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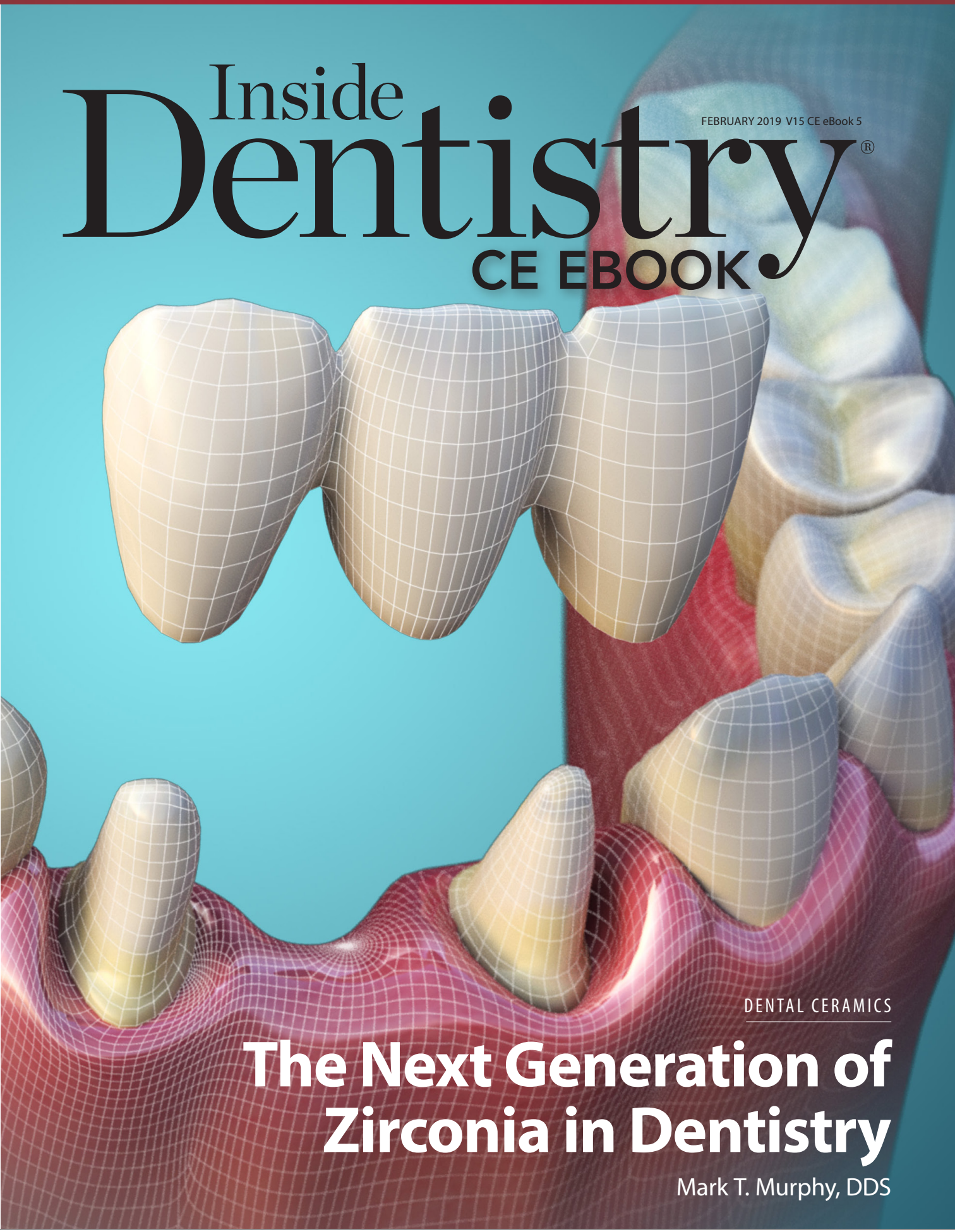

DENTAL CERAMICS

The Next Generation of Zirconia in Dentistry

Mark T. Murphy, DDS

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The Next Generation of Zirconia in Dentistry

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DISCLOSURE: The author received an honorarium for the webinar program on which this article is based.

Inside Dentistry

FEBRUARY 2019 | www.insidedentistry.net

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AEGIS Publications, LLC

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The Next Generation of Zirconia in Dentistry

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ABSTRACT

Zirconia is one of the most durable dental ceramics on the market. Next-generation zirconia and new shading technologies work together to provide restorations that are both durable and esthetically pleasing. This article explores the range of materials on the market, particularly the different types of zirconia. It then explores shading technologies that work with zirconia to create strong, esthetically pleasing restorations.

LEARNING OBJECTIVES

- List the important properties for a dental restoration material.
- Discuss how various dental restoration materials compare in strength and esthetics.
- Describe shading technologies for dental restorations.

Prosthetic dentistry is an expansive and lucrative business, so even minor improvements in materials can have large economic ramifications for provider and patient.[1] Although many materials are available on the market for dental restorations, zirconia has emerged as the most durable of the dental ceramics.[1] The challenge moving forward is to improve esthetics while maintaining the high strength of these materials.

This article will include information to make better clinical decisions when looking at laboratory-fabricated restorative materials. It reviews the progressive development of currently available and next-generation zirconias, representing a concerted drive toward greater translucency while preserving adequate strength and toughness. The article will also explore how new zirconia material compares with the spectrum of other materials on the market. It will conclude by covering the topic of shading; color and transparency are crucial for esthetically pleasing restorations.

MATERIALS

Laboratory-fabricated dental materials include polymers, alloy, porcelain, and ceramic restorations (Figure 1). Dental ceramics can be classified according to fusion temperature, application, and fabrication technique. The properties to look for in an ideal dental material include esthetics, biocompatibility, strength and

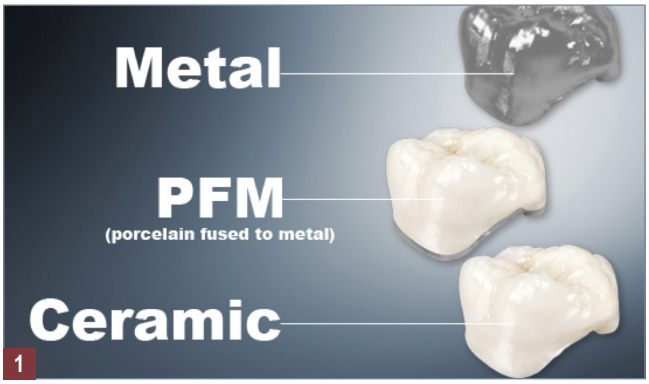
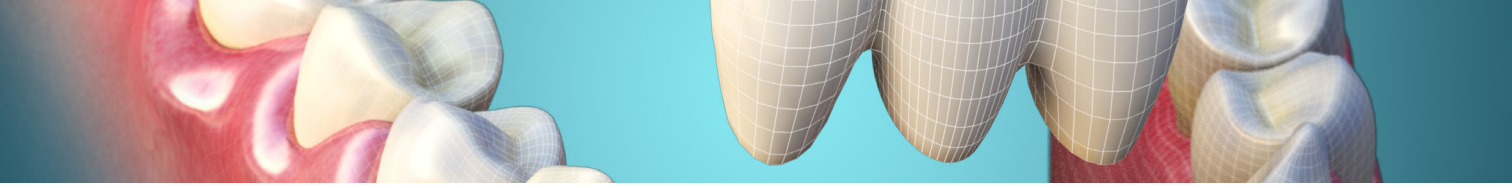
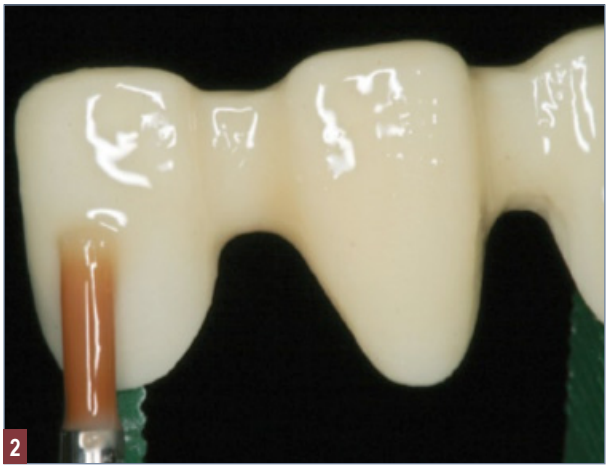


Fig 1. Laboratory-fabricated dental materials include metal, porcelain fused to metal, and ceramic restorations.





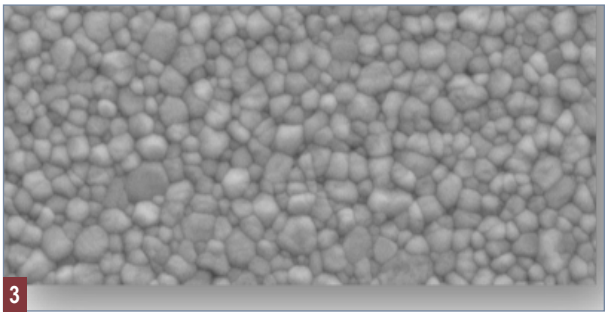


Fig 2. The earliest versions of zirconia were used as frameworks on which more esthetic, lower-strength layering ceramic was placed.
Fig 3. Tetragonal-phase zirconia crystals give a restoration its strength.

durability, corrosion resistance, tastelessness and odorlessness, nonconductivity, speed and ease of use, and affordability.

For a while, glass-ceramic systems were a popular material for restorations because they provided translucency similar to natural teeth.[2,3] Despite this esthetic advantage, glass systems did not meet the strength requirements of many restorations.[4]

Over the last few decades, titanium and titanium alloys have been the most popular material of choice for dental implantology.[5] Titanium has been referred to as the "gold standard" due to its biocompatibility, resistance to corrosion, and mechanical properties found to be most suitable for the success of implant treatment.

However, recently, zirconia has emerged as a material that may soon replace the classic gold standard of dental implants.[6] The earliest versions of zirconia were used as frameworks on which more esthetic, lower-strength layering ceramic was placed (Figure 2).[7] When eventually zirconia improved esthetically, it could be used in a restoration created out of a single material, with no layering ceramic required. These versions of zirconia were strong and inexpensive, but the esthetics were still not ideal, and the pursuit of a better zirconia continued. Over the last decade, zirconia technology has encouraged a rapid development of metal-free dentistry that may provide high biocompatibility, enhanced esthetics, and improved strength.[8] Zirconia now has the esthetic properties that are desirable for the ideal restorative material, in addition to being strong. Perhaps now, for the first time, there will not be a need to choose between esthetics and strength.

The properties of zirconia that make it ideal for dental implantology are biocompatibility, osseointegration, favorable soft-tissue response, and esthetics due to light transmission and the color; however, some studies have noted the material's drawbacks. Special considerations and technical experience are needed when dealing with zirconia implants to minimize the incidence of mechanical failure.[9] Long-term failure from a variety of fracture modes is a persistent concern.[10] The quest to develop ever more esthetic zirconias without compromising durability has become a driving force for materials development in the dental research community.[1]

TYPES OF ZIRCONIA USED IN DENTISTRY

Despite the plethora of zirconia-containing ceramic materials available on the market today, only a few have been used in dentistry. They include yttrium-stabilized tetragonal zirconia polycrystals (Y-TZP), zirconia-toughened alumina (ZTA), and alumina-toughened zirconia.[9]

Y-TZP material is available in dentistry for the fabrication of dental crowns and fixed partial dentures (Figure 3). The grain size of Y-TZP has a strong impact on the final product's stability and mechanical properties: if it is too large, it is

Fig 4. Monolithic zirconia restorations.

less stable; if it is too small, it may result in reduced fracture toughness.[11,12] However, of all the restorative ceramics, Y-TZP has been the most robust.[13] There are several variants of Y-TZP, depending on additives and dopants, sintering profiles, and ensuing heat treatments.[14-16] The main attraction is their exceptional mechanical properties, as well as their biocompatibility and resistance to corrosion. The greatest challenge is to produce them with sufficient esthetics to match existing dentition. In this regard, Y-TZP has to compete with more translucent but weaker glass-ceramics, notably the lithium-based silicates.[17]

Another type of zirconia is ZTA, which uses the stress-induced transformation capabilities of zirconia by combining it with an alumina matrix.[18] It can be processed by either slip casting or soft machining. One of the main advantages of the slip-cast technique is the limited amount of shrinkage. However, the amount of porosity is greater, which results in lower mechanical properties when compared with Y-TZP.[19]

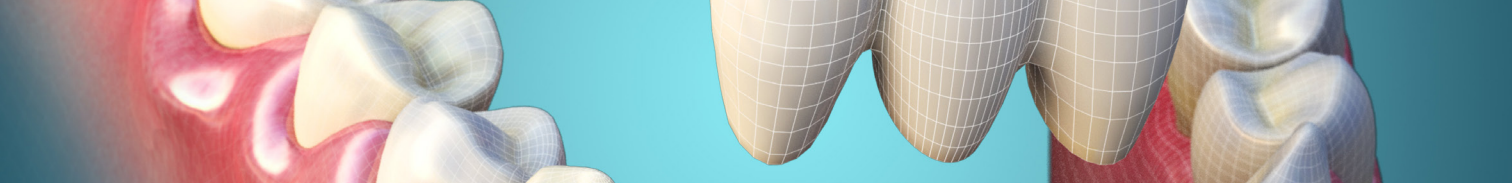
Now on the market is zirconia-containing lithium silicate (ZLS). The mechanical properties of ZLS are comparable to lithium-disilicate glass-ceramics and used with CAD/CAM techniques. The development of ZLS glass-ceramics illustrates the ongoing quest for ceramic materials that offer adequate translucency combined with superior mechanical properties.[20] These stable ceramics may offer a better reliability than other zirconia ceramics, but the search for even better materials continues.

The IPS e.max® system (Ivoclar Vivadent, ivoclarvivadent.com) is an example of an all-ceramic system that covers all indications, ranging from thin veneers to multi-unit bridges. It consists of lithium-disilicate glass-ceramic materials for both press and CAD/CAM techniques, a zirconium-oxide ceramic in disc and block form, a coordinated veneering ceramic, and a press-on fluorapatite ceramic.[21] IPS e.max ZirCAD provides high mechanical strength, minimal restoration thicknesses, impressive esthetics, and good biocompatibility.[21,22] The restorations can be glazed, stained, or veneered; a dental laboratory will finish the IPS e.max ZirCAD restorations according to the specific requirements of the individual patient. Other examples of this type of material include NexxZr+® (Sagemax Bioceramics, sagemax.com) and Beyond+Multi™ (B&D Dental Technologies, origincadcam.com).

In general, preference has shifted to monolithic zirconias (Figure 4) to alleviate material thickness requirements and to circumvent issues with mismatch residual stresses and resulting veneer chipping and delamination.[1,23,24] Compositional variants-graded structures, biomimetic structures, and nanostructures are all being explored. Overall, zirconia is esthetically preferable to a traditional metallic framework, but it is normally white and opaque. Colored zirconia has been introduced to simulate the color of natural teeth. Y-TZP blocks can be custom-colored to produce work pieces of various shades.

SHADING

As the mechanical properties of available materials improve, focus has shifted to optical properties such as color and translucency. In restorative dentistry, color and optical properties play a major role in patient satisfaction. Color is a phenomenon resultant of visual perception, which depends on the light reflected from or passed through an object. Therefore, determining an accurate shade can be challenging; inconsistent lighting conditions, human error, and variations among shade tabs and how they are used are a



few of the issues traditionally encountered when shade matching by eyesight.

In the past, visual color matching by making a comparison between a patient's tooth and the standard sample was the most common approach used in clinical dentistry.[25] However, visual evaluation can be unreliable and have variable outcomes, whereas instrumental measurements have concrete and quantitative results.[26]

A variety of digitally based shade-taking solutions have been introduced to supplement classic manual methods of shade matching. MicroShade® (MicroDental Laboratories, microdental.com) with ShadeWave® (ShadeWave, shadewave.com), SpectroShade™ (MHT International, spectroshade.us), and Easyshade® (Vita, vitanorthamerica.com) are some examples of shade-matching technologies.[27-30] Using such technology-driven and laboratory-supported processes can help simplify and streamline how dental practices obtain esthetically pleasing restorations. The benefits of digitally based shade-taking technologies for a dental office include saving time on taking shades, saving money due to fewer shade remakes or adjustments, and eliminating light and surrounding color influences.

Translucent zirconia can be colored both internally and externally. This is done internally by using preshaded porous zirconia blanks. It can be colored externally by immersion in a coloring solution or painting on the coloring solution before the sintering process.[31-33] Translucency is significantly influenced by not only the type of ceramic, but the thickness. An inverse relationship has been found between translucency and thickness.[34]

CONCLUSION

With the introduction of digital-age chairside milling,[35] coupled with novel rapid-sintering technology,[36,37] fabrication of dental restorations is becoming more automated, time effective, and precise. It is important for dentists to know the full range of products on the market and the advantages and disadvantages of each material and technology. This familiarity will ensure long-lasting restorations that make patients happy with their esthetic, natural appearance.

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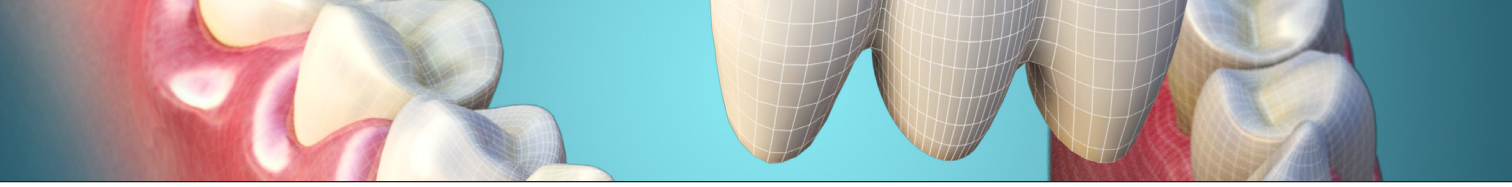

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The Next Generation of Zirconia in Dentistry

Mark T. Murphy, DDS

1. **What is the most durable of the dental ceramics?**
   A. porcelain B. zirconia
   C. clay D. polymer

2. **Over the last few decades, which have been the most popular materials of choice for dental implantology?**
   A. titanium and titanium alloys B. porcelain
   C. polymer D. none of the above

3. **Which emerging material may soon replace the classic gold standard of dental implants?**
   A. zirconia B polymers
   C. porcelain D. glass

4. **The properties of zirconia that make it ideal for dental implantology are which of the following?**
   a. biocompatibility
   b. osseointegration and favorable soft-tissue response
   c. esthetics due to light transmission and the color
   d. all of the above

5. **Yttrium tetragonal zirconia polycrystal material is available in dentistry for what purpose?**
   A. fabrication of dental crowns and fixed partial dentures
   B. filling of posterior cavities
   C. forming implant-abutment connections
   D. all of the above

6. **What is one of the main advantages of the slip-cast technique?**
   A. added durability B. esthetics
   C. limited amount of shrinkage D. translucency

7. **Which issue is traditionally encountered when shade matching by eyesight?**
   A. inconsistent lighting conditions
   B. human error
   C. variations among shade tabs and how they are used
   D. all of the above

8. **What has been introduced to supplement classic manual methods of shade-matching?**
   A. cell phones
   B. the process of combining multiple technicians' opinions
   C. digitally based shade-taking solutions
   D. fluorescent lighting

9. **What are the benefits of digitally based shade-taking technologies for a dental office?**
   A. saving time on taking shades
   B. saving money due to fewer shade remakes or adjustments
   C. eliminating light and surrounding colors influences
   D. all of the above

10. **How can translucent zirconia be colored?**
    A. internally
    B. externally
    C. both internally and externally
    D. neither internally nor externally

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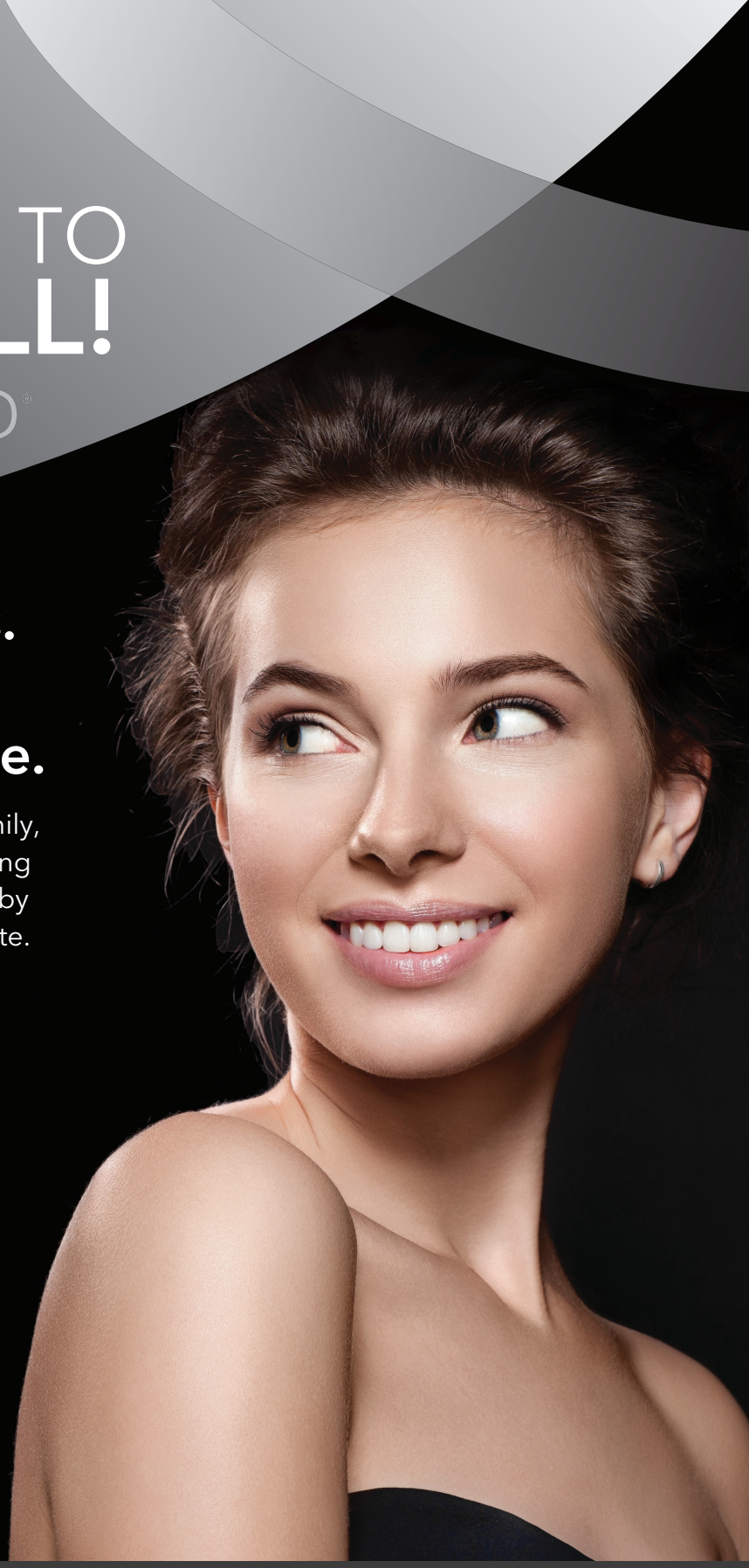

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