2023 • Vol. 1, No. 1 • pp. 26-36
Future Dental Research (FDR)

Print ISSN: 3006-0516
Online ISSN: 3006-0354
NABEA AL-AJYAL FOUNDATION PRESS
Future Dental Research (FDR)

Monolithic Zirconia in Dentistry: Evolving Aesthetics, Durability, and Cementation Techniques - An In-depth Review

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Access this article online

REVIEW A R T I C L E

Received: 05.07.2023 **Revised:** 09.08.2023

Accepted: 15.08.2023 **DOI:** 10.57238/fdr.2023.145202.1003

OPEN ACCESS

ABSTRACT

The objective of this article is to provide a thorough examination of the evolution of dental zirconia, encompassing its varieties, characteristics, uses, and methods of cementation. A thorough exploration of PubMed and Embase databases was undertaken. The inquiry was restricted to articles published in the English language. The ultimate search took place in October of 2021. Recently created monolithic Zirconia ceramics have greatly improved aesthetics and transparency. Yet, it is imperative to conduct additional in vitro and in vivo research to ascertain the material's capacity to sustain its outstanding attributes over the long term. As per the existing literature, monolithic translucent Zirconia has demonstrated encouraging outcomes and a notable rate of longevity. Therefore, this material is recommended for situations where both strength and aesthetics are required. Advancements in both the materials and techniques for cementing monolithic Zirconia have substantially improved, prompting dentists to consider using this material, particularly in situations where a conservative approach is needed. Zirconia restorations exhibited positive results, especially in the case of monolithic Zirconia crowns supported by implants and fixed dental prostheses.

Keywords: Dental Zirconia, Monolithic Zirconia ceramics, Aesthetics, Transparency, Cementation techniques, Implant-supported crowns, Fixed dental prostheses

1 Introduction

The preference for ceramic prostheses over metal-ceramic restorations has been increasing, primarily due to aesthetic and biocompatibility considerations [1]. Conversely, ceramics exhibit fragility and brittleness, especially when employed as a veneer. Numerous methods have been devised to address issues with ceramic veneers, which include enhancing the translucency and color of zirconia (Zir), allowing for the material's direct use without requiring a veneer. In contrast to other ceramic materials, the utilization of monolithic Zirconia frequently significantly decreases mechanical issues and diminishes the necessity for extensive tooth structure preparation. This results in a prosthetic restoration that preserves as much of the original structure as feasible. Monolithic Zirconia is employed in single crowns and boasts a high rate of long-term success. At present, there are ongoing trials to produce fixed partial dentures supported by teeth or implants using this material [2]. Historically, dental zirconia has been predominantly crafted from tetragonal zirconia crystals with a small amount of yttria stabilizer (3Y TZP); this variant is exceptionally robust but exhibits limited translucency [3]. This was achieved through the creation of partially stabilized Zirconia with higher yttria concentrations, such as 4 mol% (4Y-PSZ) or 5 mol% (5Y PSZ). The presence of the c-phase diminishes the stress-induced strengthening of Zirconia, leading to a decrease in both strength and toughness. Consequently, the highly translucent 5Y-PSZ materials in the front teeth area are restricted to single-unit crowns and short-span fixed dental prostheses (FDPs). Nonetheless, situations involving high stress demand more robust restorations, such as multiunit posterior restorations and the rehabilitation of bruxism patients. Therefore, it is crucial to augment the durability of these highly translucent materials. In comparison to conventional multi-layered restorations, monolithic lithium disilicate provides numerous advantages [4]. In such a scenario, the material Yttrium-tetragonal Zirconia polycrystalline (Y-TZP) can be employed [5]. Yet, the translucency of standard Yttrium-tetragonal Zirconia polycrystalline (Y-TZP) is only approximately 70% of that found in lithium disilicate [6].

It has been demonstrated that the traditional etching/silane treatment is not effective for Zirconia [7]. Nevertheless, surface modifications are required; conventionally, the inner surface of Zirconia is altered through air abrasion to enhance mechanical adhesion [8]. Zirconia-based restorations are known for their favorable mechanical attributes, longevity, and compatibility with oral tissues. However, zirconia's opaqueness hinders its application in the posterior region, and its elevated hardness may cause wear on natural teeth in opposition. Furthermore, because of zirconia's crystalline composition, it is not suitable to employ hydrofluoric acid for etching the inner surface of zirconia-based restorations, nor is it compatible with adhesive resin cement. Therefore, zirconia can be affixed using standard cement options like glass-ionomer-based cement. In contrast, zirconia-reinforced lithium silicate ceramic (ZLS) exhibits superior mechanical and optical characteristics and can be polished within the mouth. ZLS can be affixed with adhesive resin cement, which is a significant benefit as it boosts the fracture resistance of the restorations [9]. The objective of this review is to provide a contemporary overview of the varieties, characteristics, dental uses, and cementing techniques of monolithic Zirconia.

2 Zirconia History

Zirconium is a malleable, silver-hued metal derived from a silicate mineral known as zircon. In 1824, Berzelius successfully extracted the metal in a crude form for the inaugural time [10]. Zircon has been esteemed as a valuable gem since ancient eras [11]. Zirconium dioxide, a crystalline variant of zirconium, found its initial application in medicine for orthopedic uses in 1969. It was suggested as a new option for hip-head replacement in lieu of titanium or alumina prostheses [12]. ' Due to increased concern regarding the appearance, potential toxicity, and allergic reactions linked with certain alloys, both patients and dentists have shifted their interest towards metal-free, tooth-colored restorations. Consequently, in the latter part of the 20th century, there was a rise in the creation of new high-strength dental ceramics that exhibit reduced brittleness, less limitation in their tensile strength, and decreased susceptibility to stress failure over time. These attributes are especially attractive in the field of prosthetic dentistry, where both strength and aesthetics hold paramount importance [13,14]. During the late 1990s, the initial CAD/CAM-manufactured Zirconia coping was introduced to provide a robust and visually pleasing framework for porcelain fused-to-Zirconia (PFZ) restorations. The initial widely recognized product was Nobel Procera® Zirconia (Nobel Bio Care, USA), succeeded by Lava TM Zirconia (3M ESPE, St. Paul, MN, USA) in the early 2000s [15].

3 Types of Zirconia and Dental Zirconia

Zirconia, or zirconium dioxide (ZrO_2), is a versatile ceramic material that's been employed in various industries due to its unique physical and chemical properties. In the dental sector, its adoption has revolutionized the landscape of prosthetic restorations. Here, we'll first delve into the broader types of zirconia and then narrow our focus to those pertinent to dentistry.

Types of Zirconia Fig.1 [16]

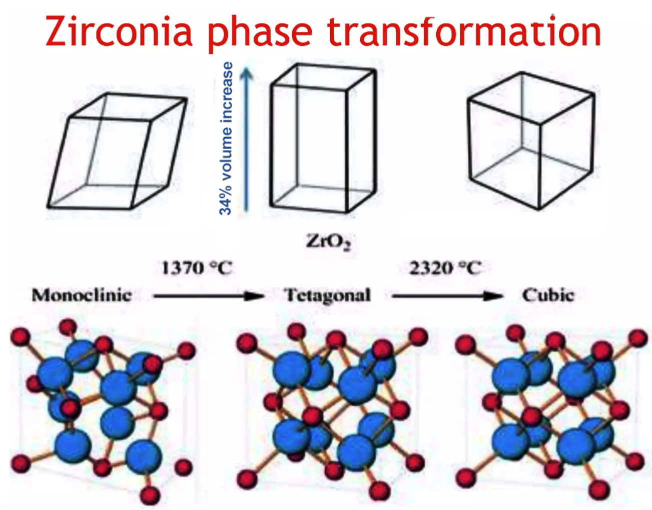

Fig. 1. Types of zirconia and zirconia phase transformation.

1. **Monoclinic Zirconia:** This is the most basic form of zirconia and is typically present at room temperature. However, it's not generally used in its pure monoclinic form due to its lack of toughness and strength.

2. **Cubic Zirconia:** When zirconia is stabilized with a sufficient quantity of certain oxide additives, such as yttria, it results in the cubic phase. In the world of jewelry, cubic zirconia is a popular gemstone substitute for diamond due to its clarity and refractive properties.

3. **Tetragonal Zirconia Polycrystal (TZP):** This is a toughened form of zirconia that's stabilized typically with yttria. The transformation toughening that occurs in this material makes it especially resistant to crack propagation.

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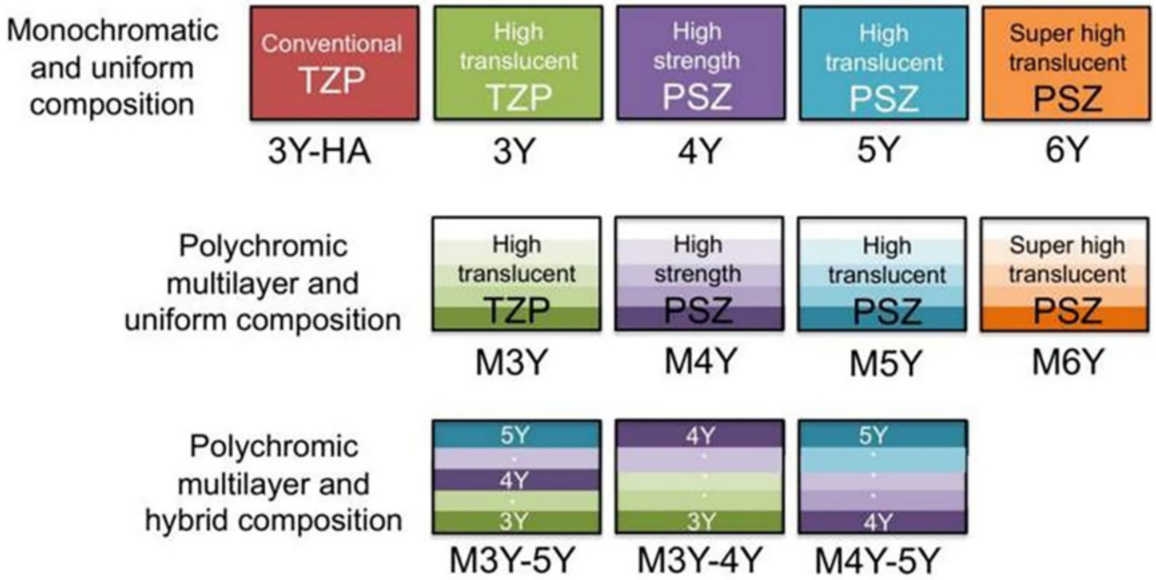

Fig. 2. Classification of yttria-stabilized dental zirconia [18].

4. **Partially Stabilized Zirconia (PSZ):** This form of zirconia contains both monoclinic and tetragonal or cubic phases. PSZ has improved mechanical properties as compared to pure monoclinic zirconia.

Dental zirconia types Fig.2 [17]

1. **3Y-TZP (3 mol% yttria-stabilized tetragonal zirconia polycrystal):** This is one of the earliest forms of dental zirconia, known for its high flexural strength and fracture toughness. It's typically white and opaque, making it suitable for posterior crowns and bridges.

2. **High-translucency or 5Y-TZP:** This version of zirconia has increased yttria content, resulting in improved translucency compared to 3Y-TZP. It's suitable for anterior crowns and veneers due to its better aesthetic properties.

3. **Multilayered Zirconia:** This form integrates layers with varying translucency, allowing the fabrication of a restoration that mimics the natural gradient of a tooth from the more opaque dentin to the translucent enamel.

4. **Nanostructured or Nano-Grained Zirconia:** Through the use of advanced manufacturing techniques, this zirconia has a fine grain size, offering a balance between strength and translucency.

5. **Zirconia Toughened Alumina (ZTA):** A combination of zirconia and alumina, this composite material capitalizes on the strengths of both materials to create a durable and aesthetic restoration.

Dental zirconia's blend of strength, aesthetics, biocompatibility, and versatility has solidified its position as a favored material in modern dentistry [19].

3.1 Strength and durability

One of the most notable attributes of dental zirconia is its high strength and toughness. In fact, it's often referred to as "ceramic steel". The mechanical properties of zirconia make it exceptionally resistant to cracks and fractures. This makes zirconia restorations, such as crowns and bridges, highly durable, allowing them to handle the functional demands of mastication with ease.

3.2 Aesthetics

With the evolution of dental materials, aesthetics has become a primary concern. Zirconia stands out as it can be fabricated to mimic the translucency and color of natural teeth, allowing for restorations that seamlessly blend in with the patient's own teeth. While earlier zirconia restorations were more opaque, newer iterations, especially translucent and multi-layered zirconia, provide excellent optical properties that meet patient aesthetic desires.

3.3 Biocompatibility

In the realm of medical and dental materials, biocompatibility is paramount. Zirconia boasts a high degree of biocompatibility, which means it's unlikely to cause an adverse tissue response when in contact with the oral environment. Its inert nature ensures that zirconia restorations don't elicit allergic reactions or inflammatory responses, making it safe for long-term intraoral use.

3.4 Versatility

Zirconia's unique blend of strength and aesthetics has expanded its applications in dentistry. It can be used for a range of prosthetic solutions including crowns, bridges, implant abutments, and even full-arch implant-supported prostheses. Its versatility is further enhanced by the ability to bond zirconia to the tooth structure using specialized cements, which ensures long-term retention of the restoration.

3.5 Low thermal conductivity

Another advantage of zirconia is its low thermal conductivity. Unlike metals that can transmit temperature changes quickly and cause discomfort to patients, zirconia acts as an insulator. This means that hot or cold stimuli are less likely to be directly transmitted to the underlying tooth structure or pulp, providing a more comfortable experience for the patient.

3.6 Wear on opposing dentition

One potential concern with some dental ceramics is their abrasiveness, which can cause wear on opposing natural teeth. Zirconia, when polished properly, tends to be kinder to the opposing dentition than other ceramics, causing less wear over time.

Despite its many benefits, working with zirconia is not without challenges. Due to its hardness, adjusting or refining zirconia chairside can be difficult. Moreover, ensuring a strong bond between zirconia and tooth structure requires meticulous surface treatment and the use of specialized cements.

4 Production of Dental Zirconia

The production of dental zirconia, used primarily for dental crowns, bridges, and implants, has risen in prominence due to the material's exceptional biocompatibility, strength, and aesthetic qualities. This specialized type of zirconia undergoes a unique production process to meet the strict standards required for dental applications.

Dental zirconia starts its journey as zircon sand (zirconium silicate, $ZrSiO_4$), which is extracted from mineral deposits through mining methods like open-pit excavation or dredging. Once mined, the sand, which contains a mix of minerals, needs to be processed to isolate zircon. This separation involves techniques such as gravity separation, magnetic and electrostatic methods, and flotation, leading to a concentrated zircon product [20].

An essential step in the preparation of dental zirconia is detoxifying the zircon, as it naturally contains trace radioactive elements. This is achieved by calcination, a heating process that neutralizes these elements, making the zircon safe for dental and medical use. Following detoxification, zircon undergoes a transformation to yield zirconium chemicals. This involves a chlorination process where zircon is treated with chlorine and carbon to produce zirconium tetrachloride ($ZrCl_4$). Once formed, this compound is purified and subsequently hydrolyzed, resulting in zirconium hydroxide. Zirconia is then precipitated from these zirconium chemicals, typically using ammonia. The reaction with ammonia results in the formation of hydrated zirconia. This hydrated zirconia is then subjected to calcination, a process that removes any lingering moisture and ensures the zirconia assumes the desired crystalline form suitable for dental applications. For its use in dentistry, blocks or discs of zirconia are crafted. These are meticulously milled into the necessary shapes using computer-aided design and computer-aided manufacturing (CAD/CAM) systems. Dental professionals or dedicated labs input the specific design of the dental prosthetic, such as a crown, and the milling machine accurately sculpts the zirconia block. However, post-milling, the zirconia isn't yet at its optimal strength.

It needs to undergo sintering, where it's heated to high temperatures, which not only increases its strength but also ensures the material reaches its desired density. A significant advantage of zirconia in dental applications is its capacity for customization to match natural teeth. The milled zirconia can be colored to align with a patient's natural tooth shade using specialized coloring solutions. After the sintering process, a glaze can be applied, offering the zirconia a natural gloss and smooth texture. Given the importance of dental prosthetics' function and aesthetics, the final zirconia products are subjected to rigorous quality control procedures. This ensures each product aligns with the exacting standards for strength, fit, aesthetics, and overall quality [21].

5 Utilizations in Dental Practice

5.1 Zirconia-Based dental posts

When all-ceramic restorations are used for anterior teeth, the use of metal posts can lead to aesthetic issues, such as staining of translucent crowns [22]. In oral environments, prefabricated posts can lead to corrosive reactions, resulting in issues like a metallic taste, mouth burning, sensitivity, and discomfort [23]. Due to these concerns, transparent posts constructed from Zirconia and other ceramic materials have been introduced. Zirconia posts come in various designs, including smooth, tapered, and parallel options, as well as those with an apex taper and a coronal parallel configuration. The tip at the apex is rounded to minimize the buildup of stress at the root tip. Zirconia posts exhibit excellent biocompatibility, radiopacity, and effective light transmission for use in both root and coronal restorations. In a clinical study, Zirconia ceramic posts showed a high rate of success [24]. Likewise, Zirconia posts with direct composite cores demonstrated a high clinical success rate after 4.7 years [25]. Zirconia posts offer benefits in aesthetics and biocompatibility [26]. Nonetheless, it comes with certain constraints like its rigidity, limited flexibility, challenges in handling smaller sizes, and potential requirements for retreatment [27]. Following dynamic loading and thermocycling, Zir posts exhibited limited resin bonding capabilities within the root dentin [28]. In comparison to serrated metal posts, Zirconia ceramic posts demonstrated reduced retention values [26]. Lately, it has been affirmed that a personalized Zirconia post and core can be manufactured using CAD/CAM technology, either by directly scanning the canal space [29] or indirectly after making an impression and scanning the replica of the cast [30].

5.2 *Crowns and bridges constructed with Zirconia*

A range of Zirconia frameworks has been utilized for crowns and bridges [31]. Zirconia frameworks present fresh opportunities for metal-free permanent partial dentures and single-tooth prostheses, displaying positive initial clinical results [32]. A research study utilized the DCS President® technology to manufacture 65 Zirconia bridges and monitored the recipients for an average period of three years. The findings revealed that 6% of the bridges exhibited slight veneering material detachment, indicating an overall cumulative survival rate of 86% [33].

5.3 *Zirconia-Based implant abutments*

Based on laboratory studies, Zirconia exhibits enhanced biocompatibility when compared to titanium oxide, and it is on par with alumina in this regard. There have been no discoveries of cytotoxicity, carcinogenicity, mutagenicity, or chromosomal alterations associated with this material [34].

Zirconia is chosen for implant-supported restorations due to its exceptional durability and lower elasticity modulus. Zirconia (Zir) offers advantages over stabilized and transformation-toughened alumina, addressing issues related to alumina's brittleness and potential implant failures [35].

These abutments are notable for their natural tooth-like appearance, excellent tissue compatibility, and minimized plaque accumulation [36]. A study conducted in living organisms showcased a notably high cumulative survival rate (98–100%) with the utilization of Zir and Al2O3 abutments [36]. In a prospective study spanning four years, a 100% cumulative survival rate was observed for 53 Zir abutments [37]. A case was documented where a patient with multiple implant-supported Zir crowns experienced metal sensitivity [38]. Both cases demonstrated successful osseointegration. Nonetheless, Zirconia remains a highly dependable biomaterial for abutments supporting implant crowns and fixed dental prostheses (FDPs). Nevertheless, the occurrence of veneering porcelain fractures poses a challenge to the clinical effectiveness of Zirconia-based implants. Fractures in Zirconia stem from a technical problem [39]. There have been concerns raised about the long-term clinical effectiveness of Zirconia in fixed implant prosthodontics, attributed to issues like veneering ceramic fractures and Zirconia's susceptibility to aging [40]. Restorations incorporating 3Y-TZP have been suggested as a substitute for titanium abutments and implants. This is because they offer improved optical characteristics, greater resistance to corrosion and wear, enhanced biocompatibility, and a reduced tendency for plaque buildup and peri-implantitis. Nonetheless, clinical studies have indicated a higher likelihood of early fracture in Zirconia implants when compared to titanium implants [41]. Therefore, ensuring mechanical integrity is the primary concern.

5.4 *Zirconia Bar-Retained implant overdenture*

The bar attachment utilized for securing overdentures is typically made from base metal and titanium alloys. Nevertheless, due to its superb biocompatibility, strength, and natural coloration, zirconia has emerged as a prospective material for fabricating bar attachments [42]. Moreover, employing CAD/CAM technology facilitates the straightforward production of a zirconia bar, eliminating numerous technical procedures and potential errors linked to conventional casting methods [43].

5.5 *Zirconia Resin-Bonded bridge with a single retainer*

When basic requirements are fulfilled, the single-retainer ceramic Resin-Bonded Bridge (RBB) has shown to be the most reliable option. In earlier times, InCeram (composed of alumina) and e.max (made from lithium disilicate) were the prevalent materials. Zirconia is currently favored as the material of choice for connector strength [44].

5.6 *Esthetic orthodontic brackets made of Zirconia*

Zirconia has been utilized in the production of esthetic orthodontic brackets [45]. Polycrystalline zirconia brackets have replaced alumina ceramic brackets due to their improved toughness [46]. Polycrystalline zirconia brackets are more cost-effective compared to monocrystalline Al2O3 ceramic brackets. However, they tend to be less aesthetically pleasing as they are opaque. Stainless steel and nickel-titanium archwires have been noted to demonstrate favorable sliding properties, along with reduced plaque adherence [47].

5.7 Veneer

Zirconia veneers have seen various alterations in their microstructure and compositions in recent times [48], aiming to improve translucency while maintaining mechanical properties intact [49]. Hence, translucent zirconia is considered a suitable material, suitable for applications like crowns, both posterior and anterior monolithic fixed dental prostheses (FDPs), traditional veneers, and ultra-thin veneers [50]. Ultra-translucent zirconia veneers, with a thickness ranging from 0.1 to 0.3 mm, offer a more conservative alternative compared to glass-ceramic restorations [51]. Due to its chemical inertness and resistance to etching with hydrofluoric acid (4–10%), polycrystalline zirconia exhibits lower adhesion compared to silica-based ceramics (which are acid-sensitive), especially in situations where there is limited mechanical retention of the preparation [52]. Laboratory experiments focused on veneers have demonstrated that Zirconia exhibits greater resistance to fractures compared to feldspathic veneers and lithium disilicate. This can be considered a substantial advantage, as the fabrication and bonding processes for ultra-thin veneers are less demanding than those for conventional glass-ceramics. However, Zirconia veneers may face debonding issues due to insufficient adhesion with resin cement [53]. The application of ultra-thin translucent Zirconia veneers leads to satisfactory aesthetics, although further research is required to validate this treatment approach [54].

5.8 Zirconia fixed dental prosthesis with inlay attachments

The loss of posterior teeth can be addressed through a range of treatment approaches and materials. In situations where placing a dental implant is not advisable, a minimally invasive resin-bonded technique provides an alternative to traditionally made FDPs with minimal tooth preparation [55]. This holds true for abutment teeth that have been previously restored [56]. Previous restorations can limit the amount of tooth structure that needs to be removed, contributing to the longevity of the inlay-retained FDP. This makes it a more conservative option compared to a full-coverage FDP [57]. Furthermore, it allows for the preservation of a greater amount of tooth structure [58] and streamlines periodontal assessment [59]. Individuals with excellent oral hygiene practices and a low susceptibility to dental caries are suitable candidates for inlay-retained Zirconia fixed dental prostheses. However, this type of restoration is not recommended in cases of severe parafunctional habits, extensive loss of marginal enamel, significant crown deficiencies, and abutment tooth mobility [60].

6 Cementing Zirconia Restorations

In the market, Zirconia competes with glass-ceramics and feldspathic porcelains based on silica. These alternatives are favored over Zirconia due to their high glass content, exceptional translucency, and resemblance to natural enamel. The ability of silicate ceramics to undergo acid etching and silanization facilitates resin bonding and reinforcement. For a long time, the clinical effectiveness of cemented prostheses has been evaluated by examining the marginal fit and microleakage [61]. Microleakage is linked to a range of problems, including bonding failure, discoloration, secondary cavities, pulp inflammation, postoperative sensitivity, and buildup of plaque. The robust mechanical properties of the Zirconia framework may enable either adhesive bonding or conventional cementation [62]. While Zirconia restorations are considered suitable for "cementation," there are advantages to utilizing composite resin-based luting agents. Zirconia restorations, such as resin-bonded fixed prostheses or veneers, are thin, possess minimal strength, do not have inherent retention, and rely on resin bonding for stability [63]. The success of resin bonding relies on the careful choice of materials and the appropriate preparation of both the tooth and the bonding surfaces of the restoration [64]. Various bonding procedures have been suggested. Yet, the enduring bond required can be established through the application of a bonding resin luting substance that incorporates particular bonding phosphate molecules, particularly 10-methacryloyloxydecyl dihydrogen phosphate (MDP), following the initial surface preparation using air-particle abrasion [65]. Air abrasion induces a transformation to the t!m (monoclinic) phase and generates a protective surface layer on 3Y-TZPs, which in turn creates surface imperfections that limit strength [66]. The impact of air abrasion on the flexural strength of 3Y-TZP can vary, with some studies suggesting a reduction [67], while others indicate potential enhancement [68]. This outcome is contingent on factors such as air pressure, as well as the type and size of the abrading particles used. Moreover, it was found that using Al2O3 for sandblasting translucent Zirconia did not lead to an increase in surface roughness. Sandblasting influences residual stress and the composition of crystalline phases in specimens [69]. The choice of cement employed seems to have minimal impact on the stress distribution in single monolithic translucent Zirconia [70]. To achieve a durable and robust bond with Zirconia, it is advised to follow a three-step bonding process. This approach involves intaglio surface abrasion using aluminum oxide, followed by the application of a dedicated Zirconia primer, and concluding with the utilization of dual-cure or self-cure composite resin cements. This technique is referred to as the "APC Zir-bonding concept" for easier recall [71].

Using a porcelain coating on the bonding surface was found to enhance the bond strength between the resin material and Zir [72]. Surface conditioning of the porcelain coating can be achieved through hydrofluoric acid etching and the application of a silane coupling agent, enhanc-

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ing the bonding strength. As per a recent meta-analysis, resin-based adhesive delivers the most effective bonding to Zirconia [72]. Dual-cure materials are frequently selected for the cementation of ceramic restorations [73]. In laboratory studies examining the bond strength of 3Y-TZP, 5YTZP, and lithium disilicate samples when bonded with resin cement, it was found that there was no significant difference in shear bond strength [74]. The attenuation of light and the subsequent curing of cement are factors that affect light-cured materials used for bonding ceramic restorations. The makeup of the resin cement, the power of the curing light, the duration of the curing process, and the proximity between the light source and the restoration are all factors that affect light-induced polymerization [75]. Consequently, the passage of light through the restoration is affected by factors such as the composition, shade, thickness, translucency, presence of defects, and distribution of porosity in the ceramic material [58]. Employing a try-in paste cement could be advantageous for addressing esthetic requirements.

The curing duration for a slender ceramic (0.5 mm) needs to be prolonged by 40% in comparison to the curing period for a resin composite devoid of ceramic (which isn't a cement material). When the thickness is increased to 1 mm, the curing duration needs to be extended to twice the standard time [76]. Nevertheless, the presence of saliva during the try-in can negatively affect the connection with the resin cement, posing a practical challenge when adhering to Zir restorations [77]. Alternative cleaning methods, such as employing alcohol or organic solvents, have shown limited efficacy [78]. Particle abrasion efficiently removes impurities, thereby restoring the bonding strength to its initial levels [79]. Nonetheless, in order to remove impurities, a relatively recent product available on the market (Ivoclean; Ivoclar Vivadent, Schaan, Liechtenstein) was developed, which is composed of hyper-saturated Zirconia particles. Impurities brought about by the Ivoclean solution can be eliminated from the mending surface. Early evaluations of the cleansing solution validated its efficiency [78]. The results of this study have prompted various clinical suggestions. Prior to the application of an MDP primer, it is advisable to cleanse any salivary contamination using either Ivoclean or additional particle abrasion. In clinical situations, it appears that bonding can be re-established with a 20-second water rinse when Zir becomes contaminated after being treated with a combination of MDP, such as intraoral bonding or using MDP before try-in [80].

7 Prospects and Hurdles in Dental Zirconia

A notable obstacle lies in employing a durable ceramic core to provide structural support for the outer porcelain veneers [81]. As mentioned earlier, the focus has shifted towards monolithic Zirconia to prevent veneer chipping and separation, as well as to lessen the necessary material thickness. The aesthetic characteristics of monolithic Zirconia are improved by incorporating different additives in the initial powders.

For instance, the addition of 0.2 mol% Al2O3 to 3Y-TZP enhances resistance to aging and translucency. Nevertheless, it does lead to a deterioration in mechanical properties. Moreover, the enhancement in translucency is not as pronounced when compared to 5Y-PSZ. Improved durability and resistance to aging have been attained through the use of Zirconia-toughened Alumina, but its opaqueness still limits its application for anterior restorations [82]. Exploring different additives and sintering techniques to improve transparent phases is a prospective area for future research. This should be approached with careful consideration of the overall balance between aesthetic appeal and mechanical performance [18].

The material's opacity is heightened by the scattering of light caused by grain boundaries and microstructural flaws. On the other hand, decreasing the grain size significantly below the wavelength of light leads to increased transmittance in Y-TZP. Producing Zirconia with nanoparticles is a challenging task, particularly when starting with well-dispersed, uniform nano powders containing controlled amounts of stabilizing additives. Commercially available Zirconia nano powders are currently utilized to reduce porosity and improve densification during sintering. However, novel manufacturing methods need to be developed. Presently, these processing techniques are in the developmental stages [3]. The mechanical assessment of nanostructured 3Y-TZPs indicates heightened strength, correlated with diminished inherent defect dimensions. Furthermore, the diminutive grain size could hinder the reversal of t!m transformation [17]. The enhanced translucency removes the necessity for veneering.

8 Conclusions

The recently introduced multicolor monolithic Zirconia demonstrates exceptional translucency and aesthetic characteristics. However, additional in vitro and in vivo studies are required to confirm their outstanding characteristics. Translucent monolithic Zirconia has shown encouraging outcomes with high rates of success. Hence, this material is recommended for situations that require a balance of strength and aesthetics. The process of cementing monolithic Zirconia has demonstrated notable advancements in its properties, which has instilled confidence in dentists to opt for this material, particularly in cases demanding a conservative approach. Several brief-term studies on Zirconia restorations have displayed encouraging results, particularly in the context of implant-supported single crowns and fixed dental prostheses (FDPs). Due to the limited available data, it is imperative to conduct well-structured clinical trials to provide insights into prognosis and long-term survival considerations.

Conflict of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
Financing: The study was performed without external funding.
Ethical consideration: The study was approved by College of Pharmacy, Basra University.
Data Availability: No data was used for the research described in the article.

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How to cite this article

Jabber H.N.; Ali R.; Al-Delfi M.N; Monolithic Zirconia in Dentistry: Evolving Aesthetics, Durability, and Cementation Techniques - An In-depth Review. Future Dental Research (FDR). 2023;1(1):26-36. doi: 10.57238/fdr.2023.145202.1003

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