



The Effect of Glazing on Full Contour Zirconia - A Systematic Review

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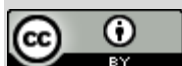
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Abstract

To assess the present condition of status of Knowledge on highly translucent Zirconia Materials as well as glazing materials. Materials and methods: enhance the process of glazing on monolithic zirconia, can be used in clinical practice as a replacement for traditional polishing procedure. An electronic systematic review was performed in different databases: (Science Direct, PubMed, Web of Science and Google Scholar searches) were consulted on this topic, as well as on a hand search of the scientific literature. Published work from 2003 to 2022 was collected; analyzed and pertinent articles were selected for inclusion on this review. Studies reported glazing on monolithic zirconia. Based on their applicability, more than sixty-seven papers were selected for this review. Results: -The findings strongly suggest that there is potential for improvement in each of the current materials and procedures for glazing material on highly translucent Zirconia. The findings indicate that current knowledge is sufficient to recommend monolithic zirconia for crowns and fixed partial dentures for routine clinical use.

Introduction:

A wide range of clinical uses, including fixed dental prostheses (FDPs), root posts, and implant abutments in reconstructive dentistry, are available for yttrium-stabilized zirconia. With flexural strengths of 900 to 1200 MPa, fracture resistance of

more than 2000 N, and fracture toughness of 9 to 10 MPa m^{0.5}, which is nearly twice the value obtained for alumina-reinforced ceramics and nearly three times the value demonstrated by lithium disilicate-based ceramics, it has the most

advantageous mechanical properties when compared to other high-strength ceramics (1). German scientist Martin Heinrich Klaproth introduced the ceramic zirconia (ZrO_2) in 1789. Driske and Helmer the first study on the use of zirconia as a biomaterial was published in 1969. Due to zirconia's strong mechanical qualities, such as its high mechanical strength, great abrasion resistance, and low friction, its application as a biomaterial for dental crowns and implants has increased tremendously in recent years. (2, 3). This prompted other researchers to employ zirconia as a biomaterial in their applications in the domains of orthopedics and dentistry. For more than 30 years, zirconia has been used in orthopedic surgery (4). Since 1998, however, zirconia has been used in the realm of dentistry for tooth restoration applications (5). Zirconium oxide is viewed as an alternative to traditional bio ceramics because of its superior mechanical qualities (toughness, wear resistance, and biocompatibility) (6). Glass-infiltrated alumina and zirconia containing lithium silicate are supported by zirconium. It was created to facilitate the manufacture of single crowns, inlay-retained FPDS, and resin-bonded FPDS. (7, 8) . Due to its excellent flexural strength, low wear, natural tooth color, and minimal dental preparation, this restoration can be produced without veneering porcelain as a monolithic restoration. Monolithic zirconia crowns may have fewer faults since they are made with CAD/CAM technology and a material with excellent homogeneity, which is another benefit (9, 10). Tetragonal zirconia polycrystals stabilized by yttrium oxide (Y-TZPs) were used to create high translucent monolithic zirconia restorations, significantly enhancing their aesthetics. Reduced alumina content, which is often added to zirconia materials to promote their durability during aging but scatters light because it has a different refractive index from zirconia, allowed for the remarkable translucency of the Y-TZP zirconia materials are susceptible to stability issues as they age because to the reduction or disappearance of the alumina content (11). **Table (1)** provides information of

physical characteristics of high translucent zirconia, and **Table (2)** provides information of chemical data of high translucent zirconia (from manufacture instruction). Zirconium oxide has been proposed as a substitute for veneering in the production of full-contour zirconia restorations with occlusal patterns. As a result, the range of indications might be increased and the chipping issue could be resolved (12). Dental restorations are routinely "glazed" to give them glass-coated surfaces that are sanitary and aesthetically pleasing. Glazing can be thought of as the creation of a surface layer of lower thermal expansion glass that, when cooled, performs a variety of tasks, and helps to reinforce brittle ceramics. A thin layer of glass reduces the depth and width of the surface, compresses it, and might theoretically reinforce the material. Plaque buildup is minimal on glazed surfaces (11). This article's purpose is to educate readers on glazing materials and how to affect full contour Zirconia.

Procedures and Materials:

The electronic databases of Google Scholar, PubMed, Science Direct, and Z-library were tried to search for the phrases dental zirconia, glazing material. Criteria for inclusion have been research articles between 2003 and 2022 that learned zirconia for chemical composition, physical properties, and others; articles that studied temperature effects, and others; and articles to dental or biomaterials implants.

The current work tries to present research challenges and future directions in addition to studying the literature that already exists on zirconia. The results of the current study on zirconia and glazing will be helpful for practice in all areas of dentistry that are interested in further study.

1.Zirconia

The name of the gray-white element zirconium stems from the Arabic term (Zar-Gun), which meant "golden color" and was taken from Persian language. Zar denotes gold, and gun denotes color.

German chemist Martin Heinrich initially proposed the ceramic substance zirconia (ZrO_2) in 1789. (13).

Before Driskell and Helmer published the first publication on the use of zirconia as a biomedical application in 1969, zirconia was not researched for medical applications (14). It has long been a popular material for hip replacements, and since 2004 it has also been used in dentistry for crown and bridge applications(15).

Zirconia was launched as a cutting-edge ceramic for use in dentistry, and advancements in CAD/CAM technology made manufacturing it possible to do so consistently, quickly, and reasonably cheaply (16). Zirconia has many advantages as a dental material, including high biocompatibility, low corrosion potential, low heat conductivity, low bacterial surface adherence, and strong radiopacity (17). It is a common biomaterial alternative to alumina that is used in dentistry to create endodontic posts, implant abutments, and crown and bridge restorations. Additionally, it is employed in the production of attractive orthodontic brackets (18). Its mechanical characteristics are equivalent to those of metals, and its color is like that of teeth. Garvie thus created the phrase "Ceramic Steel." Zirconia is the dental ceramic with the highest mechanical characteristics yet observed (19). Zirconia has an atomic mass of 91.22 and is a beautiful transition metallic element. It is incredibly resistant to corrosion. Zirconium has a boiling point of 4.682 K and a melting point of 2.128 K (3.371°F or 1.855°C, respectively) (20). These minerals cannot be used as the primary materials in dentistry due to the existence of diverse metallic impurities that affect color and due to naturally occurring radionuclides like thorium and uranium that render them radioactive. Complex, lengthy, and time-consuming techniques that effectively separate these metallic elements are needed to produce the purest zirconia powder. Ceramic biomaterials can be made from the components that were purified (21). Because they enable the tetragonal structure to be preserved at room temperature, stabilizing oxides are

essential. Depending on the amount of oxide applied, various oxides can be used to stabilize zirconia, including magnesia (MgO), calcite (CaO), yttria (Y_2O_3), and cerium (CeO_2). Zirconia can be stabilized in either the cubic or tetragonal phase at room temperature following sintering (22).

2. Phases of Zirconia

Zirconia is polymorphic by nature; without a change in chemistry, zirconia displays a variety of crystal forms at different temperatures. Zirconia existed in three crystalline phases: monoclinic (M), tetragonal (T), and cubic (C), as shown in **Fig. [1]** (23) .

- The monoclinic phase, which is a distorted prism with parallel sides stable up to 1170°C at room temperature, has a worse mechanical performance and may lessen the cohesiveness of the ceramic particles.
- Tetragonal phase, a rectangular-sided straight prism that is stable between 1170 and 2370 degrees Celsius, makes it possible to create ceramics with better mechanical qualities.
- Cubic phase, a square-sided straight prism with stability above 2370 °C, has a modest mechanical composition (24).

3. Phase Transformation Toughening

Zirconia displays allotropy, which refers to the fact that it has a similar chemical composition but a distinct atomic arrangement. There are crystallographic polymorphs called cubic (c), tetragonal (t), and monoclinic (m). These levels have different physical and mechanical characteristics, Pure zirconia is (m) at room temperature and pressure; when the temperature rises, the material changes to (t) starting at around 1170 °C, and then to (c) starting at about 2370 °C (25) .

The (t) phase is metastable, and it will change to the (m) in response to a mechanical stimulus like a crack in the ceramic's surface **Fig. [2]**. Stress accumulates at the crack's tip, causing metamorphosis. The tetragonal to monolithic t-m transition at the fracture point is followed by a four percent increase in volume because monoclinic crystals have larger dimensions (26).

Because of the t-m transformation, which occurs several microns below the surface of the materials, and the expansion of compressive strains caused by the rising in volume connected to the transformation, grinding often increases the strength of metastable tetragonal zirconia polycrystal. These compressive forces inhibit the spread of superficial microcracks, which promotes surface and subsurface damage (20). Although it makes it more challenging, the toughening process does not stop a fracture from spreading. Therefore, it is expected that cracks will spread when there is an excessive amount of stress (27).

4. Mechanism of low-temperature degradation LTD

Monolithic zirconia is subject to low-temperature deterioration (LTD), a type of aging. Low temperatures (150-400 °C) and the presence of water trigger slow t-m transitions on the surface of zirconia, which eventually spread into the material's mass. Extreme microcracking, grain pullout, and surface roughening are all effects of the enlargement of a transformation region that both lower strengths. Rougher zirconia surfaces were shown to cause LTD to be more evident, suggesting that smooth surfaces are required to prevent LTD (28).

Factors like porosity, grain size, residual stress, and stabilizer content have an impact on the aging mechanism. Aging alters the mechanical characteristics of zirconia in vitro even when the results are within scientifically acceptable ranges (22).

5. Major types of zirconia used in dentistry

Three distinct materials were created for use in dentistry, including yttria stabilized tetragonal zirconia poly crystals, magnesia partially stabilized zirconia, and zirconia toughened alumina (3Y-TZP) (29).

1-Zirconia toughened alumina

Zirconia-based ceramic is mixed with an alumina (Al₂O₃) matrix to create a structure known as (Zirconia toughened alumina). At room temperature, the stability of the tetragonal phase was

influenced by particle location, size, and shape (intra- or inter granular) (19). A hardened ceramic with 33mol% zirconia stabilized with 12mol% ceria is the In-Ceram Zirconia (Vita Zahn Fabrik, Germany) (12Ce-TPZ). This product can be processed using the slip-casting method (30).

2- Magnesia partially stabilized zirconia

The partially stabilized zirconia polycrystals are created by adding 8 to 10 mol% of magnesium oxides to the cubic zirconia that makes up the microstructure of Mg-PSZ. Due to the difficulties in getting magnesium silicate precursors free of SiO₂, which causes magnesium silicate to change from tetragonal to monoclinic and reduce the stabilizing Mg concentration (31, 32). This material has been used in the design of fully sintered blocks along with the necessary strong and stiff machining techniques. A fully sintered Mg-PSZ ceramic for dental crown and bridge treatment is the Denzir-M system from Dentronic AB in Skelleftea, Sweden. This form of zirconia also has a substantially greater sintering temperature (1680–1800 °C) than other composites (33).

3- Yttria full stabilized tetragonal zirconia polycrystals

The 3Y-TZP is made up of a kind of partially stabilized zirconia that has been stabilized with 2%–4% mol of yttria oxide. It was reported in 1977 that following sintering, fine grain zirconium oxide (typically 0.5 μm) with low concentrations of yttria oxide stabilizers might include up to 98% of the metastable tetragonal phase (34). Tetragonal grains with homogeneous diameters in the order of nanometers make up most of this microstructure, which is occasionally coupled with a minor amount of the cubic phase. Because of its high refractive index, low absorption coefficient, and great opacity in the visible and infrared spectrum, yttria stabilized zirconia (yttrium oxide) is suitable for optical applications. Due to its excellent biocompatibility and mechanical characteristics, 3Y-TZP was initially successful in the medical sector of

orthopedics (23, 35) . Microstructures with small grains (0.2 to 0.5 mm in diameter) were developed specifically for dental applications to prevent structural corrosion or deterioration in the presence of saliva and to slow the growth of subcritical cracks (SCG) (36). With 3Y-TZP, prosthetic restorations can be created by either entirely milling sintered blocks or by first sintering pre-sintered blocks at a high temperature. With the use of CAD/CAM technology, the blocks are machined, and in the case of pre-sintered blocks, prosthetic restorations are pre-shaped into a size 25 to 30% higher than required (depending on the batch of material) to account for the sintering shrinkage. Between 1350 and 1550 °C is the final sintering temperature (37). By reducing stress and preventing the transition from the tetragonal phase to the monoclinic phase, this technique creates a final surface that is essentially free of the monoclinic phase. To maintain surface safety and stop the transition from the tetragonal phase to the monoclinic phase, procedures to modify or sandblast this material must be removed. These blocks are made more stable by the structures above them, which contain a lot of crystals and have flexural forces between 900 and 1200 MPa (38). Isostatic pressure is used to thoroughly sinter the blocks at a temperature of 1400 to 1500 °C. The result of this procedure is a block with a final density that is almost 99%, a high hardness, and a low machinability. Hence, machining systems need to be reliable (39).

6. Classification of Zirconia depended on fabrication mode

1-Partial contour zirconia:

It is possible to produce veneered zirconia while Y-TZP is partially sintering. The partial contour zirconia restoration is referred to as a bi-layered restoration because it combines a porcelain layer on top of the exterior surface to give a more aesthetically pleasing result. Where a ceramic coating is simply applied to a tiny area when aesthetics are needed, the restoration is referred to as hybrid or lightly veneered (40, 41).

2- Full contour zirconia:

Whole anatomical crowns are made from tetragonal zirconia polycrystal blocks that have been fully stabilized and partially sintered with yttria. A single material block, such as monolithic, is machined to recreate the entire contour restoration(42) . It was intended for posterior crowns, complete arch bridges up to 14 units, crowns over implants, and crowns with little occlusal room. It possesses increased wear resistance, improved esthetics, high flexural strength, reduced thermal expansion, and high fracture toughness (18). the production of completely contoured monolithic zirconia crowns (43) the anguish of aesthetic porcelain fractures on posterior crowns and bridges may finally come to an end. Crowns can be prepared using a chamfer, butt shoulder, or knife-edge finish line, just like conventional PFM crowns (44, 45).

7. Monolithic and layered zirconia

A ceramic repair that is entirely constructed of ceramic material is referred to as an "all ceramic restoration." In an all-ceramic reconstruction, the ceramic material may be monolithic (uni-layer), consisting of only one ceramic material, or it may be bi-layered, with a ceramic core material covered in a veneer of ceramic. The bi-layered, all-ceramic restoration's ceramic core offers stability and strength, and the veneer gives the restoration its final form, color, and appearance. In situations when aesthetics is the main concern, a bi-layered, all-ceramic repair is typically used. On the other hand, since the monolithic restoration is built of a single ceramic material, it is more stable than the bi-layered kind. However, the appearance of such reconstructions may not be as good as (46). Monolithic zirconia ceramics now have improved translucency but a significant loss in strength due to recent changes in composition, structure, and production techniques (47).

8. Monolithic zirconia

In order to get the traditional A1 to D4 shades, the dyeing liquid is put to milling blocks with a porous green condition, and

the color ions are then absorbed into the zirconia during the sintering process (28). Monolithic zirconia must be sintered at high temperatures for extended periods of time, which uses a lot of energy. Zirconia's microstructure and characteristics, such as biaxial flexural strength, translucency, and grain size, may be significantly impacted by the different sintering temperatures (48).

9. Sintering process of zirconia

Conventional furnaces are most frequently used to sinter zirconia. These furnaces sinter materials at temperatures between 1350 and 1400°C for 2-4 hours or for nine hours. The characteristics and microstructure of zirconia can be negatively impacted by changes in the settings used to sinter the material. The zirconia grain formation is influenced by the sintering process. Zirconia's stability is inversely correlated with the size of its grains. The transition ceases entirely for grains smaller than 0.2 μ m, while the rate is modest for grains 0.2-1 μ m in size (44).

10. CAD/CAM system:

A branch of dentistry and prosthodontics known as CAD/CAM dentistry uses computer-aided design and computer-aided manufacturing (CAD/CAM) to enhance the planning and production of dental restorations (49), notably dental prosthetics including crowns, crown layers, veneers, fixed bridges, dental implant restorations, removable or permanent dentures, and orthodontic devices. In addition to improving the convenience or simplicity of the design, creation, and insertion procedures, CAD/CAM enhances prior technologies employed for these objectives by enabling repairs and appliances that would not have been conceivable without them. Other objectives include lowering unit costs and making appliances and renovations that would otherwise be prohibitively expensive and affordable. However, chairside CAD/CAM still frequently requires more dental time, and the cost is frequently at least twice as costly as for traditional restorative procedures employing lab services. One of the

excellent dental laboratory technologies is CAD/CAM (50).

11. Classification of milling unit of CAD-CAM system according to the processing technique, there are two types:

1- Dry machining

This method is frequently used for zirconia and chromium cobalt blanks/blocks with little pre-sintering and wax, and some manufacturers also provide the option of milling composite resin, polyurethane, and PMMA materials in dry condition (Paradigm MZ 100 composite/3M, ZS dental PU (polyurethane) Disc/Xiamen Zhisen, CopraTamp PMMA block/WHITEPEKS). Due to the machining device's reduced investment costs and the need for minimal moisture absorption, the repair does not require drying before sintering (51, 52).

2 -Wet machining

In this procedure, the milling diamond or carbide cutter is shielded from overheating of the milled material by a spray of cool liquid as shown in **Fig. [3]**. All metals and glass ceramic materials require this type of preparation to prevent damage from heat development. If zirconium oxide ceramic with a higher degree of pre-sintering is used for the milling process, "wet" processing is advised. More pre-sintering lowers the shrinkage factor and makes sinter distortion less likely (53).

12. Classification according to CAD/CAM material machining at different density stages, there are three stages:

1 -Green stage processing

Green stage blanks are created without pre-sintering from ceramic powder and a binding agent (un-sintered blanks). They are milled to provide a coping that is later totally sintered while still being as soft as chalk. The benefit of this milling type is that it offers quick and simple processing, but the drawback is that it is more challenging to transport and use because of its low degree of stability. using a carbide metal bur without liquid cooling to

grind a blank. A 25% linear shrinkage is anticipated after burning because the green stage is more porous. However, none of the CAD/CAM systems currently available process zirconia oxide in the green stage (51).

2- White stage processing

Compared to un-sintered blanks/blocks, pre-sintered or partially sintered blocks/blanks have acceptable stability and are simpler to utilize during production. The blocks/blanks have already shrunk by around 5% because of the thermal pre-treatment process. The ensuing liner shrinkage, which might reach 20%, happens throughout the manufacturing process. Using a diamond bur with water cooling or a carbide metal bur without water cooling to grind this material (51).

3 -Processing in hot isostatic pressing (HIP) condition

Zirconium oxide (TZP zirconia) is subjected to 1000–2000 bars of pressure while being heated at a temperature just below that of sintering as part of the pricy HIP process. It is only produced when a product requires it, for instance (aeronautics, spatial and medical implants). After this procedure, only grinding with diamond bur can be done. This approach has the advantage of giving zirconia higher mechanical qualities due to an increase in density from decreasing internal porosity and skipping the necessary sintering operation, but the disadvantages include a longer milling time and increased tool wear (51).

13. Glazing

The technique of glazing involves coating the exterior of the restoration with a thin layer of a glassy or vitreous, non-fusing silica-based material (54). Glazing creates shiny, smooth surfaces that are more resistant to fracture propagation by sealing pores on the ceramic surface that were opened during the sintering process. To create a surface that looks more natural, many professionals prefer to polish ceramic rather than glaze it (55).

Glazing after grinding is believed to increase strength by reducing the depth of

surface defects and cracks. On the other hand, it is still unknown whether glazing has a strengthening effect on porcelain (56).

Dental restorations are routinely "glazed" to give them glass-coated surfaces that are sanitary and aesthetically pleasing. Glazing can be thought of as the creation of a surface layer of lower thermal expansion glass that, when cooled, performs a variety of tasks and helps to reinforce brittle ceramics. It induces a compressive condition in the surface. Additionally, a thin coating of glass minimizes the depth and width of the surface while theoretically strengthening the substance. Plaque buildup is minimal on glazed surfaces (11).

14. Types of glazing

There are two glazing techniques that can be used to create a smooth ceramic surface. These methods are referred to as (over glaze) and (natural glaze). Glazing increases practical strength and aesthetic appeal while also producing a very smooth, hygienic surface (57).

1- Over glazing

The surface of the formed restoration is overglazed with a different paste of powder and liquid (low fusing transparent porcelain), and the restoration is then burned at a temperature that is 200 to 600 degrees Celsius lower than the fusing temperature of dentin and enamel porcelain. Using an overglaze to reinforce ceramics is another option (57).

2- Natural glazing

Natural glazing regulates surface temperature without the use of other components. The restoration temperature is frequently the same as or slightly greater than the firing temperature. If a natural glazing is desired, the crown will be burned after the stains are applied. At the entrance to the furnace muffle, the restoration must be given time to dry until the stain medium has entirely evaporated, leaving a dry, chalky surface. The crown is then cautiously inserted into the furnace and fired for a brief interval—usually 1 to 2 minutes—at the glazing temperature advised by the manufacturer, until the

porcelain's outside surface reaches the required degree of gloss (57).

15. The effect of glazing

A common laboratory procedure involves glazing ceramic restorations, which involves giving finished restorations glass-coated surfaces that are both aesthetically beautiful and hygienic. There is some debate over whether glazing actually improves restoration (58). The production of porcelain crowns and bridges is incredibly method dependent and requires excellent laboratory technician abilities. Minor laboratory errors can lead to surface layers that are clinically inappropriate. One of the major faults is the development of porosities. These porosities have an impact on surface texture, shade, and roughness. Dental porcelain porosities are frequently caused by defects during condensation, an inappropriate powder/liquid mixing ratio, and variations in fire duration and temperature (58).

Discussion:

This systematic review focused on the outcomes of clinical studies reporting on monolithic zirconia fixed dental prostheses and glaze material. Due to its exceptional biocompatibility, low cytotoxicity, chemical stability, high mechanical strength, superior fatigue resistance, high fracture resistance, and hardness, zirconia is frequently utilized in prosthetic dentistry. Zirconia is utilized to create individual dental crowns, brief fixed partial dentures, and implants due to its qualities and the further advancement of digital technology equipment (59). The development of new zirconia ceramics for dental restorations is ongoing with the aim of retaining mechanical integrity while enhancing translucency. Monoliths are becoming more popular since they are more durable and don't have interfacial or residual stress problems. It is being investigated to use compositional variants like nanostructures, graded structures, and biomimetic structures. Understanding fundamental damage mechanisms is essential for the continuous development of more aesthetically pleasing yet robust zirconia's (60). A mixture of colorless

glass powder and liquid is used in the laboratory process of glazing to smooth out the ceramic surface, close any pores, and decrease roughness (61). When considering the glazing process as a surface treatment, the external appearance of the surface is significantly influenced by the microstructure, the smoothness of the surface on which the glaze layer is formed, and the interface between them. Yes, the glaze layer serves as protection, but it may also be directly impacted by aging or by changes to the underlying material (61). Monolithic zirconia prosthesis might offer enhanced biofilm buildup, enhanced wear, and good aesthetic quality. This systematic review could not uncover any supporting data for these or other material superiority (or equivalence) claims. Assessments of quality that go beyond mechanical results (such as fracture or chipping) and esthetic outcomes, as well as patient-based outcomes, should be included in a thorough investigation of clinical outcomes for monolithic zirconia restorations (satisfaction and quality of life). The clinical options available after problems should also be considered. The archival nature of the digital workflow and preservation of the digital information suggest that the necessary CAD/CAM process of producing monolithic prostheses may give an inherent advantage in maintenance or replacement (37). Our results were also in conformity to a study performed by (62) which proved that the glazed full-contour zirconia (monolithic zirconia) have better result than other surface treatment. Our results were in line with previous study by, suggesting that glazing may not be as effective as it could be because the coating layer is not thick enough to adequately fill up the grooves and microcracks on the ceramic surface (63). Another study was done by (64) demonstrated that monolithic zirconia glazing performed lower than alternative surface treatments. When zirconia is heated during glazing surface treatments, the material weakens and changes from tetragonal to monoclinic, which is consistent with (65). Monolithic zirconia's brightness and yellowness are both reduced by glazing. Monolithic zirconia,

which is also applied after glazing, becomes darker and more yellowish as additional coloring liquid is poured to it (66), and this agree with (11) that proved the glazing decreased the highly translucent zirconia and glaze firing without the glaze material had no effect on the highly translucent zirconia. Numerous investigations have demonstrated that the glaze used to cover sintered zirconia improved smoothness, decreased surface flaws, and caused a phase change at the interface from tetragonal to monoclinic (67).

Conclusion:

The glazing over monolithic zirconia is a delicate technique. Zirconia is suitable for monolithic restorations due to their physical and chemical properties; however, careful processing method selection, ceramic material selection, Technician experience and laboratory expertise are necessary to enhance the bonding between zirconia and glazing material.

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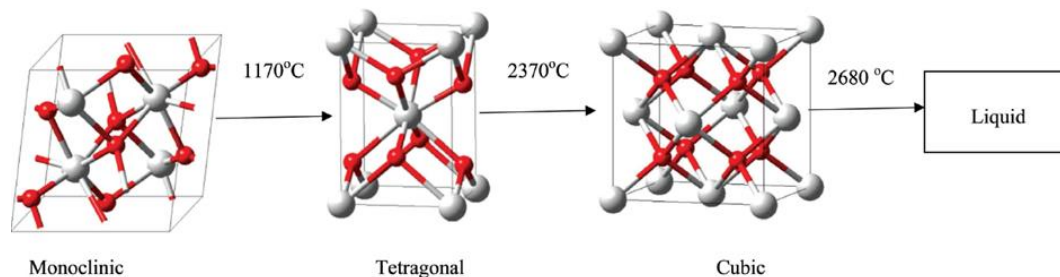


Fig. (1): Crystallographic phase change with the variation of temperature of the three ZrO₂ phases

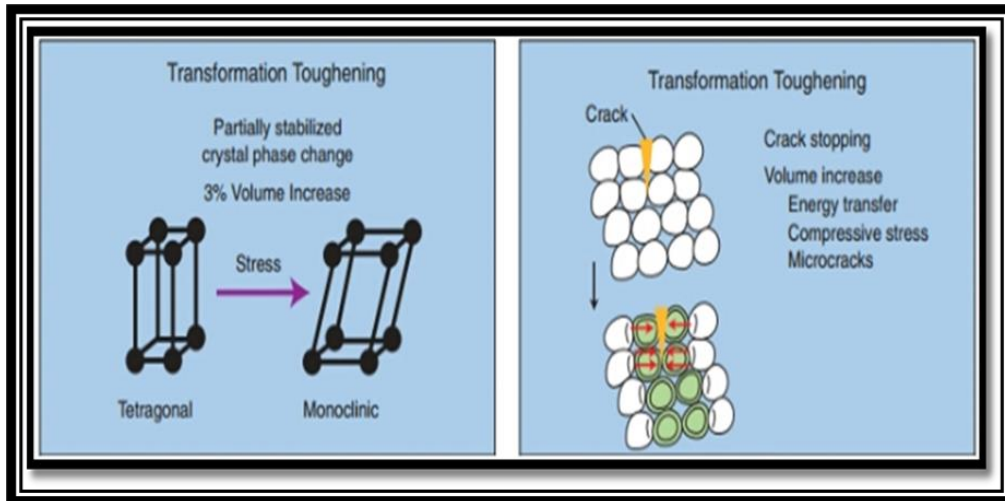


Fig. (2): Transformation Toughening of Zirconia



Fig. (3): Wet milling

Table (1): Characteristics of physical high translucent zirconia

Property	High translucent zirconia
Coefficient of thermal expansion (20 - 500 °C)	approx. 10.0
Chemical solubility (ISO 6872)	< 20
Density after sinter firing	approx. 6.03
3-point flexural strength* (ISO 6872)	> 600
Sintering temperature	1450
Type/class*	II / 4a

Table (2): Chemical composition high translucent zirconia

Component	High translucent zirconia
–	5Y-TZP
ZrO ₂	86 – 91
Y ₂ O ₃	8 – 10
HfO ₂	1 – 3
Al ₂ O ₃	0 – 1
Pigments	0 – 1

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