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CAD/CAM CERAMIC MATERIALS FOR INDIRECT RESTORATIONS IN DENTISTRY — A REVIEW

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Abstract:

The aim of this review article is to present various ceramic materials currently utilized in the field of CAD/CAM. Due to high aesthetic and functional demands of indirect restorations research on dental materials is increasing. Comparing the materials will take into account their mechanical properties, their clinical usage, their advantages and disadvantages.

Key words: ***CAD/CAM; dental ceramics; biocompatibility dental materials; mechanical properties***

Introduction

CAD/CAM stands for computer-aided design and computer-aided manufacturing. As a means of accelerating the design process and easing its transition into production, CAD/CAM is applied across various fields of engineering, science, and even art[1]. The purpose of this review is to highlight its constantly growing role in dental prosthetics, more specifically, in bridges, onlays, crowns and veneers. CAD/CAM allows us to provide patients with implants, inlays, onlays, and crowns and veneers that are placed on dental implants[2]. It is possible for a dentist to scan a patient's dental cavity, design and make their restorations, and bond them in a matter of hours because of the technology used in CAD/CAM.

CAD/CAM Advantages

- Higher efficiency and comfort.
- Sufficient edge adaptability.
- Reduce the operation time
- Increase the positive emotions of the patient
- Maintain a sufficient level of accuracy

Limitations and handling

There is no doubt that CAD/CAM technology is very innovative and offers a wide range of opportunities. CAD/CAM systems may not be enough to achieve correct teeth relations in clinical cases regarding patients with maxillomandibular disorders and occlusion distortions. As a consequence, restorations exceeding the height and width of

the blocks cannot be designed or milled. This reveals clinical problems including occlusal vertical dimensions that are inaccurate and centric relationships that are incorrect. Digital scans are more accurate when the arch included in the impression is short. Different types of materials can have different survival rates when it comes to CAD/CAM restorations. The Vita Mark II (VITA Zahnfabrik, Bad Säckingen, Germany) ceramic material showed a survival rate of 90.6% after 8 years and 85.7-89% after 10 years. As a result, the survival rate decreases with time.[3] Among Zirconia-based restoration patients with periodontal disease or conservative reasons, lasers can be used. There is a possibility that lasers can adversely affect the surface of restorative material. According to Romanyk, et al., subtractive machining causes surface and subsurface damage to the restorations which may have clinical relevance.

Figure 1. Commercially available CAD/CAM blocks (Lambert, Hugo & Durand, Jean-Cédric & Jacquot, Bruno & Fages, Michel. (2017). Dental biomaterials for chairside CAD/CAM: State of the art. The Journal of Advanced Prosthodontics. 9. 486. 10.4047/jap.2017.9.6.486.)

Dental CAD/CAM systems currently used

In recent years, CAD/CAM software providers (e.g., CEREC SW 5.1.3, Dentsply Sirona, York, PA) and manufacturing systems have emerged in great numbers. There are two types of CAD/CAM systems: in-office and laboratory systems[4]. Both of them are complex and contain many components. Among Sirona's offerings are the CEREC Omnicam scanner, CAD/design and CAM software, as well as the CEREC MC, X and XL 4-axis milling machines. Carestream Dental (Atlanta, GA), Dental Wings (Montréal, QC, Canada) and Zfx

Table 1. Commercially available ceramic cad/cam material and its application

Type of Ceramics	Clinical Application	Brand, Manufacturer
Aluminium–Oxide Ceramics	Single crowns, bridges	InCeram alumina, VITA Zahnfabrik
Leucite-Reinforced Glass Ceramics	Veneers, inlays, onlays, crowns	IPS, Empress Cad, ivoclar Vivadent
Resin Matrix Ceramics	Onlays, inlays, veneers, single crowns, implant crowns	Lava Ultimate, 3M ESPE VITA Enamic, VITA-Zahnfabrik Cerasmart, GC
Lithium Silicate Ceramics	Inlays, onlays, veneers, crowns	VITA Suprinity PC, VITA Zahnfabrik Celtra Duo, Dentsply Sirona
Zirconium–Oxide Ceramics	Single crowns, bridges, prosthetic restorations covering the entire dental arches, mainly posteriorSegment Aluminium–oxide ceramics InCeram alumina, VITA Zahnfabrik Single crowns, bridges	NobelProcera Zirconia, nobel Biocare

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(Dachau, Germany) are other examples of CAD/CAM systems used[5]. Several companies offer parts included in CAD/CAM systems that can be bought separately as well. Dental professionals usually choose an appropriate system based on their experience and office equipment, but patients' therapeutic needs must also be taken into account[6].

CAD/CAM ceramic materials

Computer-aided manufacturing uses a variety of materials. An example of the CAD/CAM block before processing is shown in Figure 1 (below).

Dental ceramics

Ceramic type has a different clinical application due to its properties (see Table 1).

Resin Matrix Ceramics

This is a relatively new material on the market, but it is said to show some beneficial properties for dentures. Resin-based ceramics are characterized by good milling performance, higher load capacity and better elastic modulus compared with silica-based ceramics[5]. Compared with pure ceramics, the manufacturing process of VITA Enamic ensures a lower fracture tendency and superior CAD/CAM processing performance . In addition, their optical properties are similar to those of natural teeth, and compared to ceramics, they are characterized by lower tooth wear.

Silicate Ceramics

These are non-metallic inorganic ceramic materials containing a glass phase. Examples of silica-based ceramics are Vitablocs TriLuxe from Vita and IPS Empress Cad multi from Ivoclar Vivadent. They have good optical properties, such as high transparency and natural appearance. Studies evaluating the tensile bond strength of lithium disilicate ceramics have confirmed that etching the bonding surface of restorations with hydrofluoric acid is still the "gold standard"[7].

Leucite-Reinforced Glass Ceramics

Discussed the long-term clinical evaluation of leucite-reinforced glass repair ceramics (such as Duraceram and Dentsply Degussa). Leucite-reinforced ceramics are not recommended for posterior dental crowns, because compared with other glass ceramics, leucite-reinforced ceramics have lower mechanical properties[8]. However, their aesthetic quality is sufficient and in recent years, it has been replaced by lithium silicate ceramics, which has better physical properties and sufficient optical properties

Lithium Silicate Ceramics

Some sources claim that lithium silicate ceramics (for example, Ivoclarivoclar Vivadentvivadent, Schaan, Liechtenstein's IPS e.max CAD, VITA Zahnfabrik's VITA Suprinity PC and Dentsply Sirona's Celtra Duo) are the strongest of all available silicate ceramics. Its flexural strength is about 407 MPa. First, lithium disilicate ceramics was introduced to the market in 1998 (IPS Empress 2)[9].

Comparison of CAD/CAM CERAMIC materials

(see Table 2)

Adhesion-bonding of CAD/CAM restoration

Successful and stable bonding leads to high clinical success rates over the long run. CAD/CAM restorations are largely recommended for resin bonding and self-adhesive resin cements. A. Mine et al. created a review providing a broad outlook on the bonding procedures of CAD/CAM materials.[10] A hydrofluoric acid etching procedure should be carried out before bonding to create microretentive surfaces[11]. Afterward, silanization is performed in order to ensure chemical adhesion. Study characteristics of the bonding procedure for CAD/CAM polymer-infiltrated ceramics (such as Vita Enamic) are compared with indirect resin composite materials (such as the Lava Ultimet,

KATANA AVENCIA block, Gradia Block, Ceras-Mart and Block HC). There are general recommendations for bonding CAD/CAM materials, but they may vary depending on producer recommendations and clinical operators' experiences. A technical and scientific document from Vita Enamic provides an example of the bonding process[12]. The author proposed the following scheme: use VITA CERAMICS ETCH (5% hydrofluoric acid gel) to etch for 60 seconds, and then use VITASIL, VITA or Monobond Plus, Ivoclar Vivadent for silanization.

Biocompatibility and cytotoxicity of CAD/CAM materials

Adapting the newly placed dental restoration to the oral cavity's conditions is extremely important, not only regarding their shape, but with the mechanical and physical properties as well. Compatibility with the surrounding tissues is crucial in the biological aspect. In the context of cytotoxicity, biocompatibility is an interdisciplinary concept that encompasses biological, chemical and physical interactions and is closely related to the concept of cytotoxicity. A CAD/CAM material must possess the mechanical, chemical, and thermal properties of human bone in addition to being biocompatible with the surrounding tissues. The material should not cause any irritation, swelling, or intolerance in the oral cavity. Biocompatibility must therefore be considered when evaluating potential materials. Surface roughness and type determine adhesion. CAD/CAM materials used for CAD/CAM were studied for adhesion

Table 2. Mechanical properties and chemical composition of CAD/CAM materials.

Material Type	Product, Manufacturer	Flexural Strength (MPa)	Hardness (HV)	Elastic Modulus (GPa)	Composition
Aluminium Oxide Ceramics	VITA in-Ceram ALUMINA, Vita Zahnfabrik	419	2035	410	Al2O3 (82 wt.%), La2O3 (12 wt.%), SiO2 (4.5 wt.%), CaO (0.8 wt.%), other oxides (0.7 wt.%)
Zirconium Oxide Ceramics	IPS e.max zirCAD, ivoclar Vivadent	1200	n/a	206.3	3 mol% Yttria-stabilized tetragonal zirconia polycrystals (3Y-TZP)
Lithium Silicate Ceramics	IPS e.max CAD, Ivoclar Vivadent	353.1	617	102.7	SiO2, Li2O, K2O, P2O5, SiO2, ZnO
Leucite- Reinforced Glass Ceramics	IPS empress CAD, ivoclar Vivadent	160	632.2	62	SiO2 (60-65 wt.%), Al2O3 (16-20 wt.%) K2O (10-14 wt.%) Na2O (3.5-6.5 wt.%), other oxides (0.5 wt.%), pigments
Resin-Based Ceramics	Lava ultimate, 3 M	200	96	12	Polymerizable resin, dispersed nanometric colloidal silica, ZrO2 spherical particles
Hybrid Cermics	VITA ENAMIC, Vita Zahnfabrik	150-160	200	30	SiO2, Al2O3, Na2O, K2O, B2O3, ZrO2, CaO, urethane Dimethylacrylate, triethylene glycol Dimethylacrylate

and development of microorganisms that form biofilms[13]. Accordingly, IPS e.max and polished IPS e.max showed the best "anti-adhesion properties" against Streptococcus mutans and Lactobacillus rhamnosus. Additionally, Materials 2021, 14, 1592 15 of 21 concluded that the ceramic materials (lithium disilicate) showed a superior response to the cells.

Conclusions

Ceramic materials are becoming more accessible and easier to handle in CAD/CAM. Modern ceramic materials for CAD/CAM are described along with their mechanical and clinical properties, which enable long-term success of restorations. Selecting the right material also requires clinical experience. To produce a successful prosthetic restoration, the technique must always be customized to each individual patient. An occlusal plan may not be able to be defined in the case of maxillomandibular relationship disorders. In order to meet the patient's individual needs, material and method selection must be individualized for each case. The use of this technology provides not only a high quality, professionalism & profit but also a steady increase of a new and satisfied patients and are easy to use.

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