



REVIEW ARTICLE

THE USE OF ZIRCONIUM DIOXIDE IN DENTISTRY AND ORAL IMPLANTOLOGY: NARRATIVE REVIEW

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Abstract

Background: Currently, in dentistry, great importance is attached not only to the functional effectiveness of treatment, but also to the aesthetic appearance. Currently, due to the growing need for alternative materials, there is an interest in the creation of biomaterials with special physicochemical properties and high biocompatibility. Zirconium dioxide has been clinically proven to be a successful restorative material for many different indications, zirconia restorations, veneers and implant-supported structures are in great demand.

The objective of this narrative review was to evaluate the properties, applications and prospects of zirconia dental materials to identify their potential:

Methodology: The sources for literature analysis were the existing literature (Google Scholar, Medline, Scopus, Web Of Sciences, PubMed) that presented the scope of zirconia applications in dentistry, including the main keywords zirconium dioxide, dental zirconia, biocompatibility, mechanical and chemical properties, esthetic properties, zirconia in dentistry and oral implantology, ceramic implants.

Results: Conducted a preliminary search and reviewed 168 titles and abstracts in this review and 64 full-text articles were selected of high methodological quality. The review was conducted according to the PRISMA guidelines. This literature review presents the current knowledge and scientific data on the use of zirconia in dentistry, assessing its advantages and disadvantages when used in various constructions, as well as possible future advances and innovative approaches to improve performance.

Conclusion: The conducted literature review made it possible to identify a number of advantages of modern technologies in orthopedic dentistry using zirconium dioxide (ZrO₂), which improves the quality of orthopedic dental care for the population in terms of safety and reliability. This review will allow dentists to have a better understanding of zirconia-based dental structures, which will allow them to take a differentiated approach and make the right choice in different clinical situations, ensuring high functional efficiency and aesthetic appeal.

Keywords: zirconium dioxide, dental zirconia, biocompatibility, mechanical and chemical properties, esthetic properties, zirconia in dentistry and oral implantology, ceramic implants

INTRODUCTION

A modern task in the field of dental materials science is the introduction and use of materials that provide esthetics, functionality and biocompatibility in dental restoration. Companies engaged in the production of dental materials are intensively working on new strategies aimed at further improving the microstructural characteristics of these materials, as well as introducing new production technologies.

In the last decade, zirconia-based dental materials have found wide application in various branches of dentistry due to their important properties such as

high flexural strength, biofunctionality, biocompatibility and esthetics.¹

Due to their opacity, zirconia frameworks are usually covered with ceramic veneers, which provide a more natural appearance but are prone to breakage. As an alternative, veneered zirconia restorations are becoming more widely used today.

Zirconium is a metal chemical element with the symbol Zr and atomic number 40.² Zirconia (ZrO₂) is a crystalline oxide of zirconium. Zirconium dioxide is in the family of full ceramics, more specifically, the oxide ceramics, also classified as

technical ceramics. Oxide ceramics are polycrystalline materials that are composed of oxides that do not degrade during sintering. It is not found as a pure oxide in nature, but it is mined as a silicate mineral called zirconium ($ZrSiO_4$ gray-white, durable transition metal similar to titanium (fig.1). Zirconium is obtained by chemical processing from a mineral raw material - zirconium sand, partially stabilized with yttrium, from which zirconium blanks are formed mechanically.



Figure.1 Zircon is a soft silver metal

Zirconium dioxide (ZrO_2), sometimes called zirconia. German chemist Martin Heinrich Klaproth (1743-1817) discovered the element zirconium in 1789, analyzed a zircon and separated zirconium in the form of its 'earth' zirconia, which is the oxide ZrO_2 . Klaproth first named the new element Zirkonerde (zircon earth, or zirconia). English chemist Sir Humphry Davy (1778-1829) suggested the name zirconium in the early 1800s. Klaproth failed to isolate the pure metal itself. In 1824, the element was isolated when the Swedish chemist Jöns Berzelius heated potassium hexafluorozirconate (K_2ZrF_6) with potassium metal and obtained some zirconium as a black powder that was 93% zirconium, but he could not purify it further. It was not until almost one hundred years later that high-purity zirconium could be made. This delayed progress in studying the element. The element zirconium is named after the mineral in which it was discovered, zircon.³

The word "zircon" was probably derived from the Persian word zargun, which means "gold-like" or "golden-colored." Some zircon crystals have a gold color.

The main sources of zirconium are zirconate ($ZrO_2 \cdot SiO_2$, $ZrSiO_4$) and baddelyite (ZrO_2), and most of the material used is chemically extracted from these two minerals. Zirconium dioxide (ZrO_2) resulting from baddelyite, which is also known as zirconia.^{4,5} The resulting reagent powder is mixed with additives. A distinction is made between agglomeration additives, which especially affect the

sintering characteristics and the characteristics of the finished ceramics, and auxiliary materials, which facilitate shaping. Accordingly, zirconium dioxide blanks are manufactured using various methods. The spatial arrangement of atoms in zirconia is characterized by different crystallographic structures, which are characterized by certain geometrics and have three basic volumetric parameters: monoclinic, tetragonal and cubic (Fig. 1a,б,в).⁶

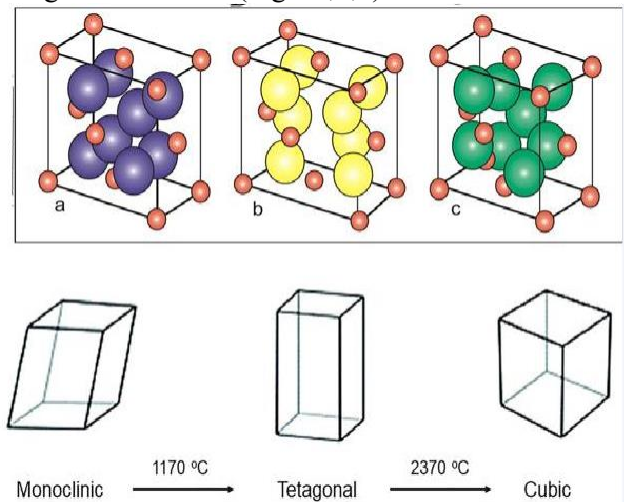


Figure 2. Crystal structure of monoclinic (a), tetragonal (b) and (c) cubic zirconia

It exists in nature in three different crystal configurations at different temperatures. Pure zirconium has a monoclinic structure at room temperature, which is stable up to 1170°C. Between this temperature and 2370°C, tetragonal zirconium dioxide is formed, while cubic zirconium dioxide is formed at a temperature higher than 2370°C. Then cooling, the tetragonal form transforms back to the monoclinic form.⁷

Transformation from tetragonal to monoclinic phase can be used to improve the mechanical properties of zirconium, especially its strength. The mechanism involved in this is known as a catalytic converter. To stabilize zirconium, yttrium oxide (Y_2O_3), calcium oxide (CaO), or magnesium oxide (MgO) are added to it, which allows it to maintain its weld shape at room temperature after annealing. Addition of various amounts of stabilizers can lead to obtaining exceptional properties, such as high bending and tensile strength, high hardness, excellent chemical resistance and good conductivity. Zirconium in the form of pure oxide is not found in nature. Besides zircon, zirconium occurs in over 140 other minerals, including baddeleyite and eudialyte. Its most natural form, with a monoclinic crystal structure, is a rare mineral. Baddeleyites are the main sources of the material and require a significant amount of processing to obtain zirconium.⁸

Today, zirconia in dentistry is commonly used as a modified yttria (Y₂O₃) tetragonal zirconium polycrystal (Y-TZP) because it has great mechanical properties. The addition of yttria improves the physical properties of zirconium. Zirconia-based dental materials mainly consist of two components: i.e., framework (Yttria Stabilized Tetragonal Zirconia Polycrystal 3Y-TZP).

- Based on the yttria content, zirconia is classified into three main groups:
- The first group is strong, 3 mole % Y-TZP (mostly tetragonal)
- The second group is more translucent, 4 mole % Y-TZP
- The third group is more translucent, 5 mole % Y-TZP with reduced mechanical properties:

Processing of zirconium includes separation and removal of unwanted materials and impurities - silica from zircon and oxides of iron and titanium from baddeleyite (fig. 3).

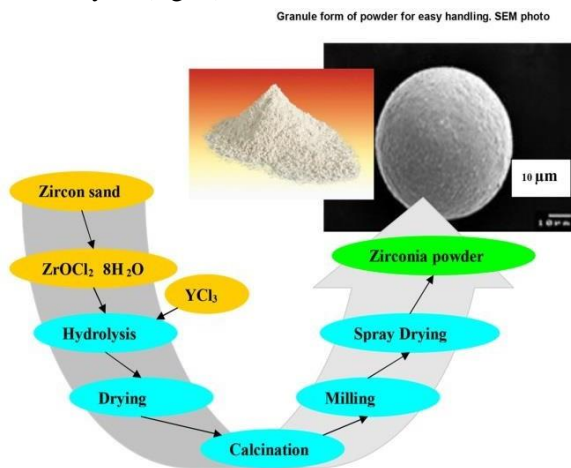


Figure 3. Production of Zirconia powder

The refined zircon is then purified into pure zirconia. There are several routes to the extraction of zirconia from zircon including:

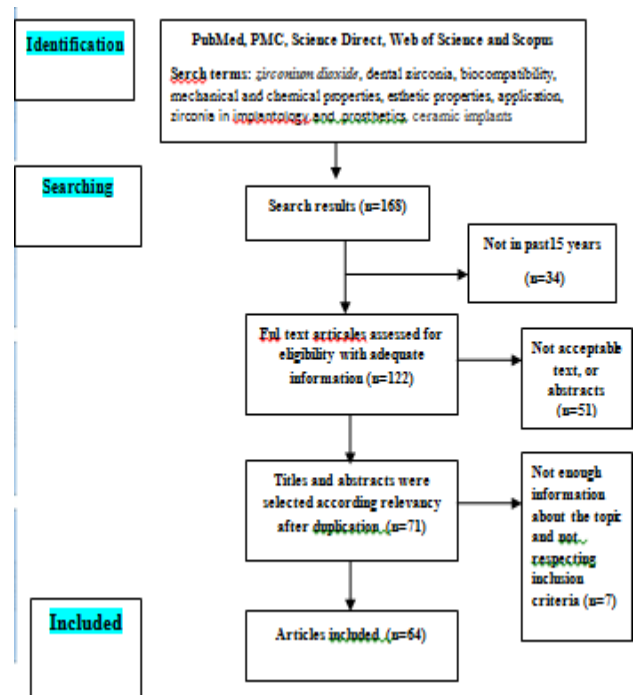
- Chlorination;
- Alkaline oxide decomposition;
- Limestone alloy;
- Plasma dissociation.

Methodology

The sources for analysis were the existing literature (Google Scholar, Medline, Scopus, Web Of Sciences, PubMed) that presented the scope of zirconia applications in dentistry, including the main keywords: Zirconium dioxide (ZrO₂), zirconia, biocompatibility, mechanical and chemical properties, esthetic properties, application”, zirconia in dentistry and oral implantology.

Results:Conducted a preliminary search and reviewed 168 titles and abstracts in this review and 64 full-text articles were selected of high methodological quality. Review was conducted according to the PRISMA guidelines (table 1).

Table1. PRISMA flow chart



Properties of zirconia

Physical properties

From a physicochemical point of view, zirconia is a metal oxide with ceramic properties, characterized by polymorphism and allotropy. ZrO₂ is a heterogenous, highly-resistant, characterized by favorable mechanical properties: ^{9,10}

- Toughness: 5–10 MPa√m;
- Flexural strength: 500–1200 MPa;
- Young’s modulus: 210 GPa;
- Compressive strength = 2.000mpa1/2 ;
- Fracture toughness = 8-10mpa·m;
- High fracture resistance;
- Wear of opposing dentition (mono).

Dental zirconia is resistant to acid erosive attacks in the mouth. It has extremely low thermal conductivity and the thermal expansion coefficient is 10 × 10 – 6/°C. Monolithic zirconia crowns with a thickness of 0.5 mm exhibit sufficient fracture resistance to withstand piercing loads in the molar region.^{11,12}

Zirconium ore is purified to obtain zirconium powder. Metal oxides are added: yttrium to stabilize the tetragonal phase of zirconium, aluminum to prevent water corrosion, and hafnium oxide to reduce pore formation and color components.¹³⁻¹⁵

Due to saliva, temperature & stress, zirconia may transform more aggressively to monoclinic phase with micro-crack formation. This mechanical property degradation in zirconia is known as “aging”.

This can cause:

- Increase in water penetration;
- Crack propagation;
- Surface deterioration;
- Phase destabilization;
- Decreased resistance to load.

The aging process depends on porosity, residual stresses, grain size, and the content of the stabilizer (Y2O3).

Chemical properties (figure):¹⁶

Low thermal & electronic conductivity;
High ionic conductivity;
Opaque; Chemically inert;
Corrosion resistant.



Figure 4. Typical properties exhibited by zirconia that are commonly utilized

Biological properties

Zirconia is a biocompatible biomaterial that does not cause mutations in the cellular genome.^{16,17}

Zirconia has shown less bacterial adhesion and less biofilm formation compared to titanium.^{18,19} The material is a hypoallergenic polycrystalline ceramic that combines perfectly with tooth tissues.²⁰⁻²² Since there is no metal in the crown, there is no need to hide its edge under the gum, thereby injuring it. Also, thanks to the absence of metal, there is no staining of gums by oxidation products. In addition to being very biocompatible, zirconia is entirely non-toxic. It also has excellent bone adherence, cell proliferation and metabolism, and a reasonable hemolytic rate. When contrasted with titanium implants, ZrO2 implants demonstrated comparable levels of biocompatibility and osseointegration.

Because of more than 15 years of global experience of using zirconium dioxide in dentistry, not a single case of allergic reactions to this material has been

recorded. This also includes longer experience of using zirconium dioxide in other areas of medicine, which also shows the highest degree of biocompatibility.

Zirconium oxide is especially suitable for patients with intolerance to certain materials and metals. In terms of biocompatibility, this type of metal-free restoration is ideal.

The advantages are as follows:

- Harmless composition (no silicon oxide), very low solubility, high stability in relation to acids.
- Smooth surface that prevents plaque accumulation.
- Absolute bioinertness in relation to other materials in the oral cavity.
- High thermal insulation properties, allowing you to fully enjoy the intake of cold or hot food or drinks.

Bioinert surface helps in rapid proliferation of gingival fibroblasts over the implant surface and formation of a strong mucosal barrier (figure 5):

- Less bacterial plaque;
- Healthier mucosa;
- Better soft tissue adaptation.



Figure 5. Zirconia Biological application

Absence of galvanoz

For most patients who follow the hygiene recommendations of dentists, zirconium dioxide crowns last for decades, while maintaining their original shape and color throughout the entire period of operation.

Optical properties

Zirconia is an optically opaque material and is less aesthetically appealing than glass ceramics. The transparency of the structure and color rendering ensure that the prosthesis is invisible in the oral cavity. In order to improve its aesthetic properties, translucent zirconia has been synthesized, which is characterized by the presence of 30–35% cubic crystals. However, the strength of translucent zirconia with better optical properties is reduced

compared to tetragonal, with flexural strength values ranging from 500 to 900 MPa, and it is more prone to aging. Translucent zirconia is preferred in the anterior regions for the preparation of restorations. As an alternative to highly opaque tetragonal zirconia, manufacturers have recently begun to offer cubic phase zirconia. Although this phase has better esthetics due to its higher light transmission, the phase transformation effect is lost, making the material mechanically weaker (400 – 800 MPa).²³

Coloring Effect

Coloring monolithic Zirconia restorations can be accomplished by either utilizing pre-colored blocks or immersing or brushing white Zir restorations in coloring solutions. Metal oxide solutions such as ferric chloride, manganese chloride, cerium acetate, cerium chloride, bismuth chloride, terbium (III) chloride, chromium (III) chloride, manganese (II) sulfate, and others are used to make coloring liquids. Pre-coloring includes integrating metal oxides such as.^{24,25}

Due to the excellent light transmittance of zirconium dioxide, the ability to paint it in colors that match the shade of the patient's teeth, dentures are highly aesthetic, close to the natural color of the teeth. The light shade of the material eliminates the presence of dark edges, typical for any metal structure. The only condition is the right design. The larger the distance between the abutments, the taller and wider the connectors should be. However, in light of the stability of this material, sound dental principles should be adhered to.

Manufacturing procedures

When manufacturing a zirconium dioxide framework, the computer modeling and hardware milling technique (CAD/CAM technology) is used, which achieves exceptional manufacturing precision. First, a zirconium framework is manufactured (according to the color of the tooth), then a ceramic mass is applied to the zirconium framework.

New technologies are currently advancing, but to date zirconia is produced using CAD-CAM milling according to two different manufacturing techniques: Soft machining and hard machining.²⁶

Literature data are still conflicting as to which technique is the best, as the choice is mainly driven by operator preference according to the shape, volume and complexity of the prosthetic geometry.²⁷ Soft machining is based on milling pre-dispersed zirconia blanks, which are prepared by cold isostatic pressing of a mixture of zirconia powder, stabilizing oxides and binders. Soft machining requires precise matching of CAD dimensions and material shrinkage to avoid dimensional inaccuracies. Hard machining is based on milling fully sintered zirconia blanks, which are usually produced by hot isostatic pressing (HIP)

at 1400°-1500°C. Immediately after hard machining, zirconia frameworks may undergo a certain amount of monoclinic transformation phase due to mechanical stress, work piece contact and overheating, sintering) significantly affect the mechanical properties and stability of zirconia.²⁸ To obtain the appropriate color of the restorations, specific metal oxides can be used in the zirconia powder mixture. The coloring process does not affect the mechanical properties of tetragonal zirconia, while there is still no clarity regarding translucent cubic crystals.²⁹⁻³¹

Use of Zirconium dioxide in dentistry

The use of zirconia in dentistry and medicine has rapidly increased over the last decade due to its advantageous physical, esthetic, biological, and corrosion characteristics. Zirconia began to be used in dentistry in the 1990s, first for root canal posts, then for prosthetics, an alternative to metal-ceramic dental restorations. It is the first choice today in cases with high aesthetic requirements.³²⁻³⁴ Zirconia is used in oral and maxillofacial surgery, in prosthodontics and in implant dentistry (figure 6).

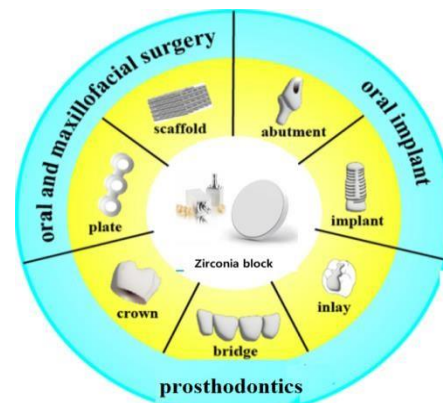


Figure 6. Use of Zirconia in oral and maxillofacial surgery, in prosthodontics and in implant dentistry

Zirconia is an excellent solution for restoring the function and esthetics of teeth. The use of zirconium dioxide in dentistry has improved the quality and esthetics of prosthetic structures. This material, together with all the technological subtleties of the manufacture of prostheses, meets the requirements of patients, doctors and society for orthopedic structures today. Zirconium dioxide has been clinically proven to be a successful restorative material for many different indications. For example, zirconia has demonstrated excellent clinical results in the fabrication of crowns in both anterior and posterior teeth. Zirconia crowns are visually almost impossible to distinguish from adjacent, real teeth. They have a color and transparency as close as possible to natural tooth enamel.

In prosthetic dentistry, zirconium dioxide is used to

produce almost all types of restorations (figure 7):

- Bridge prostheses,
- Single crowns.



Figure 7. Single crowns, bridge prostheses

Zirconium oxide restorations allow for more gentle grinding of teeth. Due to the exceptional strength properties of zirconium oxide, the thickness of the framework and facing ceramics can be less than that of all-ceramic restorations. Thus, your dentist ensures that more healthy tissue is preserved during prosthetics.

If esthetics are not critical, the monolithic reconstruction method is preferred due to fewer technical complications (no risk of ceramic chipping).

Aesthetic comparison of zirconia ceramics and metal ceramics

ICE zirconium dioxide frameworks are transparent, and thus aesthetically superior to opaque metal frameworks.

One of the main advantages of zirconium crowns is their appearance, which is as close as possible to natural teeth.

For esthetic purposes, the framework has to be veneered with feldspathic ceramic. A more natural looking appearance and depth effect can also be achieved by staining and glazing the zirconia framework.³⁵ Zirconia is an excellent solution for restoring the function and esthetics of teeth. Zirconia can also be used as a framework for full arch prosthetics. Although the results of this reconstruction method seem promising, it should be noted that there is limited long-term documentation available at present. In general, zirconia can be used to fabricate a monolithic structure or as a framework for a two-layer structure. In the dental laboratory, zirconia is usually milled from a block of pre-crystallized material using CAD/CAM technology and then sintered at high temperatures.

The most important technological aspect of the use of zirconium dioxide is the use of CAD / CAM systems, which also contributes to their further improvement and development.

Before sintering, it is advisable to polish the blank to achieve a smooth surface relief. When working with

monolithic restorations, glaze should only be applied to the axial surfaces, not to the occlusal area. This is because the glaze layer wears off after approximately 6 months of use, leaving potentially unpolished zirconia exposed. To avoid jeopardizing the opposing dentition, it is preferable to have an optimally polished occlusal surface of the zirconia structure, minimizing wear. If zirconia is used as a framework, it is essential to select a veneering ceramic that is compatible with the coefficient of thermal expansion (CTE) of zirconia, which compensates for the lower heating and cooling rates.

When an adhesive bond to zirconia is required, acid etching cannot be used to pre-treat the material, as there is no silicon matrix available. Therefore, to achieve an optimal chemical bond to zirconia, the surface should be sandblasted (with a silica coating) with alumina particles of approximately 30 μm . When using larger grain sizes, sandblasting can lead to micro cracks, which reduces mechanical stability. After sandblasting, a bonding agent containing the molecule 10-MDP (10-methacryloyloxy-decyl-dihydrogen phosphate) must be applied to the bonding surface. Ideally, a cement that also contains the molecule 10-MDP is selected to achieve optimal adhesive properties.

In dentistry, Zirconium dioxide is used in the form of ceramic blocks, which are produced by a series of compression molding processes.³⁶⁻³⁸

Sintered dental zirconia has a whiteness and translucency that very much resembles a natural tooth. A minimum area of 9 mm^2 should be available to connectors and framework wall thickness should not be less than 0.5 mm. Copings or frameworks must be anatomically shaped to ensure even layer thicknesses of veneering ceramic. Insufficient support for the veneering ceramic on the coping or bridge framework can trigger so-called chipping fractures. There's no limit to the span of a zirconia bridge or to the number of pontics.^{39,40}

A modern modified material based on zirconium dioxide, Prettau Zirkon ("Prettau zircon") fully meets the high requirements for strength. Areas of occlusal-chewing contact and functional areas are completely made of this material. An exception is the vestibular surface of the frontal teeth, except for the cutting edge; it is lined with ceramic masses. Prettau Zirkon has high strength, which provides resistance to abrasive wear, guarantees the absence of chipped bumps and cutting edges. As for classic bridge-like prostheses made of solid ceramics, the probability of such damage is extremely high.

Advantages of zirconium dioxide crowns

The strength of the construction allows them to create bridge-like prostheses that are large. Possibility of fitting on vital teeth. Therefore, the

thickness of the preparation is minimal compared to other techniques. The wall of the crown frame does not exceed 0.3-0.6 mm, therefore depulpization of the tooth is not required in most cases, the pulp of the tooth is not damaged as a result of preparation.^{41,42}

Disadvantages of zirconium dioxide crowns

Cracks and chips may be caused by failure to follow the recommendations for wearing dentures, or by a mistake by the dentist, who did not take into account the presence of contraindications for installing a zirconium denture. High cost, which consists of a complex manufacturing technology, mandatory use of computer equipment, high quality of the finished structure and a long service life of the denture.⁴³⁻⁴⁶

Frequent reasons for fractures Zirconia

1. Non-compliance with coping or framework wall thickness (min. 0.5 mm).
2. Connecting cross-sections are too small (9 mm² three sections, 12 mm² four sections).
3. Dry grinding the densely sintered framework, use of coarse diamonds, excessive rpms and/or exerting excessive pressure.

Facing ceramic fractures and delaminations are:

1. Insufficient support for the facing ceramic by the coping or bridge framework.
2. Copings or frameworks that are not anatomically shaped.
3. Uneven thickness of facing layers.
4. Non-compliance with the returning procedure.
5. Use of conventional ceramic heating and cooling rates.

Cementation

Based on the physicochemical properties of zirconia, glass-ionomer and hybrid cements (i.e., resin-modified glass). Ionomer cements can be considered a good choice for cementation.⁴⁷ Use of zirconia dental implants in implant dentistry

Until recently, the only material for implants was medical titanium. Implants made of this metal and its alloys have proven themselves well, but, unfortunately, were not suitable for people with allergies to some metals. Sometimes patients refuse titanium implants for aesthetic reasons. Dentists offered an alternative to the titanium implant - a zirconium implant. Although the first ceramic implant designs appeared in the late 80s of the last century, they have become widespread in the last 10-15 years. In the USA, their use was approved only in 2011 and in Europe - a little earlier, in 2005.

In the last few years, the zirconia dental implant has emerged as an alternative for titanium implant due to its potential to osseointegrate.⁴⁸ Some studies have reported that zirconia has more biocompatibility as compared to titanium, as the latter produces corrosion products at the implant site, its naturally white color also makes it a great choice for

Patients(table2).⁴⁹⁻⁵¹

Table 2. Comparison of Zirconia and Metal Ceramic Crowns

Characteristics	Zirconium dioxide crowns	Metal ceramic crowns
Possibility of prosthetics without nerve removal	+	-
Minimal tooth grinding	+	-
Color selection at the level of the prosthesis framework	+	-
Excellent aesthetics (complete illusion of a real tooth, no grey metallic shade)	+	-
Any length of the structure	+	+
Computer precision design and manufacturing	+	-
Complete absence of metal (no metallic taste in the mouth)	+	-
Absence of dark border near the gum	+	-
No negative reaction to heat and cold in teeth	+	-
Low risk of developing caries under crowns and periodontal disease	+	-
Resistance to deformation	+	+
Light weight construction	+	-

According to published literature, the prevalence of titanium allergy in dental implant patients is estimated to be quite low (0.6%), which makes ceramic implants a suitable option for patients with metal allergies as they are hypoallergenic. Zirconium dioxide (ZrO₂) demonstrates excellent biomechanical properties, such as high fracture toughness and flexural strength, and also ensures successful osseointegration. In vivo study, zirconia showed significantly lesser adhesion of bacteria than titanium.^{52,53}

Advantages of Zirconia Dental Implants

1. Zirconia dental implants are hypoallergenic;
2. Zirconia is corrosion resistant;
3. Zirconia implants are very strong;
4. Bone integration;
5. Zirconia helps with plaque buildup;
7. Faster healing time;
8. Aesthetic advantage.

Zirconium dioxide implants are white, they do not show through the gums, which is especially important if you need to restore the front teeth. With gum recession (volume reduction), the gray strip of the titanium pin becomes visible. In such cases, the ceramic pin blends organically with the crown.

A global survey by the European Society of Ceramic Implantology (ESCI) 2021 on the operation of ceramic implants confirmed the advantages of zirconium dioxide in terms of biocompatibility and weak connection with inflammation. Ceramic implants made of zirconia represent a significant complement to titanium implants and thus an expansion of the treatment spectrum in dental implantology.

The ESCI Scientific Advisory Board states, based on the conclusions above, that the two-piece zirconia implant concept is appropriate for clinical application.⁵⁴

- The two-piece zirconia implant concept offers advantages over the one-piece concept regarding prosthetic flexibility and clinical indications.
- Two-piece zirconia implants can resist clinical masticatory forces.
- Fracture resistance and mechanical stability of two-piece zirconia implants may vary as a function of different manufacturing processes, material properties, implant geometries and prosthetic connection concepts.

Ceramic dental implants were initially produced as monoblocks, but two-stage implants are now also produced. However, no conclusion regarding the application of two-piece ceramic implant systems can be drawn based on the existing data. Regardless of whether one-piece or two-piece implants are being placed, this drilling speed starts at approximately 800 rpm for the first drillings and decreases to 400 rpm for the last drillings. The prosthetics of a single-sided implant are almost completely identical to the prosthetics of natural teeth. In the case of two-piece implants, the procedures are identical, as for two-piece titanium implants: open or closed tray.



Figure 8. One-piece zirconia

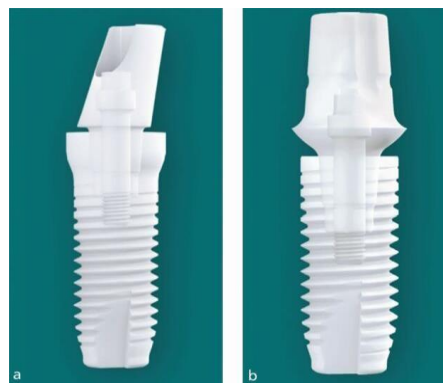


Figure 9 The two-piece zirconia

One- and two-piece zirconia implants demonstrate the same level of osseointegration and biological integrity (figure 8,9). In addition to zirconium implants, it is also recommended to use metal-free components - an abutment and a crown. When installing a zirconium abutment, the tooth will have a natural transparency and white tint, whereas when using a metal abutment, a dark metal rod may be visually visible inside the tooth (figure 10,11).⁵⁵⁻⁵⁹



Figure 10. Zirconium abutment, Figure 11. Zirconium crown (photo professor Curd Bollen)

A zirconium crown is also transparent and white, whereas metal ceramics have a number of disadvantages, which include a metal rim that shines through the gum, oxidation of the metal, an unnatural color of the tooth, gum recession and a change in its color due to interaction with the metal (figure 12-16).⁶⁰⁻⁶¹



Figure 12. Full-Arch UJ Zirconium abutment (photo professor Curd Bollen)



Figure 12. Full-Arch UJ Zirconium until fixation(photo professor Curd Bollen)



Figure 14. Full-Arch UJ Zirconium fixed in the oral cavity image from the palatal side (photo professor Curd Bollen)



Figure 15. Full-Arch UJ Zirconium fixed in the oral cavity, image from the vestibular side (photo professor Curd Bollen)

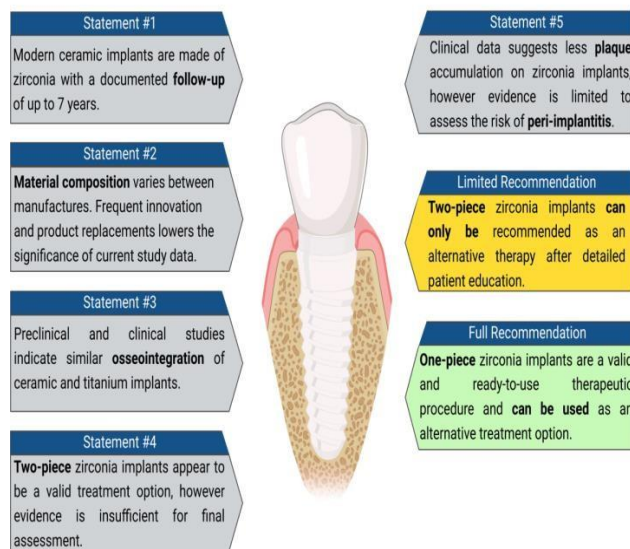


Figure 16. Full-Arch UJ Zirconium,OPG after fixation(foto professor Curd Bollen)

In the presence of an allergy to metal, zirconium prevents all the negative effects of metal ceramics, such as a metallic taste in the mouth, a galvanic effect, irritation of the mucous membrane, etc.

German Implantology Society (DGI) together with the German society for Dental and Oral Medicine (DGZMK) has developed a new S3 guideline for the use of zirconia dental implants according to the current evidence.⁶²

German S3 Guideline on Ceramic Dental Implants
Statements and Recommendations



Zirconia and titanium implants demonstrate similar soft and hard tissue integration capabilities. Titanium, however, tends to show accelerated initial osseointegration compared to zirconia.

Studies of recent implantations (3 years) show that the degree of osseointegration of ceramic implants is the same as that of titanium (95% and higher). However, numerous publications confirm that such a percentage of survival for titanium remains after 10 years. There is no data on ceramic pins from 10 years ago. It is difficult to predict what will happen to them after such a period, since long-term observations have not been conducted. According to the scientific literature, there is less peri-implantitis around ceramics than with titanium implants.^{63,64}

Zirconium and materials that include, have promising indicators of strength and biocompatibility with living tissues in comparison with other materials for use in surgery. However, the use of ZrO₂ is a new issue, so more in vivo experiments are needed to make widespread use of zirconium in surgery possible. This material requires special processing techniques that all laboratories must master, as it is fundamentally different from the classically employed metallic framework materials

The data on the use of modern zirconia-based ceramic implants has significantly improved in recent years. However, more long-term clinical studies are required to assess the use of dental ceramic implants more reliably.

CONCLUSION

The conducted literature review made it possible to identify a number of advantages of modern technologies in orthopedic dentistry using zirconium dioxide (ZrO₂), which improves the quality of orthopedic dental care for the population in terms of safety and reliability.

This review will allow dentists to have a better understanding of zirconia-based dental structures, which will allow them to take a differentiated approach and make the right choice in different clinical situations, ensuring high functional efficiency and aesthetic appeal.

DECLARATIONS

Conflicts of interest and financial disclosures

The author declares that he has no conflict percent and there was no external source of funding for the research in question.

Ethical approval

The study was approved by the Institutional Ethics Committee and was conducted in accordance with the Declaration of the World Medical Association.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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