

# CRITERIA FOR CHOOSING PROSTHETIC BIOMATERIALS ACCORDING TO THEIR PHYSICOCHEMICAL PROPERTIES FOR ANTERIOR AND POSTERIOR SECTORS. A COMPREHENSIVE REVIEW

CRITERIOS PARA LA ELECCIÓN DE BIOMATERIALES PROTÉSICOS SEGÚN SUS PROPIEDADES FÍSICOQUÍMICAS PARA LOS SECTORES ANTERIOR Y POSTERIOR. UNA REVISIÓN EXHAUSTIVA

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## ABSTRACT

**Objective:** To describe the existing knowledge about metal-free prosthetic biomaterials according to their physicochemical properties and based on this, define criteria for their placement in both the anterior and posterior sectors. **Materials and methods:** A digital search was carried out in the databases: PubMed/Medline, Scopus, Web of Science and Google Scholar of the literature published in the English language without time restrictions and included original articles such as case reports, retrospective and prospective studies, narrative, comprehensive, systematic reviews and meta-analysis. Meanwhile, short communications, editorials and articles in a language other than English were excluded. **Results:** 40 articles were evaluated, published between 2000 and 2023. The main characteristics and physicochemical properties of ceramic biomaterials such as zirconia, feldspathic based ceramics, lithium disilicate and alumina, among others, were analyzed and summarized. In addition, certain criteria were defined based on the available scientific evidence on the use of different ceramic systems both in the anterior sector and in the posterior sector for patients who need some type of prosthetic restoration. **Conclusions:** Among the different metal-free materials used for the construction of fixed dental prostheses, zirconia has been shown to have better aesthetic, biomechanical and biocompatibility properties, which makes it a candidate material for the rehabilitation of partially edentulous patients.

**Keywords:** prosthetic biomaterials, ceramics, dental alloy, oral rehabilitation, physical properties, chemical characteristics

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## RESUMEN:

**Objetivo:** Describir el conocimiento existente sobre los biomateriales protésicos libres de metal, según sus propiedades fisicoquímicas, y definir, con base en ello, criterios para su colocación tanto en el sector anterior como en el posterior. **Materiales y métodos:** Se realizó una búsqueda digital en las bases de datos PubMed/Medline, Scopus, Web of Science y Google Scholar de la literatura publicada en idioma inglés, sin restricciones de tiempo. Se incluyó artículos originales como reportes de casos, estudios retrospectivos y prospectivos, revisiones y metanálisis narrativos, exhaustivos y sistemáticos. Por otra parte, se excluyeron comunicaciones breves, editoriales y artículos en idioma distinto al inglés. **Resultados:** Se evaluaron 40 artículos, publicados entre 2000 y 2023. Se analizaron y resumieron las principales características y propiedades fisicoquímicas de biomateriales cerámicos, como zirconia, cerámicas de base feldespática, disilicato de litio y alúmina, entre otros. Además, se definieron ciertos criterios basados en la evidencia científica disponible sobre el uso de diferentes sistemas cerámicos, tanto en el sector anterior como en el posterior, para pacientes que necesitan algún tipo de restauración protésica. **Conclusiones:** Entre los diferentes materiales libres de metales utilizados para la construcción de prótesis dentales fijas, la zirconia ha demostrado tener mejores propiedades estéticas, biomecánicas y de biocompatibilidad, lo que la convierte en un material candidato para la rehabilitación del paciente parcialmente edéntulo.

**Palabra clave:** biomateriales protésicos, cerámica, aleaciones dentales, rehabilitación bucal, propiedades físicas, características químicas

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## INTRODUCTION

There is an increasing demand for full crowns that combine pleasing esthetics and optimum physical and chemical properties, which has led to the introduction of various types of dental ceramics and some fiber-reinforced composite resins <sup>(1)</sup>. The progression of the development of all-ceramic materials continues, and clinicians are constantly searching for the ideal material that can be used in different clinical applications <sup>(2)</sup>. It is common to find patients who have suffered the loss of one or more teeth, resulting in a large number of esthetic and functional sequelae that affect the individual's health and masticatory function <sup>(3,4)</sup>.

Currently, metal-free ceramics are no longer only used to fabricate anterior crowns, since many ceramic materials have demonstrated the potential to be used even as crowns and fixed partial dentures (FPD) in the posterior sector. This has been supported by the fact that during mastication the maximum stress supported in the posterior sector is 500 Newtons <sup>(1,3)</sup>.

The most frequent fixed prosthetic treatment corresponds to the use of single crowns in the posterior sector, metal-free crowns have been achieving better esthetic results in addition to solving other problems such as galvanism and toxicity <sup>(4,2)</sup>.

The professional should be aware of the restorative materials available to him/her. With the development of ceramic technology, metal-free restorations emerged. The changes and contributions in this field in the last 20 years have been so important and revolutionary that today there is a multitude of ceramic systems. There is no doubt that in today's environment, talking about esthetic restorations implies talking about metal-free ceramics <sup>(5)</sup>. These materials can be classified by the method of fabrication, by the melting point or by the chemical composition of the substructure also called core or coping <sup>(1,2)</sup>.

Porcelain fractures can occur in relation to certain factors such as impact and fatigue, occlusal forces, incompatibility in the coefficients of thermal expansion of substructure and porcelain, inadequate design, micro

defects inside the materials and trauma <sup>(4,5)</sup>. Porcelain strength is determined by the crystalline phase in which its atoms are uniformly located, while esthetics is determined by the glassy phase in which the atoms are disordered <sup>(3,6)</sup>. Most dental ceramics have this mixed structure, both glassy and crystalline. The flexural strength of a material is its ability to flex before fracturing <sup>(1,4)</sup>. Ceramics prepared industrially by computer-aided design and isolated manufacturing (CAD/CAM) are a very structurally reliable material even though the procedure may induce defects such as decreased marginal fracture toughness and clinical life time <sup>(3)</sup>. Porcelain is very resistant to wear, approximately 0.2µm per year, therefore it has to be adequately glazed or highly polished to reduce damage to the antagonist. The importance of considering the resistance of the materials used in a restoration, this is defined as the maximum stress required to fracture a structure and depending on the force applied can be tractional, tangential and compressive <sup>(6,7)</sup>.

In addition to their physical-chemical characteristics, it is important to mention that metal-free ceramic prostheses are more biocompatible with the supporting tissues of the teeth, compared to metal-ceramic prostheses, and this is demonstrated on the one hand, on the basis that metal-free ceramic prostheses manufactured by CAD/CAM system present a better marginal and internal fit, which favors a lower retention and accumulation of bacteria in the area, producing a direct damage on the gingiva, In addition, it has been demonstrated that the levels of proinflammatory cytokines (IL-1α, IL-1β, IL-6, IL-8, TNF-α, IL1ra, CRP, PGE2, MIP-1 and IgG) and even enzymes such as resistin, aspartate aminotransferase, alkaline phosphatase and matrix metalloproteases (MMPs), mainly MMP-2, MMP-8, aMMP-8 and MMP-9 detected in gingival crevicular fluid are also found to be decreased compared to conventionally fabricated metal-ceramic restorations, resulting in less damage to the periodontium <sup>(7)</sup>.

For this reason, a comprehensive review was carried out to provide the importance of the properties of each restorative material used for metal-free fixed restorations, which will benefit the clinical practice of dentists, expanding their knowledge in this area and thus providing a variety of material options to the patient.

## MATERIALS AND METHODS

A digital search was performed in four databases: PubMed/MEDLINE, Scopus, Web of Science and Google Scholar from December 15th, 2022, to June 15th, 2023. The following keywords were used: "Prosthetic biomaterials" "Ceramics" "Dental alloy" "Oral rehabilitation" "Physical properties" "Chemical characteristics". There were no restrictions as to the date of publication for the selection of the articles, since the aim was to carry out a complete and updated review of the subject. Titles and abstracts were taken into account for the full text review. Two independent researchers were in charge of reviewing the articles sought. A critical and rigorous reading was carried out, emphasizing the selected studies and identifying the main topics addressed, recommendations and conclusions of each one. The articles found in the different search engines were subjected to a second review according to the inclusion and exclusion criteria of the present study.

Research focused on what type of prosthetic biomaterials are ideal for oral rehabilitation in the anterior and posterior sector according to their physicochemical characteristics were included, such as case reports, original research, comprehensive and narrative reviews, systematic reviews and meta-analyses; all research was restricted to the English language. Editorials, short communications and research conducted in a language other than English were excluded. Finally, if any conflicts arose between the principal investigator, another investigator was consulted for resolution.

## CERAMIC BIOMATERIALS IN FIXED DENTAL PROSTHESES

### Vitreous or glass-ceramic ceramics

Most dental ceramics have a mixed structure. They are composite biomaterials formed by a vitreous matrix (such as feldspar that provides translucency) in which are immersed particles of crystallized minerals (lithium disilicate and leucite), being reinforced by these crystals, their biomechanical properties (resistance) are increased in relation to conventional porcelains<sup>(8)</sup>.

The systems in this group are:

- IPS e.max press.
- IPS e.max CAD.
- IPS Empress CAD.
- Vita Mark II.
- Finesse AllCeram.

### IPS e.max press

Consists of glass-ceramics reinforced with lithium disilicate crystals (LS2). The flexural strength was increased to 400 MPa. The restoration can be obtained by pressing with the lost wax replacement technique and is characterized by staining or, a pressed core is obtained and by layered layering it is finished by sculpting with IPS e.max Ceram.

Ceramic system called IPS Empress I (Ivoclar North America, Amherst, NY, USA), which is based on a glass-ceramic reinforced with leucite crystals (35-55% - IPS Empress I System - E1) to be subsequently reinforced with lithium disilicate crystals (60-65% - IPS Empress II System - E2), in which the ceramic is pressed into a investment mold obtained by the lost wax technique, under high temperature and pressure. The IPS Empress system simplifies the problem of shrinkage during ceramic firing, common for feldspathic ceramics, due to the high pressure of ceramic injection into the mold at high temperatures. Due to this it presents greater homogeneity of the crystalline phase, and has great marginal adaptation, color stability, biocompatibility and esthetics, This can be attributed to the elimination of water, alcohol or acetic acid in silanized porcelain.

Indications: It can be used in anterior and posterior crowns, even in opaque stumps.

Advantages: its properties such as strength are improved by a different casting process. It also has high accuracy of fit and esthetics. It is possible to produce translucent

restorations. Able to mimic natural enamel. High opacity blocks can be used to mask metal stumps and teeth without vitality <sup>(9)</sup>.

### IPS e.max CAD

It is a lithium disilicate glass-ceramic block for CAD/CAM technology. Its flexural strength is 360 MPa. It can also be used in the staining or layering technique. Lithium disilicate glass-ceramics is a material consisting of a high share of needle-like and interlocking crystals that hinder fracture propagation with relatively high bending strength and fracture toughness results 2-2.5 MPa/m<sup>1/2</sup>. The IPS E-max press /CAD system which is reinforced only with lithium disilicate crystals but improving transparency and translucency and thus increasing esthetics, however, they offer a higher fracture toughness than Empress II due to a higher homogeneity of the crystalline phase. A conventional feldspathic porcelain is applied on these ceramics for esthetic veneering using the layering technique <sup>(10)</sup>.

The industrial fabrication of isolated lithium metasilicate rough blocks that thanks to partial crystallization are easily millable and allow the clinician the testing of the crowns with respect to marginal adaptation, proximal contacts and occlusion directly in the patient's mouth before full crystallization. Final crystallization of milled crowns by firing at 850 °C which in approximately 35 minutes converts lithium metasilicate to lithium disilicate with a minimum shrinkage of 0.2% <sup>(5,6)</sup>.

There are few prospective clinical trials on the evaluation of monolithic lithium disilicate crowns, one of them published by Reich and Schierz where 96.3% clinical success is evidenced after 4 years of follow-up. Another study by Gehrt and Wolfart evidenced clinical success of 94.8% in lithium disilicate crowns after 9 years of follow-up finding similar values to metal ceramic crowns.

Indications: Designed to be used by CEREC inLab System.

Advantages: The blocks are available in various shades. They have convenient optical characteristics, especially color, translucency and gloss <sup>(10)</sup>.

### IPS Empress CAD

Achieves its high homogeneity and strength of 160 MPa. In an optimized manufacturing process. IPS Empress restorations are efficiently polished to a high gloss or characterized with staining materials in just a few steps and then glazed to significantly enhance their esthetic appearance <sup>(11)</sup>.

Indications: Indicated for crowns, inlays, onlays and veneers.

### IPS Empress 2

The IPS Empress 2 press system for ceramic restorations with the layering technique was introduced in 1998; IPS Eris for E2, a fluorapatite layering material, which is chemically more similar to the framework material matrix, is available; the firing temperature of 755°C for dentin and incisal and 750°C <sup>(12)</sup>.

The framework is responsible for the strength of IPS Empress 2 restorations. The IPS Eris for E2 layering material is translucent, so in this respect it differs considerably from metal-ceramic, it should represent approximately 2/3 of the total thickness of the restoration <sup>(9)</sup>.

The apatite-based glass-ceramic of the layering material IPS Eris for E2 is the second component of the system. The apatite crystals are present in the natural tooth enamel, responsible for the natural balance between opacity and translucency of the restoration; the lithium oxide (Li<sub>2</sub>O) and zinc oxide (ZnO) substances have also been added to the framework material ingots <sup>(13)</sup>.

Indications: Inlays, onlays, veneers, partial crowns and crowns are indicated.

### Vita Mark II

Introduced in 1991 as a feldspathic porcelain that was milled for the CEREC 1 system. The strength of the material has improved due to its particle size, resulting in abrasion resistance similar to natural tooth and much

better fatigue resistance clinically, as well as fluorescence similar to natural tooth. It is available in multiple shades and can be additionally characterized (14).

Disadvantage: It is monochromatic; however, VITA has a multi-colored block line: Vita TriLuxe Bloc, the operator controls it visually to align the restoration by CEREC software (10,14).

Indications: Indicated for small esthetic reconstructions (inlays, onlays, partial crowns).

### **Finesse AllCeram**

Indications: Complete anterior crowns (15).

### **Alumina-based ceramics**

The material has high strength which leads to increased stiffness and brittleness thus making it more vulnerable to radial fractures of the cement surface and or coping from the internal surface. The coping can be manufactured by CAD/CAM or by the condensation technique on refractory die, the latter is modeled with a brush, a slurry is spread on the die and heated in the furnace for the manufacture of the partially sintered coping (16). The final hardness of the core is obtained after sintering, when glass is melted to a liquid state and penetrates into the alumina, this is known as glass infiltrate. Next, the alumina-compatible veneering porcelain is placed, which usually has a coefficient of thermal expansion ranging from 6.5 to 7.2 depending on the brand. Alumina is more resistant than vitreous ceramics but is weaker than zirconia, the copings obtained with this group of materials are less translucent, however they have better esthetic characteristics than zirconia (17).

In this group of characteristics the most representative systems are:

- In-Ceram Alumina
- In-Ceram Spinell
- Procera AllCeram

### **In-Ceram Alumina**

Introduced in 1989, it is a high strength ceramic substructure composed of 99% aluminum oxide, glass infiltrated to eliminate residual porosity and coated with feldspathic porcelain. It is also available in blocks to be milled with CEREC. Survival rate after five years is 90.4% for posteriors. Flexural strength is 480 to 530 Mpa. Infiltration to eliminate porosity increases strength and limits potential crack propagation sites (18).

Indications: This material is recommended for imitating opaque natural teeth or posterior teeth and in areas where esthetics is not paramount.

Advantages: It is more resistant than e.Max Press (19).

### **In-Ceram Spinell**

Introduced in 1994 as an alternative to the opaque In-Ceram Alumina coping. The shell contains a mixture of magnesia and alumina. It has the option of being milled with the CEREC inLab System, infiltrated with glass after sintering and followed by feldspathic porcelain veneering (20).

Indications: These copings are recommended only for anterior crowns on vital dies

Advantages: it is the only alumina with extraordinarily high translucency, has the lowest conductivity of the alumina ceramic oxide systems, can be cemented without adhesion.

Disadvantages: lower flexural strength than In-Ceram Alumina (21).

### **In-Ceram Zirconia**

It is a modification of the In-Ceram Alumina system with the addition of 35% partially stabilized zirconia oxide. The traditional technique can be used on the refractory die or the material can be milled from partially sintered blocks, then infiltrated with glass. The frameworks are

coated with fine particle ceramic powders: VITA VM 7<sup>(22)</sup>.

Indications: The material is particularly recommended for posterior crowns. It is recommended for mimicking opaque natural teeth, posterior teeth and/or in non-esthetic areas<sup>(23)</sup>.

Advantages: it has reinforced ceramics, high accuracy and biocompatibility. Restorations can be cemented conventionally or by adhesive cementation<sup>(24)</sup>.

### Procera AllCeram

These copings are 99.9% high-purity, densely synthesized aluminum oxide. It is coated with low melting porcelain with a thermal expansion coefficient similar to aluminum oxide. Its hardness is only lower than zirconia. Its flexural strength is 687 MPa. CAD/CAM technology is used<sup>(20)</sup>.

Indications: Anterior and posterior crowns<sup>(22)</sup>.

Advantages: Because it does not contain silica, procera has the highest strength of the alumina-based materials, and the occurrence of cracks is reduced. Marginal adaptation is very acceptable. Its porcelain wears its antagonist 74% less than traditional feldspathic porcelain. Excellent survival. And quality control is guaranteed during the manufacturing process of the coping<sup>(13,15)</sup>.

## CURRENT CERAMICS CAN BE CLASSIFIED INTO FELDESPATE, LITHIUM DISILICATE, ALUMINA AND ZIRCONIA

### Feldespate

The first feldspathic porcelain crown was made in 1903 by Land in the wake of that contribution increased interest and demand for biocompatible and metal-free restorative materials<sup>(25)</sup>. Different types of ceramics have been introduced for the fabrication of metal-free crowns. The first attempt was to strengthen conventional

feldspar ceramics by adding leucite. The optical results obtained with these materials were similar to the natural tooth appearance. However, due to their low mechanical strength and brittleness these reinforced ceramics were limited to the exclusive use of crowns in the anterior sector<sup>(26)</sup>.

Some studies show fracture-related failures of the veneering feldspathic ceramic. In vitro methods of fatigue testing with cyclic loading have been developed where the susceptibility of zirconia crowns covered with feldspathic ceramics has been confirmed<sup>(27)</sup>.

Considering studies conducted by Reeh et al. who showed that crown stiffness can be recovered to 100% when a feldspathic porcelain is used as an enamel substitute, most dental ceramics present an upper limit of tensile strength higher than that of natural enamel. Therefore, it does not seem that materials with higher strength are needed, in order to comply with biomechanical principles<sup>(28)</sup>.

The mechanical properties of feldspathic porcelains are low; the flexural strength is barely around 70 Mpa<sup>(20-22)</sup>.

### Lithium disilicate

Lithium disilicate (IPS e.max, Ivoclar Vivadent), is composed of quartz, lithium dioxide, phosphorus oxide, alumina, potassium oxide, and other components<sup>(21,29)</sup>.

Lithium disilicate ceramics contain feldspar responsible for translucency, quartz that composes the crystalline phase, kaolin that provides plasticity and lithium disilicate to improve strength; they are ceramics with excellent optical properties, with a translucency of 75%. Thus, they provide optimal esthetic characteristics for the rehabilitation of the anterior segment<sup>(26)</sup>.

In terms of fracture toughness, this ceramic exceeds the limit value of 100 MPa, established by ISO 6872, recorded between 100-300 MPa<sup>3</sup> and a flexural strength of 350 MPa. These are considered within the low levels<sup>(7-10)</sup>.

Therefore, their use is indicated in veneers, single crowns and short sections up to the premolar area respecting the thicknesses indicated for the connectors by the commercial house, of an area of 16 mm<sup>2</sup>, which is difficult to apply in normal clinical conditions since an availability of interocclusal space is required, which is only achieved in some cases. Failure of three-unit prosthetic sections around the connectors between abutments and pontics has been reported to be relatively high especially in thin connectors (15,17).

Contraindicated in the rehabilitation of posterior teeth and in prostheses with more than three units with a single pontic, because it does not present sufficient strength to withstand masticatory forces under such conditions. Despite the advantages achieved by lithium disilicate, its dental application is uncommon, due to its high cost in the market (22,23).

The deflection of a FPD is inversely proportional to its width. Thus to prevent FPD failure, the connector must be sufficiently tall and wide, and the length of the pontic must not exceed a certain size. The primary causes of failure vary from connector fracture for alumina and lithium disilicate and cohesive fracture of the veneering porcelain for zirconia (7,24).

## Alumina

After six decades, the physical and mechanical properties of feldspathic porcelain were improved by adding aluminum oxide (Al<sub>2</sub>O<sub>3</sub>) thanks to McLean (30).

Crystalline aluminum oxide is used to increase the strength of dental ceramics (so-called dispersion hardening). The technique developed by Dr. Sadoun made it possible for the first time to produce anterior bridges with up to 3 teeth (26).

The aluminum oxide content of In-Ceram AUMINIA was increased to 80% and, by means of the special lanthanum glass infiltration technique, a strength of about 500 Mpa was achieved for the first time, which is at the level of high-purity aluminum oxide (22).

The elimination of alumina in translucent zirconia decreases mechanical strength by 10% but increases translucency with respect to conventional zirconia allowing to make anatomic or monolithic crowns with a flexural strength slightly lower than that of conventional zirconia but higher than a monolithic crown of lithium disilicate glass-ceramics; however, the translucency of this material does not reach the values of a glass-ceramic (21).

The risk of fracture for the elaboration of prosthetic sections of three units in the anterior segment, the use of ceramics such as alumina has been recommended, in which they incorporated to the feldspathic porcelain important amounts of aluminum oxide, improving the mechanical properties of the ceramic, presenting a fracture resistance of 300-700 MPa and a bending strength of 500 MPa considered as a moderate resistance; but this has as a disadvantage a great reduction in translucency, since when the proportion of alumina exceeds 50% it produces a significant increase in opacity, notably affecting the esthetics, which is of great importance in the anterior segment (31).

### Advantages:

- Excellent esthetics and biocompatibility, the gingivae do not retract, there are no uncovered edges and the quality of fit is excellent.
- It has a high degree of translucency.
- The prosthesis is very resistant thanks to the physical characteristics of the material.
- No thermal irritation due to low thermal conductivity good cost/benefit ratio (32).

### Contraindications:

- If it cannot be guaranteed that the prosthesis is suitable for its function.
- If the oral hygiene is not sufficient
- If there is insufficient hard substance

- If the preparation results are unsatisfactory
- In cases of bruxism.

### Zirconia

Zirconia, composed of 95% highly sintered zirconium oxide, partially stabilized with 5% yttria oxide, has high toughness because its microstructure is totally crystalline and it has a reinforcement mechanism called resistant transformation. Its translucency is only 30%.<sup>3, 8</sup> It has fracture toughness above 700 MPa and flexural strength between 1000 and 1500 MPa, but ceramic coating with conventional feldspathic ceramic to improve its opaque appearance considerably decreases its toughness<sup>(7,33)</sup>.

Recent studies have shown that zirconia surfaces accumulate less bacteria than pure commercial titanium. It has also been demonstrated in various studies the high tissue biocompatibility and good tolerance of ZrO<sub>2</sub> after subcutaneous placement for a period of six to twelve months<sup>(34)</sup>.

Zirconium or zirconium (Zr) is a chemical element of atomic number 40 and atomic weight 91.22 located in group 4 of the periodic table of the elements. It is a hard, grayish-white, corrosion-resistant metal. The most important minerals in which it is found are zircon (ZrSiO<sub>4</sub>) and baddeleyite (ZrO<sub>2</sub>). Partially stabilized zirconia represents a high resistance to temperature changes, therefore it is an appropriate consequence for its use as a ceramic material in dental technique since high temperatures are required<sup>(25,28)</sup>. Studies show that a pronounced anatomical framework design and a prolonged cooling period lead to a significant reduction in the fracture rate of single crown veneering ceramics in the posterior sector<sup>(15,19,23)</sup>.

The use of fully anatomical zirconia crowns in the posterior sector is a novel option. The elimination of the possibility of a fracture produced at the junction of the veneering ceramic is a clear advantage<sup>(17)</sup>.

Zirconium is high strength, besides having a 100% biocompatible, in modern dentistry, most commonly

used in what are: "interarticular posts, crowns and bridges P.P.F."<sup>(18)</sup>

Disadvantages:

- Spontaneous attenuation (is going to be related to hydrothermal modification).
- Occurring stress process which is derived from manufacturing development.
- Its low thermal conductivity means that there is generally no sensitivity to thermal changes (unlike metals)<sup>(29)</sup>.

Advantages:

- Maximum aesthetics due to natural light transmission.
- Shape and color individually adaptable for each patient.
- High flexural strength.
- Excellent biocompatibility.
- Long-term strength<sup>(25)</sup>.

## BASIC CHEMICAL COMPOSITION OF CERAMICS

Feldspar. It is the main material of porcelains (proportion of 75 to 85%), which is characterized by being crystalline, of color that varies between pink and gray, chemically (aluminum silicate and potassium). It melts at about 1,160 to 1,500 °C and passes to a vitreous state, which is called leucite, which has the function of reinforcing the porcelain<sup>(20)</sup>.

Quartz or Silica: SiO<sub>2</sub>, in a proportion of 15%, has a crystalline structure with four different forms: Quartz, tridymite, cristobalite and fused silica. Its function is to stabilize the porcelain mass formed during heating, in addition to contributing to the strength of the material<sup>(23)</sup>.



Kaolin or clay. It is formed from the decomposition of solid rocks such as granite or quartz porphyry. 3 to 5% proportion, it achieves the plasticity of the mass, facilitates the handling and molding of porcelain, to which it provides opacity (27).

## CHARACTERISTICS AND PROPERTIES OF CERAMIC BIOMATERIALS FOR FIXED DENTAL PROSTHESES

The properties of porcelains to be mentioned refer to several points of interest among which are mentioned the:

**Biocompatibility:** Porcelain is a material related to human tissues, as it does not cause any type of irritation or alteration.

**Aesthetics:** This is a very important property when choosing a restorative material. Therefore, porcelain is the choice because it achieves greater mimicry with natural teeth due to its translucency, color, texture and brightness.

**Resistance:** Porcelain has the property of resistance to abrasion and resistance to fracture. The former is a disadvantage, since it wears down the antagonist pieces due to its hardness and it is also difficult to carve.

**Dimensional stability:** It does not suffer dimensional changes of consideration.

**Thermal conductivity:** The capacity of dental porcelain to conduct temperature changes to the dental tissues is low.

**Radiolucency:** This property is advantageous because if there is caries genesis it would be contrasted radiographically with the porcelain.

**Compatibility with other materials:** It can cover other materials and not present incompatibility.

**Medium difficulty processing:** The processing technique has a certain degree of difficulty, therefore dental ceramics will have a medium high cost.

The aesthetic requirements of patients are increasingly greater, because they seek to enhance their personal image through a more attractive smile, using materials with better characteristics that meet the needs and exceed patient expectations (35).

Dental ceramics should have properties similar to natural teeth such as:

Optical properties (36):

- **Brightness or luminosity:** This is what distinguishes light colors from dark colors is to define how much light an object reflects or absorbs.
- **Tint:** The quality by which we distinguish one familiar color from another.
- **Chroma:** Quantity or saturation of pigment.
- **Translucency:** Property that partially allows light to pass through.
- **Brightness:** A characteristic of the surface of the material that reflects light.
- **Transparency:** Passage of light through it.
- **Opacity:** Scattering of light.

## CLASSIFICATION OF DENTAL PORCELAINS

According to their melting temperature (37):

**High melting porcelains:** (1300-1370 °C) which contain feldspar as flux and are used in the elaboration of artificial teeth.

**Medium melting porcelains:** (1100-1300 °C) to which borax and carbonate are added, being used in the manufacture of caps.

**Low melting porcelains,** which due to the presence of borax and carbonate melts at a low temperature (850-1100 °C). They are used as covering porcelain for copings.

Ultra low melting porcelains: which melt at temperatures below 850 °C.

The room temperature melting porcelains that are processed in the clinic.

According to resistance <sup>(38)</sup>:

Low resistance. Such as feldspathic porcelains, with a resistance of 100-300 MPa.

Moderate resistance: This group includes alumina porcelains with 300 to 700 MPa of resistance.

High resistance: To this group belong the zirconia ceramics with more than 700 MPa of resistance.

Ceramic materials are rigid but fragile: Especially the design of fixed partial dentures must guarantee 400 N of force in the anterior region and 800 N in the posterior part of the teeth.

## GENERAL INDICATIONS OF CERAMIC BIOMATERIALS IN FIXED DENTAL PROSTHESES

### Indications for the use of porcelain in anterior teeth

Dental porcelain will be used in those anterior teeth: with presence of caries; with fractures after traumatic injuries; in those with color changes due to endogenous pigmentation (product of consumption of antibiotics such as tetracyclines, fluorosis, alterations in the development of dental tissues) or exogenous (by consumption of snuff, coffee, poor dental hygiene); with diastemas (which are spaces between teeth, with unsightly appearance); with alterations in shape and size (such as dysmorphic teeth, eumorphic, microdontia, macrodontia); or with bad dental position (pieces with rotations) <sup>(39)</sup>.

### Indications for the use of porcelain in posterior teeth

For the selection of zirconium material, the following conditions must be met: over 18 years of age, harmonic

occlusal relations, gingival, periodontal and periapical health, as well as good oral health <sup>(3-6)</sup>.

The articles report cases with gaps of medium extension, straight and with a maximum of two posterior pontics. Regarding the abutment conditions, it should have a height greater than 4 mm in the gingivo-occlusal direction before starting the dental preparation, due to the physical-mechanical demands to which the structure will be subjected <sup>(15,17)</sup>.

The selection criteria is similar to a conventional fixed prostheses, although the area for the connectors should be taken into consideration, which should be 6 mm<sup>2</sup> at the anterior level and 9 mm<sup>2</sup> in the posterior sector, and the values should not be below these references <sup>(19)</sup> (Table 1).

## GENERAL CONTRAINDICATIONS OF CERAMIC BIOMATERIALS IN FIXED DENTAL PROSTHESES

Similar to what happens in a conventional fixed prostheses, it is not indicated in patients who present evidence of severe parafunction. Also excluded are patients with poor oral hygiene, adverse general health, or allergy to any of the materials to be used. It is not indicated in abutments whose gingivo-occlusal height is less than 4 mm and/or that present loss of structural strength <sup>(35)</sup>.

Zirconium is a hard metal, resistant to corrosion, lighter than steel and similar in hardness to copper. Yttrium oxide is added to pure zirconium dioxide (zirconia) to control the expansion volume and stabilize it in the tetragonal phase at room temperature, resulting in densely sintered and therefore very strong zirconium oxide. Currently, this material is in great demand and threatens to displace alumina from the market <sup>(40)</sup> (Table 1).

## RESTORATIVE CONSIDERATIONS

The fixed prosthetic treatment on a natural tooth or an implant presents a procedure to follow with several

Table 1. VITA all-ceramic; indications

Recommendation of ceramic biomaterials in different types of prosthetic restorations										
	Feldespate	e.max	Lava	VITA In-ceram SPINELL	VITA In-ceram ALUMINA	VITA In-ceram ZIRCONIA	VITA In-ceram AL	VITA In-ceram YZ	VITABLOCS Mark II	VITABLOCS TriLuxo
	-	-	-	-	-	-	○	○	-	-
	○	○	-	-	-	-	-	-	○	-
	○	○	-	-	-	-	-	-	○	○
	○	○	-	-	-	-	-	-	○	○
	-	○	-	○	○	-	○	○	○	○
	-	-	○	-	○	○	○	○	○	○
	-	○	○	-	○	○	○	○	-	-
	-	-	○	-	-	○	-	○	-	-
	-	-	-	-	-	-	-	○	-	-
	-	-	-	-	-	-	-	○	-	-

○ = Recommended and - = Not recommended

steps, starting with the realization of the design; then the definitive restoration will be made, which will comply with marked improvement in its physical, mechanical and biological properties <sup>(38,40)</sup>.

When performing a prosthetic rehabilitation, one of the therapeutic goals is the preservation of the remaining natural dentition, in any rehabilitation it is essential to rigorously diagnose the problem in its complexity, to clearly understand the patient's demand and to achieve the confident acceptance of the therapeutic proposals. The restoration to be used in an endodontically treated tooth is dictated by the extent of coronary destruction and the type of tooth <sup>(15,23,27)</sup>.

The type of full crown margin is another important aspect. Some modifications are required in the design of the prosthetic preparation. A flat emergence profile of the preparation margin is essential to establish an environment that allows adequate plaque control; an available tooth structure of less than 3 mm. From these data, it can be inferred then, that the restorations performed extend subgingivally <sup>(14,15)</sup>.

A FPD occludes with natural teeth, and these are in normocclusion, the masticatory load is regulated through the proprioceptors present in the periodontal ligament, thus allowing the application of greater force <sup>(38)</sup>.

## CONCLUSIONS

Compiling the information on the characteristics of these different families of ceramics, it is important to highlight that there are certain biomaterials that are exceptions according to the patient's own characteristics (parafunction, Angle classification, type of diet, socioeconomic factor and lack of hygiene). However, among the different metal-free materials used for the construction of fixed dental prostheses, zirconia has been shown to have better esthetic, biomechanical and biocompatibility properties, which make it a candidate material for the rehabilitation of the partially edentulous patient.

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Conceptualization: MAAS, ALGM

Formal Analysis: MAAS, ALGM

Investigation: MAAS, ALGM

Methodology: MAAS, ALGM

Writing – Original Draft : MAAS, ALGM

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