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REVIEW

Hybrid ceramic as an alternative material for crown restoration treatment

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ABSTRACT

All ceramic materials are often used in crown restorations for anterior and/or posterior teeth due to their aesthetic value and high strength. However, some all-ceramic materials such as monolithic zirconia have the disadvantage that they can cause wear problems on antagonistic teeth due to their high hardness. As an alternative to overcome this problem, hybrid ceramic materials are being developed. This literature review aims to look at using hybrid ceramic materials as an alternative material for making crowns. A hybrid ceramic material blends the characteristics of ceramic and composite materials, resulting in a material with excellent mechanical strength and aesthetic qualities. It has a similar elastic modulus value to dentin thus reducing the occurrence of wear on antagonistic teeth. Hybrid ceramic materials is fabricated by CAD/CAM system with subtractive (milling) and additive (3D printing) processes. The subtractive fabrication method (milling) produces restorations with high strength properties but has a longer and more complicated manufacturing process. The additive (3D printing) method, on the other hand, is faster and requires less material than subtractive (milling). Therefore, hybrid ceramic materials should be considered as an alternative material for crown restorations. (IJP 2025;6(1):55-59)

Introduction

All ceramic materials have often been used for crown restorations. The choice of All-Ceramic material for crown restorations is generally used in anterior teeth and some cases in posterior.[1] All ceramic materials consist of oxide ceramics, silicate ceramics, and resin matrix ceramics (RMC). The most commonly used all-ceramic material for crown restoration cases is Monolithic Zirconia which belongs to the Oxide Ceramic group which has high aesthetic properties and biocompatibility. However the material has the disadvantage that it can cause wear on antagonistic teeth because it has a high level of hardness (1387 Hv).[2] Tooth wear can cause loss of vertical dimension, tooth sensitivity, and also reduce the aesthetics of the patient.[3]

Alternative materials have been developed that can be used to overcome this. Hybrid ceramic is one of the materials used which belongs to the Resin Matrix Ceramic (RMC) group. The material is designed to have the mechanical and aesthetic strength of ceramic and composite materials. Ceramic hybrid materials are indicated in the case of single tooth (anterior /posterior) crowns restorations, and implant-supported crowns.[4] The laboratory procedure for the manufacture of Hybrid ceramic materials can be carried out with CAD/CAM system procedures. The advantage of using CAD/CAM system is the quality, speed, and ease of manufacturing a restoration. In the chairside system, the restorative procedure can be done in a single visit.[5]

Currently, additive (3D Printing) and subtractive (Milling) processes are often used as CAM (Computer-Aided Manufacturing) processes in various fields of dentistry in the manufacture of restorative materials. The advantages of the Additive (3D Printing) process is that it has a faster fabrication process and can make more complex prosthesis shapes such as facial prostheses and metal frameworks. Making prostheses that require greater load resistance is done by the subtractive process (Milling) because it can produce more uniform objects microscopically.[6] The disadvantages are higher cost and produce more residual material.[7]

Literature Study

Dental Ceramics

Dental ceramic materials are often described as non-metalic, inorganic structures composed primarily of oxygen compounds combined with one or more metallic elements.(8) Dental ceramic materials consist of various types based on their chemical composition, manufacturing method, and structure. Dental ceramics are mainly divided into 3 groups: Resin matrix ceramics (RMCs), silicate ceramics, and oxide ceramics figure 1.[9] Each type of ceramic mentioned has different clinical applications table 1.

Hybrid Ceramic / Resin Matrix Ceramics

The term keramos is derived from a Greek word meaning ceramic. According to the American Ceramic Society (ACS), ceramic are defined as inorganic , non-metallic materials.[8] Some historians say

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Table 1. Types of ceramics and its applications

Type of Ceramic	Brand	Application
Lithium Silicate Ceramics	VITA Suprinity PC, VITA Zahnfabrik	Inlays, onlays, veneers, crowns
Leucite-Reinforced Glass Ceramics	Celtra Duo, Dentsply Sirona IPS Empress CAD, Ivoclar Vivadent	Veneers, inlays, onlays, crowns, anterior and posterior crowns
Zirconium Oxide Ceramics	NobelProcera Zirconia, Nobel Biocare	Single crowns, bridges, prosthetic restorations covering the entire dental arches, mainly posterior segment
Aluminium Oxide Ceramics	InCeram Alumina, VITA Zahnfabrik	Single crowns, bridges, primary telescope crowns, cantilever bridges
Resin Matrix Ceramics (Hybrid Ceramic)	Lava Ultimate, 3M-ESPE VITA Enamic, VITA-Zahnfabrik Cerasmart, GC	Onlays, inlays, veneers, single crowns, implant crowns

Table 2. Mechanical characteristics and chemical composition of resin matrix ceramics

Type of Materials	Flexural Strength (MPa)	Fracture Resistance	Modulus of Elasticity (GPa)	Composition
Resin based Ceramics/Nano-Ceramic	200	5.1 ± 0.4 MPa m1/2	12	Polymerized resin, dispersed nanometric colloidal silica, ZrO2 spherical particles
PICN	124-180	1.09-1.4 MPa m1/2	30	SiO2, Al2O3, Na2O, K2O, B2O3, ZrO2, CaO, urethane dimethylacrylate, triethylene glycol dimethylacrylate

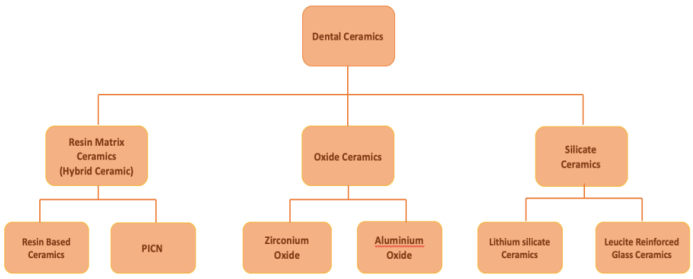

Figure 1. Classification of dental ceramics

the use of ceramics was already done by the Chinese.[11] In recent years, hybrid ceramic materials have been developed, which consist of organic and inorganic materials.[4,12,13] Resin-based ceramics are a new type of composite material, although they are not technically ceramics. However, they have properties similar to ceramic materials, including aesthetics, strength, adhesion, wear resistance, and other characteristics close to porcelain materials.[10]

Technological developments in the field of composites have evolved in the last 10 years. Hybrid ceramic materials can be used for several types of restorations such as inlays, onlays, veneers, crown restorations, and bridge restorations. Paradigm MZ100 (3M ESPE, USA) is a type of composite that was first designed for CAD/-CAM systems in 2000. MZ100 has components of composite resin and 85% wt filler ceramic (ultrafine zirconia and silica).[7] Resin matrix ceramics are divided into 2 according to their structural differences, Resin-based ceramics (Resin nano-ceramic) and Polymer Infiltrated Ceramic Network (PICN).

Resin Based Ceramics / Resin nano-Ceramic

Lava Ultimate & OnX (Sprintray) figure 2 are types of Resin Nano-Ceramic (RNC) materials because they contain nanoceramic particles (nanomer and nanocluster particles) cross-linked with a polymer matrix. These materials exhibit strong fracture resistance and strength, similar to composite materials. Lava Ultimate also inherits advantages from glass ceramics, including gloss retention and excellent esthetic properties. Resin Nano-Ceramic consists of nano-sized particles of ceramics, along with resin matrix. The resin matrix is composed of nanomer silica (20 nm) and nanomer zirconia (4 to 11 nm). Silane molecules create chemical bonds that link the resin matrix with the nano-particle structure.The small dimensions scale of the nanoparticles allow a high proportion of ceramic filler (80%) material and integrated it into the resin (20%). The material is then put into a process by heat treatment for several hours, and it will cause the material to hydrate, so no further firing is required after the milling process.[14,15] Nano-ceramic resin-based materials have higher flexural strength (200Mpa), wear and fracture resistance than composite-based materials, along with high polish and aesthetic properties.

Polymer Infiltrated Ceramic Network (PICN)

In recent years, PICN materials consisting of organic and inorganic materials are also referred to as hybrid materials that consist of ceramic matrix structure (86%) that has been infiltrated by the polymer matrix (14%).[16,17] Its indications include anterior and posterior restorations as well as implant-supported crowns.(18) VITA ENAMIC and VarseoSmile figure 3 ceramic PICN are the result of polymer-permeable ceramic materials based on glass-permeable ceramic technology. In this material, the material is put into a heat process to create porosity for the ceramic network. Then coupling agent is applied. The mixture of monomers will then infiltrate the inorganic network, followed by a polymerization process to form a polymer network. Chemical bonding is then achieved through the

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Figure 2. A. Example of 3d printed nano-ceramic material, B. Example of Nano-ceramic Milling material

Figure 3. A. Example of PICN 3d Printing material, B. Example of PICN Milling material

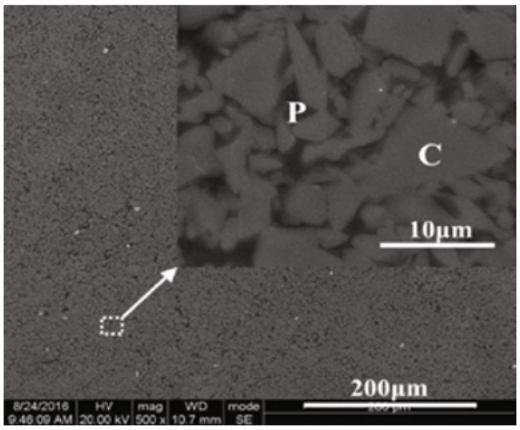

Figure 4. The microstructure of Enamic. 'C' shows the ceramic and 'P' indicates polymer

coupling agent for the two networks figure 4.[4]

Additive (3d Printing) and Subtractive (Milling)

Hybrid ceramic materials can be fabricated using CAD/-CAM methods for various types of dental restorations. The CAM process that is often used in the fabrication of restorations is a subtractive process (milling). The milling method uses a milling bur to shape the restoration according to the CAD design. The subtractive (milling) process is able to produce restorations with high flexural values because the material is more uniformly shaped.[6] Meanwhile, the additive (3d printing) process forms a restoration layer by layer. The additive process (3d printing) has several advantages, namely, a short fabrication process, being able to fabricate complex model shapes (dental models, surgical guides, etc.), low cost, reducing waste by as much as 40%.[7]

Mechanical characteristics of Resin Matrix Ceramics and its Chemical Composition

The following are some of the mechanical characteristics and chemical composition of materials made from resin matrix ceramics, table 2.

Utilization of Hybrid Ceramics in Crown Fabrication

Hybrid ceramic materials offer advantages similar to composite resins, such as good repairability, causing minimal wear on opposing teeth, and excellent chemical compatibility with adhesive resin materials. According to a study by Tokunaga et al.[24] hybrid ceramics possess mechanical properties similar to enamel in terms of hardness and wear characteristics, making them suitable materials for dental restorations. These materials also have a low modulus of elasticity resembling dentin and exhibit adequate fracture resistance compared to other ceramic materials.[10]

Discussion

Hybrid ceramic contains both organic (resin matrix) and non-organic materials (silica & zirconia).[25] Fracture resistance is an important mechanical property to determine how much load the material is capable of receiving before fracture. Alaaeldin Elraggal et al. evaluated the fracture strength of PICN (Vita Enamic) material with a value of (0.76 ± 0.17) with artificial saliva.[26] Della Bona et al. conducted a similar study obtaining a result of 1.09 MPa.(27) Coldea et al. was comparing PICN and other ceramic materials and found PICN with 1.51 MPa, feldspathic porcelain (Mark II and VM9) with 1 MPa, glass-infiltrated alumina-based ceramic with 3.73 MPa,lithium disilicate glass-ceramic with 2.37 MPa , and 4.94 MPa for Y-TZP.[28]

According to Satheesh B. Haralur's research, the fracture resistance of a restoration material is also affected by the occlusal thickness of the crown. The author compared 3 different materials namely, Lithium disilicate (LD), High translucency zirconia (HTZ), and PICN materials with thicknesses of 2mm, 4.5mm, and 4.5mm with radicular expansion of 2mm. The study showed the a few results being, fracture resistance of LD ceramics at 2 mm, 4.5 mm, and radicular extension thicknesses were 62.55 MPa, 45.80 MPa, and 74.27 MPa, respectively. The corresponding values for PICN and HTZ ceramics are 26.30 MPa, 21.65 MPa, 25.66 MPa, and 23.47 MPa, 27.30 MPa, 37.29 MPa, respectively.[23]

According to Möhn M et al, 2022, the occlusal thickness required for Hybrid Ceramic materials is 1-1.5mm.[29] The research conducted by Suksuphan et al., 2024, showed that the fracture resistance of the Hybrid Ceramic material (Cerasmart, CE; PICN, Vita Enamic, VE) with a milling procedure with a load force of 2000N was not found to occur at a thickness of 1 and 1.5mm, while the Hybrid Ceramic material with 3D Printing technique (Varseosmile, VS) showed the occurrence of fractures with a thickness of (0.8mm, 1480.3

±226.1; 1mm, 1629.4 ±118.5; 1.5mm, 1747.2 ±108.7B).[30]

Cristian et al (2023) compares the fracture resistance of PMMA material with the Milling technique with two hybrid ceramic materials with printing technique with occlusal thickness of 2mm, showed that the fracture resistance of PMMA (Poly-methyl methacrylate) which was Milled was higher (1427.94 N) compared to two hybrid ceramic materials with printing technique (1231.0 N; 1029.9 N). This is because the milling process produces a more microscopically uniform material. While the printing technique produces a more irregular and porous material. All restorations that require greater load acceptance are recommended to use the milling fabrication technique.[6] However, in a study conducted by Khalid et al. compares hybrid ceramic materials with 3d printing method (with angles of 0º, 45º, and 90º) and milling, showed that hybrid ceramic with 3d printing method has a lower flexural strength value than milling, but has a higher compressive strength value.[7] This proves that the angle of the 3d printing method affects the properties of a material.

Aside from fracture resistance, the mechanical properties of flexural strength of hybrid ceramic materials were also investigated by Satheesh et al. (2020) who found the flexural strength of PICN to be 130MPa with a modulus of elasticity similar to dental dentin.[23] This is supported by Albero et al (2015), the flexural strength with 3mm thickness value of PICN (180.9 MPa) has similar values from nano-ceramic resin (164.3 MPa). Lithium disilicate (271.6 MPa) showed higher values compared to PICN, but PICN has higher values compared to feldspathic porcelain (137.8 MPa).[31] Argyrou et al (2016), showed higher flexural strength in nano-ceramic resin (170 MPa) compared to PICN (124 MPa).[21] Similarly, Choi et al (2019) found higher flexural strength with 1.5mm thickness values with nano-ceramic resin (159.1 MPa) when compared to PICN (140.1 MPa).[32]

Tooth of wear of antagonistic teeth caused by ceramic restorations is very common. Lithium disilicate and zirconia have higher Vickers hardness values than tooth enamel, while hybrid ceramic materials have a Vickers hardness values and elastic modulus similar to tooth enamel, resulting in lower wear rates than other ceramic materials. Research conducted by Francesco et al (2018) who compared wear rates with hybrid ceramic materials (0.9 ± 1.9 Bab) and lithium disilicate (6.0 ± 7.3 Aa) found that lithium disilicate produced high wear rates on antagonistic teeth.[22] The glazed zirconia material has a rough surface that causes wear on the antagonist teeth.[24,33]

Repairability of a material is also very important to preserve the remaining tooth structure. The repair process of CAD/CAM materials is cost effective because it eliminates laboratory processes. Research conducted by Hasibe and Yusuf (2020), evaluated several surface treatments for nano-ceramic and PICN resin materials, concluding that both materials could be repaired with composite resin after surface treatment application with laser (Er,Cr:YSGG) with 2.78 μm wavelength and bur grinding.[34] The use of silane materials is still recommended even if silane-containing adhesive materials are used.

Conclusion

From the literature review on Resin Matrix Ceramics (Hybrid Ceramic), we can conclude that hybrid ceramics materials have been made to combine mechanical properties and aesthetics from ceramic and the flexibility of resin materials. These materials are able to reduce wear on antagonistic teeth, which is one of the problems with traditional ceramic materials such as monolithic zirconia. The process of creating restorations using CAD/CAM technology, whether through subtractive (milling) or additive (3D printing) techniques and/or Occlusal thickness can also affect the mechanical properties of a material.

Therefore further studies are needed to determine which fabrication process combined with occlusal thickness to obtain the best mechanical properties values.

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