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Review | Derleme

Resin Matrix Cad/ Cam Materials

Rezin Matriks Cad/ Cam Materyaller

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ABSTRACT

Objective: CAD/CAM stands for computer-aided design and computer-aided manufacturing. CAD/CAM systems are used to speed up the design and production process in dentistry. With three-dimensional design and milling, various restorations can be fabricated without the need for a physical model. It is possible to scan the oral cavity and take digital impressions. The restoration can be designed with the software's help and fabricated in a shorter time without laboratory stages. In addition, the mechanical strength and edge compatibility of the restorations are improved and the fabrication of aesthetic restorations is aimed. CAD/CAM technology offers advantages such as time savings, elimination of potential errors, ease of use, and treatment quality. With the increasing demand for CAD/CAM restorations, various materials have been developed.

Conclusion: Nowadays, CAD/CAM materials are widely available on the market and restorations can be produced from prefabricated blocks and discs. In this review, resin matrix CAD/CAM materials, which are relatively new on the market and claimed to have some positive properties for dental restorations, are described.

Key Words: CAD/CAM, Nanoceramic, Hybrid, Resin Matrix.

ÖZ

Giriş: CAD/CAM, bilgisayar destekli tasarım ve bilgisayar destekli üretim anlamına gelmektedir. Diş hekimliğinde tasarım ve üretim sürecini hızlandırmak için CAD/CAM sistemleri kullanılmaktadır. Üç boyutlu tasarım ve frezeleme ile fiziksel bir modele ihtiyaç duymadan çeşitli restorasyonlar üretilebilmektedir. Ağız boşluğunu taramak ve dijital ölçü almak mümkündür. Restorasyon, yazılım vasıtasıyla tasarlanır ve laboratuvar aşaması olmadan daha kısa sürede üretilebilir. Ayrıca restorasyonların mekanik dayanımı ve kenar uyumluluğu iyileştirilir ve estetik restorasyonların üretilmesi amaçlanır. CAD/CAM teknolojisi zaman tasarrufu, olası hataların ortadan kaldırılması, kullanım kolaylığı ve tedavi kalitesi gibi avantajlar sunmaktadır. CAD/CAM restorasyonlarına yönelik artan talep ile birlikte çeşitli materyaller geliştirilmiştir.

Sonuç: Günümüzde CAD/CAM malzemeleri piyasada yaygın olarak bulunmaktadır ve prefabrike bloklardan ve disklerden restorasyonlar üretilebilmektedir. Bu derlemede piyasada nispeten yeni olan ve dental restorasyonlar için bazı olumlu özelliklere sahip olduğu iddia edilen rezin matriks CAD/CAM materyaller anlatılmaktadır.

Anahtar Kelimeler: CAD/CAM, Nanoseramik, Hibrit, Rezin Matriks.

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INTRODUCTION

The introduction of digital technologies in dentistry and the development of mechanical and aesthetic properties of materials are leading to changes in restorative dentistry. With CAD/CAM systems, aesthetic restorations in natural tooth color can be fabricated in a single session without the need for a temporary restoration. This eliminates wasted time for both the dentist and the patient (1). Digital scanners eliminate the need for conventional impressions (2). Greater efficiency and convenience are provided compared to the conventional method (3). CAD/CAM restorations provide adequate marginal adaptation (4). Plaque accumulation and caries development are reduced (5). Since the laboratory stages of traditional ceramic production are also eliminated, restoration can be fabricated faster and easier (1). The error rate is lower than traditional methods (6). The risk of cross-infection is lower because most of the stages of the traditional method are omitted (2,7). Standard plaster models are difficult to store for an extended period. Digital models created with CAD/CAM systems can be stored on a computer (8).

Long-term restorations can be fabricated with CAD/CAM systems (6). In dental laboratories, the technicians' work is also made easier as dies and restorations are created with CAD software (9). All these advantages of CAD/CAM technology are reflected in patient satisfaction and long-term restoration success. CAD/CAM technology enables the fabrication of dental restorations such as crowns, veneers, bridges, inlays, onlays, endo crowns, and implant-supported restorations (10-12).

Although CAD/CAM technology offers numerous opportunities, the cost of materials, equipment, and software is still considered high (13). The need for training, time, and money to use the CAD/CAM system increases the cost (6). Aesthetic restorations could not be achieved with monochromatic blocks that came on the market in the early days. Nowadays, more aesthetic restorations can be achieved with polychromatic blocks in different shades (13). With CAD/CAM systems, a clear digital measurement of the tooth to be restored as well as surrounding teeth and tissues should be made. As in the traditional method, gingival retraction is required to scan the subgingival areas (14). In addition, the size of the block limits the milling of restorations that exceed their size (15).

With the increasing demand for CAD /CAM restorations, various materials have been developed to provide durable and aesthetic restorations with high biocompatibility (16). The survival rate of CAD/CAM restorations may vary with different material types. One material type may not be suitable for all clinical applications. In addition, selecting the best material can be confusing for the practitioner due to the variety on the market. Mechanical limitations in the fabrication of CAD/CAM restorations are also very important. Subtractive machining can lead to strength limitation as well as surface and subsurface damage to restorations (17).

In addition, the material properties influence the clinical outcome of the restoration. The different types of dental ceramics differ in their chemical composition, manufacturing process, and structure. These materials can be divided into 3 groups: resin matrix ceramics, silicate ceramics, and oxide ceramics (18).

1. RESIN MATRIX CAD/CAM MATERIALS

This review focuses mainly on resin matrix CAD/CAM materials. Resin matrix CAD/CAM materials are relatively new to the market. These materials are claimed to have some positive properties for dental restorations. Compared to glass-ceramics, resin matrix ceramics exhibit higher resilience and modulus of elasticity (19). They exhibit optical properties similar to those of natural teeth. These materials can be repaired in the mouth with light-cured composites and can be fabricated more quickly because no sintering is required (20). Resin matrix CAD/CAM materials can be divided into several subgroups. We can summarize resin matrix materials as resin-based materials and hybrid ceramics (21). Resin matrix CAD/CAM materials are categorized in Figure 1 and a summary of resin matrix CAD/CAM materials is presented in Table 1.

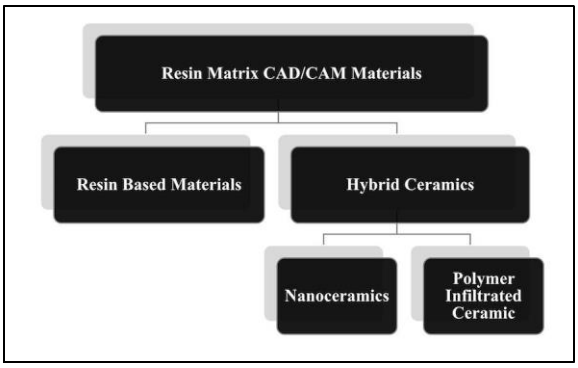

Figure 1. Categorized of Resin Matrix CAD/CAM Materials.

Resin Based Materials	Composite Resin	**Paradigm MZ100**	Bis-GMA, TEGDMA, zirconium-silica filler	%85	3M
		Brilliant Crios	Cross-linked methacrylates, barium glass, SiO_2, inorganic pigments (ferrous oxide or titanium dioxide)	%70.7	Coltene/Whaledent
		Grandio Block	Barium aluminium borosilicate glass, SiO_2, polymethacrylate, stabilisers, pigments	%86	Voco
		LuxaCam composite	Polymer, silicate glass	%70	DMG Fabrik
		Tetric CAD	Bis-GMA, Bis-EMA, TEGDMA, UDMA, barium aluminum silicate glass, SiO_2	%71.1	Ivoclar Vivadent
Hybrid Ceramics	**Nanoceramics**	**Lava Ultimate**	SiO_2, ZrO_2, Si/ZrO_2 cluster	%80	3M
		Cerasmart	Bis-MEPP, UDMA DMA, SiO_2, barium glass	%71	GC Corporation
		Shofu Block HC	UDMA, TEGDMA, silica powder, zirconium silicate, pigments and others	%61	Shofu
		Mazic Duro	Bis-GMA, TEGDMA, silica, Ba-glass, ZrO_2	%80	Vericom co.
		Avencia Block	Copolymer of UDMA, other methacrylate monomers, SiO_2, Al_2O_3, and pigments	%62	Kuraray Noritake Dental
	PICN	**Enamic**	UDMA, TEGDMA, SiO_2, Al_2O_3, Na_2O, K_2O, B_2O_3, CaO, TiO_2	%86	Vita Zahnfabrik

Table 1. Summary of resin matrix CAD/CAM materials presented in the study.

1.1. RESIN-BASED MATERIALS (RESIN COMPOSITE MATERIALS)

Simultaneously with the widespread use of ceramic blocks used with CAD/CAM systems, significant advances have been made in composite resin technology with the development of nanofill and nanohybrid composite resins. Therefore, CAD/CAM resin composite blocks are also now widely used. Composites consist of at least two materials that have the properties as each. Resin composite blocks are fabricated by heat polymerization. These blocks are formed by transferring the filler to a monomer mixture (22). In the production of composite blocks significantly increases the monomer conversion rate and reduces polymerization shrinkage compared to light-cured composites. In this way, more homogeneous restorative materials are obtained and the irregularities and pores that can occur in the material structure are reduced (23). In addition, the inorganic filler content in composite blocks can be increased to a greater extent than indirect composites (24).

cate and repair than ceramic blocks (25). Long-term temporary restorations can also be made from composite blocks. These materials cause less wear on the antagonist tooth and absorb masticatory forces in implant-supported restorations and patients with bruxism. They are easy to repair because they can be repaired directly in the mouth with composite materials. They do not need to be sintered like ceramic materials and can be applied in a single session (23).

Paradigm MZ100

Paradigm MZ100 Block (3M ESPE, Rüschlikon, Switzerland) was developed from 3M Z100 composite resin material, which was introduced to the market in 2000 and is the first composite block (23). The organic matrix is composed of Bis-GMA and TEGDMA. It contains 85 wt% of a filler of silica-zirconia (0.6 µm). The reported flexural strength for Paradigm MZ100 is 157 MPa (26). The most important advantage of this material is its superior milling properties (27). The wear characteristics are similar to natural teeth. It is suitable for inlay, onlay, veneer, and crown restorations. It is available in one size (14) and six shade options. Adhesive resins are recommended for cementing restorations. They can be fitted directly in the patient's mouth, polished, and repaired with hybrid composites (28).Awada et al. (26), reported that the flexural strength of Paradigm MZ100 was similar to feldspathic ceramic materials. In addition, similar values for margin edge roughness were detected for Cerasmart, Lava Ultimate, Paradigm MZ100, and Vita Enamic in this study.

Brilliant Crios

Brilliant Crios (Coltene AG; Altstatten, Switzerland) is a reinforced composite CAD/CAM block used for the fabrication of permanent indirect restorations. It consists of barium glass (<1.0 µm), amorphous silica (<20nm), crosslinked methacrylate resin matrix, and pigments. Its mechanical properties are obtained by heat polymerization. Its modulus of elasticity (10 GPa) is close to dental tissues and its flexural strength is 250 MPa. Its dentin-like modulus of elasticity offers advantages such as minimizing stress formation, preventing fractures, and making the material suitable for implant-supported restorations. The material causes low wear on the antagonist tooth and has high wear resistance. This composite block can be used production of crowns, inlays, onlays, veneers, and implant-supported crowns in the anterior and posterior regions. It is available as blocks (12/14) and discs (H14/H18). Fifteen shades and three translucency options are available. It does not require sintering and can be easily modified and repaired. It can be precisely milled and fine margins can be achieved. It can be polished intraorally or extraorally with composite polishing agents or polishing paste (29).

Reymus et al. (30), reported that indirect Brilliant Crios restorations should be sandblasted and pretreated with a methyl-methacrylate-containing primer for adhesive cementation. In the study by Papadopoulos et al. (31), similar micro-tensile bond strength values were observed for Brilliant Crios, Shofu Block HC, Lava Ultimate, and Vita Enamic after artificial aging.

Grandio

Grandio Blocks (VOCO GmbH, Germany) is a nano-hybrid composite CAD/CAM restorative material with a high filler content (86%). It has a similar coefficient of thermal expansion to dentin and enamel. Its flexural strength is 250–290 MPa and its modulus of elasticity is 15.5 GPa (21). It is indicated for inlay, onlay, veneer, crown, and implant-supported crown restorations. Grandio is available in blocks (12 and 14L) and disc (H15). HT and LT blocks are available in four and seven shades, respectively. It does not require sintering. Fine margins can be achieved. It can be optimally polished with composite polishes, either intraorally or extraorally (32).

In the study by Sarahneh et al. (33), the highest bond strength values among resin matrix ceramic materials were observed for Grandio block and KZR CAD HR2. The application of only silane agent did not improve the bond strength. However, the bond strength values were increased with the application of universal adhesives for the resin matrix ceramic materials.

LuxaCam Composite

LuxaCam Composite (DMG, Hamburg, Germany) consists of a polymer matrix in which silicate glass fillers are embedded. The ratio between organic and inorganic materials has been optimized so that the mechanical properties of the composite material are close to the natural tooth. The modulus of elasticity (10.1 GPa) and flexural strength (164 MPa) of LuxaCam are very close to dentin (21). In this way, excessive wear and damage to the teeth of the opposing jaw can be prevented. Suitable for patients with bruxism. Indicated for veneers, inlays, onlays, partial crowns, full crowns, and bridges (up to three units). It is available as a block (19) and discs (H15/H20). They are available in seven shades. Sintering is not required. It has an aesthetic appearance and good polishing properties. It provides stable edges and smooth surfaces. The manufacturer recommends pre-treatment of the surface with primers and adhesive cementation with a dual-cure or self-cure adhesive resin (34).Winter et al. (35), reported that the flexural strength and fracture resistance of LuxaCam Composite material are adequate for use in the first molar region.

Tetric CAD

Tetric CAD/CAM Block (Ivoclar Vivadent AG, Schaan, Liechtenstein) is an esthetic composite block for the fabrication of single-tooth restorations. Tetric CAD consists of a mixture of crosslinked dimethacrylate and inorganic fillers. The organic matrix consists of Bis-GMA, Bis-EMA, TEGDMA, and UDMA. 71.1 wt% of the composite material consists of barium aluminum silicate glass with an average particle size <1 µm and silicon dioxide with an average particle size <20 nm. The fillers reinforce the resin matrix, provide translucency, and control polymerization shrinkage. Glass fillers provide low wear and high gloss. The flexural strength was reported to be 273.8 MPa and the modulus elasticity

10.2 GPa.[21] The material is produced industrially and then milled. After milling, it can be polished intraorally and cemented with adhesive resins. It is indicated for veneers, inlays, onlays, and crown restorations in the anterior and posterior regions. Tetric CAD/CAM block is available in two sizes (I12 and C14) and two translucency options (MT and HT). MT and HT blocks are available in five and four shades, respectively. It is not suitable for self-adhesive resins or conventional cementation. The chameleon effect blends well with the surrounding teeth. The stability of the material allows for minimal wall thickness and minimally invasive preparation techniques. It can be repaired intraorally with composite resin materials (36).

Fouquet et al. (37), reported that sandblasting was the most effective treatment for Tetric CAD and the application of universal primer did not increase the shear bond strength values for this material. In the study by Rosentritt et al. (38), crowns fabricated from Tetric CAD had significantly higher fracture forces than crowns fabricated from nanoceramic materials. In the study by Niem et al. (39), it was observed that the thermocycling process had no effect on the resilience and toughness properties of Tetric CAD.

1.2. HYBRID MATERIALS

Although the variety of materials achieved in dental ceramics and composite resins is great with the development of today's technology, both groups have advantages and disadvantages. Besides the advantages of ceramics, such as flexural strength and color stability, there are also disadvantages, such as wear of the antagonist tooth and a minimum preparation of 1.5-2 mm. These undesirable properties are less with composite materials. However, composite materials wear more against natural teeth. Therefore, the search continues for materials that exhibit similar wear to dental structures (40). Hybrid ceramics are a category of CAD/CAM materials developed to take advantage of the lower brittleness of composite materials and the aesthetic properties of ceramic materials. It consists of two different groups: Nanoceramic and Polymer Infiltrated Ceramic Network (PICN).

1.2.1. Nanoceramics

Nanotechnology has a wide range of applications in dentistry. This technology was first used to improve the physical properties of materials, and thus new restorative materials were developed (41). By using nanomaterials, the properties of dental materials can be changed. The addition of nanoparticles can improve the optical, chemical, and mechanical properties of dental materials. Nanoparticles are added to composite materials to fill the space between larger filler particles and reduce the resin content (42). Nanoceramic materials have a similar modulus of elasticity to dentin. Therefore, nanoceramic materials absorb stresses better than glass-ceramics. The shock absorption properties lead to more successful results in implant-supported restorations than glass-ceramics (43). Nanoceramics are the most suitable materials for aesthetic restorations. Nano-sized zirconia and silica particles reduce light scattering and provide high translucency to the material (44). In addition, nanoparticles improve tensile and compressive strength. Thus, secondary caries are reduced by eliminating microleakage (45).

Lava Ultimate

The structure of Lava Ultimate (3M ESPE, St Paul, MN, USA) is based on the polymerizable composite resin Filtek Supreme Ultra (3M). This material contains silica particles with a diameter of 20 nm and zirconia particles with a diameter of 4-11 nm embedded in the resin matrix containing UDMA in agglomerated and non-agglomerated form (80% by weight) (46). The addition of silane to the structure during fabrication provides a chemical bond between the ceramic particles and the resin matrix. The ceramic structure predominates in this material. Its hybrid structure is not as fragile as ceramics but also has an aesthetic appearance like glass-ceramics (43,47). It is indicated for use in inlay, onlay, and veneer restorations. It is available in high and low translucency options. HT and LT blocks are available in eight shades and two sizes (12 and 14L) (48).

The nanoparticle structure makes the material more resistant to breakage and abrasion. It has a flexural strength of 200 MPa and a dentin-like modulus of elasticity of 15 GPa. Thanks to its high flexural strength, it can also be used at lower thicknesses. It causes less abrasion to the opposing enamel than glass-ceramics. However, the polymer structure of the material causes it to wear more quickly than glass-ceramics (40). It is polymerized with high heat during fabrication, so no sintering is required after milling. This allows the restoration to be completed in a single session. The milling, adjustment, and polishing stages are easier. Polishing can be performed with rubber burs and polishing paste. After the restorations are fabricated, the characteristic features can be obtained intraorally or extraorally. Adjustments and repairs can be made with light-curing materials (48).

Fasbinder et al. (49), reported that adhesive retention of Lava Ultimate onlays using the self-etch or totaletch cementation technique resulted in a similar clinical outcome after 5 years of clinical service. In addition, Lava Ultimate onlays exhibited a lower incidence of fracture compared to leucite-reinforced ceramic onlays. In a recent study, the silane-containing universal adhesive materials were found to improve the bond strength of Lava Ultimate CAD/CAM material (50). In another study, it has been observed that only silane primer application to CAD/CAM resin composite materials resulted in inadequate adhesion (51). In the study by Venturini et al. (52), Lava Ultimate demonstrated the best fatigue performance compared to polymer-infiltrated network ceramic and glass-ceramics.

Cerasmart

Cerasmart CAD/CAM Block (GC Corp., Tokyo, Japan) is a high-strength nanoceramic hybrid material with ultrafine glass particles. It has a homogeneous and evenly dispersed ceramic network. Cerasmart contains 71% by weight silica (20 nm) and barium glass (300 nm) nanoparticle filler (44). It exhibits wear properties similar to natural teeth. Its modulus of elasticity is 7.5 GPa. Its flexural strength is 220-240 MPa (53). After milling, precise and smooth margins are obtained without chipping. It is suitable for implant-supported restorations, as its high filler ratio increases flexural strength and fracture resistance. This material can be used in patients with bruxism as it is abrasion resistant in the long term (54). It is available in high and low translucency. It is available in five shades and three sizes (12, 14, 14L). While HT blocks are indicated for inlay, onlay, veneer, and partial and full crown restorations LT blocks are indicated for masking discolored teeth and for partial crown restorations. It does not require sintering and glazing, can be easily polished manually, and characteristic features can be created and repaired intraorally (55).

Canatan et al. (56), reported that self-adhesive and dual-cure resin cement systems showed acceptable clinical performance in the cementation of indirect Cerasmart restorations. Coşkun et al. (53), reported that Cerasmart onlays exhibited acceptable marginal integrity, similar to the lithium disilicate glass-ceramic tested in the posterior region.

Shofu Block HC

Shofu Block HC (Shofu Inc., Kyoto, Japan) has a hybrid ceramic structure. It is characterized by a resin matrix based on UDMA and TEGDMA-based. This material is composed of 61% zirconium silicate nanofillers (23).

The skeletal structure increases the strength and resistance of the material by absorbing masticatory forces. Thin restorations can be fabricated as it has adequate durability. It can be milled and polished quickly and precisely in a short time, and the restoration can be fitted and bonded immediately (43). It has a flexural strength of 191 MPa. Its modulus of elasticity is 7.8 GPa (21). Its Vickers hardness is 66 Hv0.2, so it can be used for anterior and posterior restorations, implant-supported crowns, and long-term temporaries. Thanks to its high flexural strength and low flexural modulus, it can disperse stresses in the restoration, and this property makes the material an alternative to lithium disilicate and zirconia. Since the hardness of the material is close to the dentin, the wear that may occur on antagonist teeth is acceptable. It can be used for the restoration of aesthetic anterior teeth as it has enamel-like translucency. It can be milled quickly, has good marginal integrity, and does not require sintering; therefore, the digital workflow is simple. It is one of the materials that can be repaired intraorally. This material is indicated for the anterior and posterior crown, inlay, onlay, veneer, and implant-supported crown restorations. It has high and low translucency and is available in small and medium sizes. HT and LT blocks are available in three and six shades, respectively (57).
In a recent study, methyl-methacrylate-containing primer was found to provide stronger adhesion to Shofu Block HC than a silane application after prolonged aging (58). In the study by Şişmanoğlu et al. (50), it was reported that the silane-containing universal adhesive materials improved the bond strength values for Shofu Block HC CAD/CAM material.

Mazic Duro

Mazic Duro (Vericom, co., Gangwon-do, Korea) has a polymeric matrix structure consisting of highly crosslinked monomers. It consists of approximately 80% ceramic fillers (silicate, zirconia) and 20% resin matrix. The high-density resin matrix provides elasticity, easy workability, strength, stain resistance, and aesthetics. This material is indicated for single tooth restorations such as inlays, onlays, veneers, and full crowns. Mazic Duro Block is available in three sizes (10, 12, and 14L), two translucency options (HT and LT), and nine shades. Sintering and glazing are not required (59).In the study by Yin et al. (60), it was detected the biaxial flexural strength of Mazic Duro was significantly higher than that of polymer infiltrated ceramic. In addition, Mazic Duro demonstrated less abrasion on the opposing tooth than polymer infiltrated ceramic material.

Avencia Block

Avencia Block (Kuraray, Noritake, Dental) is a hybrid ceramic containing a methacrylate resin matrix (UDMA and other methacrylate monomers) and inorganic nanofillers (silica and aluminum filler) (21). The nanofillers are densely compacted and then homogeneously impregnated with the resin matrix. Then they are polymerized by heat treatment. It has excellent mechanical strength, wear resistance, polishability, polish retention, and gloss protection. The manufacturer reported flexural strength of 230 MPa and compressive strength of 680 MPa. Recommended indications are inlays, onlays, crowns for pre-molar, anterior crowns, posterior crowns, and 3-unit bridge restorations. Avencia Block is available in two sizes (12 and 14L), three shades, and LT translucency (61). Hagino et al. (62), reported that the combination of the silane agent and resin primer advanced the bonding effectiveness of Avencia Block. In the study by Okada et al. (63), it was reported that crowns fabricated from Avencia Block showed fracture strength approximately 3-4 times higher than the average maximum bite force of molars.

1.2.2. Polymer Infiltrated Ceramic (PINC)

The development of polymer infiltrated ceramic blocks was an attempt to combine the positive properties of ceramics and composites. The ceramic framework, which predominates in these block structures, is reinforced by a fully interlocking polymer network (64). The polymer in the structure is surface-modified PMMA (polymethyl methacrylate). The polymer network reduces the propagation of cracking often observed in ceramic materials. This results in an increase in the fracture strength of the restoration compared to ceramics (40,47,64). The fabrication of polymer infiltrated ceramic under high pressure and temperature resulted in a higher volume of fillers and higher conversion rates than indirect composite resins. Therefore, the mechanical properties have improved significantly (65).

Enamic

Enamic (VITA, BadSäckingen, Germany) has a polymer infiltrated ceramic structure. The hybrid structure combines the beneficial properties of ceramics and composites. The ceramic structure constitutes 75% by volume and 86% by weight of the material. In this dental material, the predominant fine-grained ceramic network is reinforced by a polymer network, and both networks are fully integrated. The ceramic component increases wear resistance but make the material more brittle. The polymer network increases fracture resistance. Its modulus of elasticity (30 GPa) is close to dentin. It has a flexural strength of 150-160 MPa. It exhibits lower brittleness than ceramics and lower wear than composite resins. Compared to glass-ceramics, it is possible to mill reduced wall thickness. This provides the possibility of manufacturing implant-supported restorations. It is a suitable material for minimally invasive restorations. Perfect marginal fit is achieved through accurate milling. This material can be easily polished manually and exhibits polished surfaces comparable to ceramic materials. Enamic has optimum flexibility, stress resistance, and light conductivity. When cemented with adhesive or self-adhesive resins, it can be used to fabricate fully anatomical, aesthetic single-tooth restorations. It is indicated for anterior and posterior crowns, inlays, onlays, partial crowns, veneers, and implant-supported crowns. Anatomically sensitive restorations can be achieved. Available in mono-color and multi-color types with three levels of translucency. It is available as blocks (EM-14 and EM-10) and discs (H12 and H18). Enamic HT and T blocks are available in ten shades. Enamic ST and Enamic multi-color HT blocks are available in five shades (66).

In a recent study, it was observed that the silane-containing universal adhesive materials improved the bond strength values for Enamic CAD/CAM material (50). In the study by Lucsanszky et al. (67), Enamic showed the highest values for flexural modulus and aged fracture toughness among the resin composites, but the lowest flexural strength. In another study, it was reported that the volumetric wear of Vita Enamic was similar to lithium disilicate glass-ceramic but higher than zirconia material (68).

CONCLUSION

This review presents the resin matrix CAD/CAM materials, their characterization, and their mechanical and clinical properties. There are a wide variety of resin matrix CAD/CAM materials on the market. Choosing the right material requires experience. Restorations should always be planned individually. The material properties should be matched to the individual needs of the patient. The choice of the right material also affects the clinical success of restorations. Today, CAD/CAM systems still provide advanced dental restorations in dentistry. At the same time, clinical research continues to develop dental materials with superior properties.

REFERENCES

1. Mörmann WH, Brandestini M, Lutz F, Barbakow F. Chairside computer-aided direct ceramic inlays. Quintessence Int. 1989; 20:329-339.

2. Duret F, Preston JD. CAD/CAM imaging in dentistry. Curr Opin Dent. 1991;1:150-154.

3. Gjelvold B, Chrcanovic BR, Korduner EK, Collin-Bagewitz I, Kisch J. Intraoral digital impression technique compared to conventional impression technique. A randomized clinical trial. J Prosthodont. 2016; 25:282-287.

4. Papadiochou S, Pissiotis AL. Marginal adaptation and CAD-CAM technology: A systematic review of restorative material and fabrication techniques. J Prosthet Dent. 2018; 119:545-551.

5. Zimmermann M, Koller C, Reymus M, Mehl A, Hickel R. Clinical evaluation of indirect particle-filled composite resin CAD/CAM partial crowns after 24 months. J Prosthodont. 2018; 27:694-699.

6. Santos GC, Santos MJ, Rizkalla AS, Madani DA, El-Mowafy O. Overview of CEREC CAD/CAM chairside system. Gen Dent. 2013; 61:36-41.

7. Liu PR. A panorama of dental CAD/CAM restorative systems. Compend Contin Educ Dent. 2005; 26:507-527.

8. Birnbaum NS, Aaronson HB. Dental impressions using 3D digital scanners: virtual becomes reality. Compend Contin Educ Dent. 2008; 29:494-505.

9. Feuerstein P. Can technology help dentists deliver better patient care? J Am Dent Assoc. 2004; 135 Suppl:11-16.

10. Duret F, Blouin JL, Duret B. CAD-CAM in dentistry. J Am Dent Assoc. 1988; 117:715-720.

11. Mörmann WH. The origin of the Cerec method: a personal review of the first 5 years. Int J Comput Dent. 2004; 7:11-24.

12. Vichi A, Sedda M, Siena F, Louca C, Ferrari M. Flexural resistance of Cerec CAD/CAM system ceramic blocks. Part 1: Chairside materials. Am J Dent. 2013; 26:255-259.

13. Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. Dent Clin North Am. 2011; 55:559-570.

14. Henkel GL. A comparison of fixed prostheses generated from conventional vs digitally scanned dental impressions. Compend Contin Educ Dent. 2007; 28:422-431.

15. Saponaro PC, Yilmaz B, Heshmati RH, McGlumphy EA. Clinical performance of CAD-CAM-fabricated complete dentures: A cross-sectional study. J Prosthet Dent. 2016; 116:431-435.

16. Li RWK, Chow TW, Matinlinna JP. Ceramic dental biomaterials and CAD/CAM technology: State of the art. J Prosthodont Res. 2014; 58:208-216.

17. Romanyk DL, Martinez YT, Veldhuis S, Rae N, Guo Y, Sirovica S, et al. Strength-limiting damage in lithium silicate glass-ceramics associated with CAD-CAM. Dent Mater. 2019; 35:98-104.

18. Ruse ND, Sadoun MJ. Resin-composite blocks for dental CAD/CAM applications. J Dent Res. 2014; 93:1232-1234.

19. Blatz MB, Conejo J. The current state of chairside digital dentistry and materials. Dent Clin North Am. 2019; 63:175-197.

20. Kuijper M, Gresnigt M, Kerdijk W, Cune MS. Shear bond strength of two composite resin cements to multiphase composite resin after different surface treatments and two glass-ceramics. Int J Esthet Dent. 2019; 14:40-50.

21. Marchesi G, Camurri Piloni A, Nicolin V, Turco G, Di Lenarda R. Chairside CAD/CAM materials: Current trends of clinical uses. Biology. 2021; 10:1170.

22. Alamoush RA, Kushnerev E, Yates JM, Satterthwaite JD, Silikas N. Response of two gingival cell lines to CAD/CAM composite blocks. Dent Mater. 2020; 36:1214-1225.

23. Lauvahutanon S, Takahashi H, Shiozawa M, Iwasaki N, Asakawa Y, Oki M, et al. Mechanical properties of composite resin blocks for CAD/CAM. Dent Mater J. 2014; 33:705-710.

24. Mainjot AK, Dupont NM, Oudkerk JC, Dewael TY, Sadoun MJ. From artisanal to CAD-CAM blocks: State of the art of indirect composites. J Dent Res. 2016; 95:487-495.

25. Nguyen JF, Migonney V, Ruse ND, Sadoun M. Resin composite blocks via high-pressure high-temperature polymerization. Dent Mater. 2012; 28:529-534.

26. Awada A, Nathanson D. Mechanical properties of resin-ceramic CAD/CAM restorative materials. J Prosthet Dent. 2015; 114:587-593.

27. Rusin RP. Properties and applications of a new composite block for CAD/CAM. Compend Contin Educ Dent. 2001; 22:35-41.

28. 3M™ Paradigm™ MZ100 Blocks for CEREC® | 3M United States. Accessed September 5, 2022. https://www.3m.com/3M/en_US/p/d/b00008160/

29. Brilliant Crios. Accessed September 5, 2022. https://global.coltene.com/products/restoration/cadcam-solutions/brilliant-crios/

30. Reymus M, Roos M, Eichberger M, Edelhoff D, Hickel R, Stawarczyk B. Bonding to new CAD/CAM resin composites: influence of air abrasion and conditioning agents as pretreatment strategy. Clin Oral Investig. 2019; 23:529-538.

31. Papadopoulos C, Dionysopoulos D, Pahinis K, Koulaouzidou E, Tolidis K. Microtensile bond strength between resin-matrix CAD/CAM ceramics and resin cement after various surface modifications and artificial aging. J Adhes Dent. 2021; 23:255-265.

32. Grandio blocs - CAD / CAM Material | VOCO GmbH.AccessedAugust8,2022.https://www.voco.dental/en/products/indirectrestoration/cadcammaterial/grandio-blocs.aspx

33. Sarahneh O, Günal-Abduljalil B. The effect of silane and universal adhesives on the micro-shear bond strength of current resin-matrix ceramics.J Adv Prosthodont. 2021; 13:292-303.

34. LuxaCam Composite. DMG - High quality dental materials for dentists and dental technicians. Accessed August6,2022.https://www.dmgdental.com/en/products/product/luxacam-composite/

35. Winter A, Schurig A, Rasche E, Rösner F, Kanus L, Schmitter M. The flexural strength of CAD/CAM polymer crowns and the effect of artificial ageing on the fracture resistance of CAD/CAM polymer and ceramic single crowns. J Mater Sci Mater Med. 2019; 31:9.

36. Tetric CAD : Ivoclar. Accessed September 5, 2022. https://www.ivoclar.com/en_li/products/digitalprocesses/tetric-cad.

37. Fouquet V, Lachard F, Abdel-Gawad S, Dursun E, Attal JP, François P. Shear bond strength of a direct resin composite to CAD-CAM composite blocks: relative contribution of micromechanical and chemical block surface treatment. Materials. 2022; 15:5018.

38. Rosentritt M, Krifka S, Strasser T, Preis V. Fracture force of CAD/CAM resin composite crowns after in vitro aging. Clin Oral Investig. 2020; 24:2395-2401.

39. Niem T, Youssef N, Wöstmann B. Influence of accelerated ageing on the physical properties of CAD/CAM restorative materials. Clin Oral Investig. 2020; 24:2415-2425.

40. Coldea A, Swain MV, Thiel N. Mechanical properties of polymer-infiltrated-ceramic-network materials. Dent Mater. 2013; 29:419-426.

41. Atabek D, Sillelioglu H, Olmez A. The efficiency of a new polishing material: nanotechnology liquid polish. Oper Dent. 2010; 35:362-369.

42. Schmalz G, Hickel R, Landuyt KL, Reichl FX. Nanoparticles in dentistry. Dent Mater. 2017; 33:1298-1314.

43. Fasbinder DJ. Chairside CAD/CAM: an overview of restorative material options. Compend Contin Educ Dent. 2012; 33:50-58.

44. Kurtulmus-Yilmaz S, Cengiz E, Ongun S, Karakaya I. The effect of surface treatments on the mechanical and optical behaviors of CAD/CAM restorative materials. J Prosthodont. 2019; 28:e496-e503.

45. Bapat RA, Joshi CP, Bapat P, Chaubal TV, Pandurangappa R, Jnanendrappa N, et al. The use of nanoparticles as biomaterials in dentistry. Drug Discov Today. 2019; 24:85-98.

46. Eldwakhly E, Ahmed DRM, Soliman M, Abbas MM, Badrawy W. Color and translucency stability of novel restorative CAD/CAM materials. Dent Med Probl. 2019; 56:349-356.

47. Gracis S, Thompson VP, Ferencz JL, Silva NR, Bonfante EA. A new classification system for all-ceramic and ceramic-like restorative materials. Int J Prosthodont. 2015; 28:227-235.

48. 3M™ Lava™ Ultimate CAD/CAM Restorative for CEREC® | 3M United States. Accessed August 3,2022.https://www.3m.com/3M/en_US/p/d/b00008161/

49. Fasbinder DJ, Neiva GF, Heys D, Heys R. Clinical evaluation of chairside Computer Assisted Design/Computer Assisted Machining nano-ceramic restorations: Five-year status. J Esthet Restor Dent. 2019; 1–11.

50. Sismanoglu S, Yildirim-Bilmez Z, Erten-Taysi A, Ercal P. Influence of different surface treatments and universal adhesives on the repair of CAD-CAM composite resins: An in vitro study. J Prosthet Dent. 2020; 24:238.e1-238.e9.

51. Reymus M, Roos M, Eichberger M, Edelhoff D, Hickel R, Stawarczyk B. Bonding to new CAD/CAM resin composites: influence of air abrasion and conditioning agents as pretreatment strategy. Clin Oral Investig. 2019; 23:529-538.

52. Venturini AB, Prochnow C, Pereira GKR, Segala RD, Kleverlaan CJ, Valandro LF. Fatigue performance of adhesively cemented glass-, hybrid- and resin-ceramic materials for CAD/CAM monolithic restorations. Dent Mater. 2019; 35:534-542.

53. Coşkun E, Aslan YU, Özkan YK. Evaluation of two different CAD-CAM inlay-onlays in a split-mouth study: 2-year clinical follow-up. J Esthet Restor Dent. 2020; 32:244-250.

54. Spitznagel FA, Vuck A, Gierthmühlen PC, Blatz MB, Horvath SD. Adhesive bonding to hybrid materials: An overview of materials and recommendations. Compend Contin Educ Dent. 2016;37:630-637.

55. GC America | Cerasmart® - Force Absorbing CAD/CAM Block. Accessed September 5, 2022. https://www.gcamerica.com/products/digital/cerasmart/

56. Canatan S, Oz FD, Bolay S. A randomized, controlled clinical evaluation of two resin cement systems in the adhesion of CAD/CAM-fabricated resin nanoceramic restorations: 18-month preliminary results. J Esthet Restor Dent. 2022; 34:1005-1014.

57. SHOFU Block & Disk HC – Shofu USA. Accessed September5,2022.https://www.shofu.com/en/product/shofu-block-disk-hc/

58. Hagino R, Mine A, Kawaguchi-Uemura A, Tajiri-Yamada Y, Yumitate M, Ban S, et al. Adhesion procedures for CAD/CAM indirect resin composite block: A new resin primer versus a conventional silanizing agent. J Prosthodont Res. 2020; 64:319-325.

59. MAZIC® Duro (5pc x mandrel-type/Cerec-type blocks) – JSI Global. Accessed August 6, 2022. https://www.jsidental.com/products/mazic-duro.

60. Yin R, Kim YK, Jang YS, Lee JJ, Lee MH, Bae TS. Comparative evaluation of the mechanical properties of CAD/CAM dental blocks. Odontology. 2019; 107:360-367.

61. KATANA Avencia Block | a new type of hybrid ceramic.AccessedAugust6,2022.https://www.kuraraynoritake.eu/en/katana-avencia-block

62. Hagino R, Mine A, Matsumoto M, Yumitate M, Ban S, Yamanaka A, et al. Combination of a silane coupling agent and resin primer reinforces bonding effectiveness to a CAD/CAM indirect resin composite block. Dent Mater J. 2021; 40:1445-1452.

63. Okada R, Asakura M, Ando A, Kumano H, Ban S, Kawai T, et al. Fracture strength testing of crowns made of CAD/CAM composite resins. J Prosthodont Res. 2018; 62:287-292.

64. Lambert H, Durand JC, Jacquot B, Fages M. Dental biomaterials for chairside CAD/CAM: State of the art. J Adv Prosthodont. 2017; 9:486-495.

65. Goujat A, Abouelleil H, Colon P, Jeannin C, Pradelle N, Seux D, et al. Mechanical properties and internal fit of 4 CAD-CAM block materials. J Prosthet Dent. 2018; 119:384-389.

66. Vita Enamic® - A new definition of stability. Accessed September 5, 2022. https://www.vita-zahnfabrik.com/en/VITA-ENAMIC-24970.html

67. Lucsanszky IJR, Ruse ND. Fracture toughness, flexural strength, and flexural modulus of new CAD/CAM resin composite blocks. J Prosthodont. 2020; 29:34-41.

68. Tokunaga J, Ikeda H, Nagamatsu Y, Awano S, Shimizu H. Wear of polymer-infiltrated ceramic network materials against enamel. Materials (Basel). 2022; 15:2435.