaze firing is necessary despite the already crystallized stage.

Zirconia

Presentation

Zirconia has the particular property to change its crystallographic form under stress. The transition phase is accompanied by a substantial increase in volume sufficient to lead to a catastrophic failure. The transformation allows to stop crack propagation, leading to high toughness.[27-29]

The mechanical properties of zirconia are the highest ever reported for any dental ceramic. This may allow the realization of posterior FPD (Fixed Partial Denture) and permit a substantial reduction in core thickness. These capabilities are highly attractive, when strength and aesthetics are paramount.[29] However, due to its microstructure, this ceramic cannot be bonded with conventional techniques.

Chairside CAD/CAM zirconia blocks are yttrium cation-doped tetragonal zirconia polycrystals (3Y-TZP). The restorations are processed either by soft machining of pre-sintered blocks followed by sintering at high temperature, or by hard machining of fully sintered blocks.[30] However, only pre-sintered blocks can be milled by chairside milling units, less sophisticated than those used in laboratory. Restorations produced by soft machining are sintered at a later stage, this process prevents the stress-induced transformation from tetragonal to monoclinic and leads to a final surface virtually free of monoclinic phase unless grinding adjustments are needed or sandblasting is performe.[29]

Indications

Full zirconia restorations, milled chairside, are very recent. There is limited clinical experience on this kind of restoration. It seems possible to realize crowns or small bridges (maximum 3 items). The microstructure of this material does not allow a conventional bonding protocol. Currently, no consensus exists regarding the best adhesion protocol for zirconia used in dentistry. MDP-based resin cements tend to present higher results than those of other cements.[20]

For manufacturers, this material requires a support, having no sharp corners, to avoid the risk of fractures. *In vitro* studies show that the surface condition is the main factor of antagonist abrasion. A polished zirconia piece would not be more abrasive than other dental ceramics.[31]

However, the aesthetics of this material is limited by the low translucency due to its microstructure and the absence of glassy matrix, and the risk of breakage of the dental support due to its very high mechanical properties is significant.

However, some monolithic zirconia may present an acceptable degree of translucency.[26] Mean grain size influences translucency through the number of grain boundaries. Smaller grain sizes is leading to decreased translucency due to the larger number of grain boundaries. A larger grain size is therefore beneficial to mechanical properties but decreases the resistance to low-temperature degradation (LTD). The grain size is depending on sintering temperature and will also determine the amount of cubic phase and yttrium distribution, which has been shown to directly influence resistance to LTD.[32]

Implementation and finish

The prosthetic workpiece is machined slightly oversized to compensate the shrinkage during sintering. The computer software (CAD) manages the oversizing according to the information supplied by the manufacturers. This sintering lasts about 400 minutes in a sintering furnace that reach 1500°C. A glaze may then be necessary to characterize the prosthesis.

Resin

Different types of resins

There are 3 types of resins currently available (Fig. 3):
• PMMA
• Resin composite
• Nanoceramics

PMMA (polymethyl methacrylate)

Presentation

PMMA are composed of methyl methacrylate polymers without incorporation of fillers. This thermoplastic polymer is transparent. Pigments have been incorporated for use in dental technology.[33] The lack of fillers gives them a low mechanical strength.

Indications

PMMA are indicated to achieve temporary restorations for a period of 6 months to 1 year. Its tender structure permits an easy and fast milling, with a less wear of the milling burs.

Depending on manufacturers, PMMA are appropriate to realize every type of temporary prostheses (veneers, inlay/onlay, crown, bridge).

Resin composites

Presentation

There are materials composed of a matrix resin formed by monomers with incorporated inorganic fillers. Fillers improve the properties of resins. Mechanical and physical properties are favorably modified by the increase of the charge percentage. Shrinkage outlet is also reduced. Load size decrease improves the surface finish, aesthetics, and wears resistance.[34-36]

The polymerization of composite resins is never complete. Some monomers are free or partly linked to the chain. The conversion rate is the proportion of monomers that reacts to the total initial number of monomers. Machinable composite blocks have an industrial production (polymerization under pressure up to several thousand bars) and a thermal polymerization.[6,37] Conversion rate is then higher than 90% or even 95%. In comparison, a conventional chairside composite technique reaches a conversion of 50 - 60%.[38] In dental laboratory, the rate would be increased to 70 - 80%.[39-41]

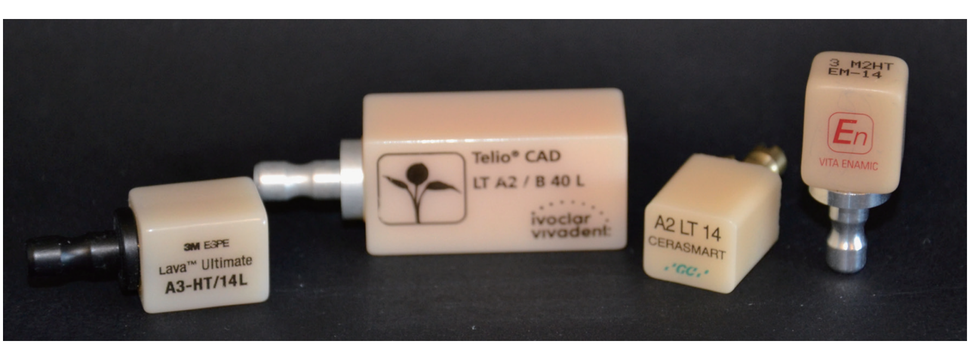

Fig. 3. Different types of resin blocks with different mandrels.

Indications

Actually, there is only one resin composite proposed for chairside CAD/CAM. This is a temporary restorative material, with a clinical wearing period up to 3 years. Its milling is easy and fast as for PMMA, but charges incorporated in the PMMA matrix allow greater mechanical resistance than "classic PMMA".

Veneers, inlay/onlay, anterior and posterior single crowns, as well as anterior and posterior bridges can be produced with this material. The flexural strength is 80 MPa.

Nanoceramics

Presentation

Nanoceramics and resin composite have the same microstructure but in different proportions. They have a polymeric matrix and a filler of ceramic nanoparticles about 80% of weight. Moreover, fillers have size less than 100 nm. These fillers may be composed of conventional ceramic, polycrystalline ceramic (zirconia), or a combination of both.

Indications

Nanoceramics have characteristics similar to the natural tooth, whether for flexure (usually close to 200 MPa), compression (380 MPa), and abrasion (around 2 to 10 microns per year). The elasticity is around 15 GPa. These characteristics indicate these materials for single tooth restoration or small bridges, preferably in the posterior area. Make-up makes a possible use in the anterior sector. However, the matrix is a polymer that will wear faster than the ceramic, making it more abrasive than antagonists compared to a traditional ceramics.

These materials are indicated for veneers, inlay/onlay, anterior and posterior single crowns, anterior and posterior bridges.

Implementation and finish

These materials can be machined easily with their soft matrix, and work pieces require no post-milling treatment, except the possible make-up photopolymerization. A conventional bonding protocol is achievable for this type of materials.

Note

However, the biocompatibility of materials containing resins is questionable, because possible release of monomers, as bisphenol-A.[42,43]

These materials can be repaired directly in case of fracture of the initial prosthetic component. Simply to make a surface treatment protocol (alumina air abrasion, mechanical abrasion...), applying bonding, and realize a direct composite.[44] This property is very interesting, especially for temporary restorations.

These materials are recent and there is only limited evidence of such material use. Some manufacturers gave some initial information and later on, after many failures reported by dentists, preferred to remove such data (3M, Lava Ultimate) or even remove the material from the market (3M, Paradigm MZ100).

PICN (Polymer-Infiltrated-Ceramic-Network material)

Presentation

The PICN material combines the properties of ceramic and polymer. It consists of a hybrid structure with two interpenetrating networks of ceramic and polymer, a so-called double network hybrid (DNH).[45] The fabrication process of this material requires two steps: first, a porous pre-sintered ceramic network is produced and conditioned by a coupling agent; second, this network is infiltrated with a polymer by capillary action.[46,47] Due to the fine structure of feldspar ceramic and the acrylate polymer network, this material has a similar abrasion, high flexural strength, and elasticity close to dentin.[45] PICN has better wear resistance compared to composite resins.[45,46] This material has good bonding ability through its microstructure. Work pieces can be thin, restoration will not present burst, the interpenetration of the phases prevents crack propagation in the material.[45]

Since this material is recent, long-term *in vivo* studies are still in progress. The shade range is limited and there is no information on the durability regarding cervical areas or discolorations. Nevertheless, novel PICN materials are promising and further research should be performed.[45]

Indications

PICN is indicated for veneers, inlay/onlay, anterior and posterior single crowns, as well as implant prosthesis. However, such material is more appropriate for posterior reconstructions due to the lack of gradient shades, the aesthetic result being obtained by make-up.

Implementation and finish

This new material is easily machinable with a good level of precision. Furthermore, its structure allows low burs wears of the milling unit. No post milling thermal treatment is required, and a simple make-up can be achieved before bonding.

Manufacturers

Actually, there is only one PICN material available, the VITA Enamic.

CONCLUSION

CAD/CAM monolithic restorations are fast and reliable.[2,5,48,49] The different block materials available allow the production of every type of prosthetic reconstruction (Table 1, Table 2, Table 3, Table 4). However, none of these materials seems to have ideal clinical properties for universal applications. Intense research efforts are under way to promote the strength, aesthetics, accuracy and an ability to reliably bond to dental substrates.

These materials are accomplished on a structural level. However, there is a low clinical experience on recent material, so a cautious use is necessary. Some materials offered few years ago have been withdrawn from the market due to a high failure rate. A practitioner must choose the milling unit adapted to his work habits and his favorite restorative materials. On the other hand, improvements are necessary to standardize the block spindle, but also to enhance speed milling and, post-milling treatment.

Table 1. Characteristics and indications of Chairside CAD/CAM ceramics

	Feldspathic and leucite-reinforced ceramics	Lithium disilicate and zirconium oxide and lithium silicate	Zirconia
Microstructure	Glassy matrix + crystalline loads (Feldspath, Leucite)	Glassy matrix + Lithium disilicate Zirconium oxide and lithium silicate	Polycristalline
Flexural strength	Low: 160 MPa before bonding	High: 370 à 420 MPa before bonding	Very high: 800 à 1200 MPa
Optic properties	Excellent	Good	Medium/Weak
Bonding aptitude	Excellent	Excellent	Medium/Weak
Indications	Veneer Chips Inlay Onlay Overlay Crown Endocrown V-Prep Endo V-Prep	Inlay Onlay Overlay Veneer Crown Endocrown V-Prep Endo V-Prep Bridge of small extent in the anterior Abutment	Crown Bridge
Advantage	Clinical experience Esthetic Wide range (shades) Translucidity	Clinical experience (e.max) Esthetic Mechanical strength Wide range (shades, translucidity)	Mechanical strength
Disadvantage	Relative fragility Translucidity	Less light than conventional feldspathic ceramic	Esthetic Translucidity Implementation
Available blocks	Mark II (Vita) Triluxe/ Triluxe Forte (Vita) Real Life (Vita) Cerec bloc/ Cerec PC (Sirona) Empress CAD (Ivoclar-Vivadent)	e.max CAD (Ivoclar-Vivadent) Suprinity/ Suprinity FC (Vita) Celtra (Dentsply)	Bruxzir (Bruxzir) YZ HT (Vita)

Table 2. Scientific data for chairside CAD/CAM ceramics

Ceramics	Blocks available	Biaxial strength (MPa)	CTE (.10^{-6}/K)	Young modulus	Density (g/cm^3)	Hardness Vickers
Feldspathic ceramics	VMII Triluxe/forte Cerec bloc	154 ± 15	9.4 ± 0.1	45 ± 0.5	2.44 ± 0.001	640 ± 20
Leucite-reinforced ceramic	Empress CAD	160	17.5	62	Not specified	6200 MPa
Lithium Disilicate ceramic	E.max CAD	Precrystallized: 130 ± 30 Crystallized: 360 ± 30	10.45 ± 0.4	95 ± 5	2.5 ± 0.1	Precrystallized: 5400 ± 200 Crystallized: 5800 ± 200
Lithium silicate and zirconium oxide ceramics	Suprinity Celtra duo	Approx. 540 Polished: 210 Glaze firing: 370	Approx. 12.3 11.8	Approx. 70 Approx. 70	Not specified 2.6	Approx. 7000 MPa 700
Zirconia	Bruxzir YZ HT	> 800 Approx 1200	11 Approx. 10.5	Not specified Approx. 210	6.05 Approx. 6.05	Not specified 12 GPa

Table 3. Characteristics and indications of Chairside CAD/CAM resins

	PMMA	Resin composite	Nanoceramic	PICN
Microstructure	Resin polymers	Inorganic fillers in resin matrix	Ceramic nanoparticles in resin matrix	Ceramic network infiltrate of polymer
Flexural strength	Very weak	Weak	Weak	Weak
Optical properties	Weak	Weak	Medium	Medium
Bonding aptitude	Excellent	Excellent	Excellent	Excellent
Indications	Temporary restorations: Inlay Onlay Veneer Crown Bridge of small extent	Temporary restorations: Inlay Onlay Veneer Crown Bridge of small extent	Inlay Onlay Overlay Veneer Crown (except Lava Ultimate) Bridge of small extent	Inlay Onlay Overlay Crown
Avantage	Speed of implementation Rapid milling Direct composite reparation	Speed of implementation Rapid milling Direct composite reparation	Speed of implementation Rapid milling Direct composite reparation Mechanical properties	Speed of implementation Rapid milling Mechanical properties
Disadvantage	Esthetic	Esthetic	Sustainability Esthetic +/-	Sustainability Esthetic
Available blocs	Telio CAD (Ivoclar-Vivadent) Sinergia block tempo Multi (Nobil Metal) Sintodent (Sentis)	CAD Temp mono/multicolor (Vita)	Ultimate (Lava) Cerasmart (GC) Ambarino High class (Creamed) Shofu block HC (Shofu)	Enamic (Vita)

Table 4. Scientific data for chairside CAD/CAM resins

	Block available	Biaxial strength (MPa)	CTE	Young Modulus (MPa)	Density	Hardness Vickers (MPa)	Water absorption (μg/mm^3)
PMMA	Telio CAD (Ivoclar-Vivadent)	130 ± 10	Not specified	3200 ± 300	Not specified	190 ± 5	< 28
	Sinergia block tempo multi (Nobil Metal)	> 100	Not specified	2200	Not specified	Not specified	22
	Sintodent (Sentis)	Not specified	Not specified	Approx. 2800	Not specified	Not specified	Not specified
Resin composite	CAD Temp (Vita)	> 80	Not specified	Approx. 15000	Not specified	Not specified	Complies with EN ISO 10 477 polymer based crown and bridges materials.
Nanoceramic	Ultimate (Lava)	204	Not specified	12770	Not specified	Not specified	Not specified
	Cerasmart (GC)	238	Not specified	Not specified	Not specified	Not specified	Not specified
	Ambarino High Class (Creamed)	191	Not specified	13812	Not specified	815	< 5
	Shofu block HC (Shofu)	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified
PICN	Enamic (Vita)	150-160	Not specified	30000	Not specified	2500	Not specified

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