

# Material Classification and **Shade Selection** **Protocol** for All-Ceramic Restorations

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## Abstract

With the myriad options available to the clinician, selecting the appropriate ceramic material for a restoration can be a daunting task. This article seeks to simplify the selection protocol by classifying the materials as either glass ceramics or oxide ceramics. The physical and optical properties of these materials will also be discussed.

Additionally, when using certain materials, there are several variables that will affect the final shade of the restoration. These factors will be discussed and clinical examples will illustrate how to best optimize prosthetic results.

## Learning objectives

After reading this article, the reader should be able to:

- Recognize how to select the appropriate ceramic restoration based on material properties.
- Understand the differences between glass and oxide ceramics.
- Gain familiarity with the variables that affect the final shade of the ceramic restoration, including material translucency and opacity.

## Introduction

The use of all-ceramic restorations has gained popularity just within the past three decades, although the first all-ceramic crown was described by Charles H. Land in 1903.<sup>1</sup>

These restorations are used as alternatives to porcelain fused to metal (PFM), which certainly enjoys a notable track record in terms of longevity. However, PFMs have certain shortcomings, including an inherent high opacity, and the potential of unesthetic exposed-metal margins (Fig. 1).

With the development of all-ceramic restorations came the need to classify the various categories of materials. This can be done in several ways—for example, according to firing temperature or abrasiveness.<sup>2</sup>

One simple and succinct way to categorize the materials is to classify them as either glass ceramics or oxide ceramics.<sup>3</sup>



Fig. 1  
Typical issues with PFM restorations include metal margins and high opacity.

When choosing a shade for an oxide ceramic, as is done with PFM restorations, only the desired final shade needs to be determined. This is due to the inherently opaque nature of the oxide materials.

## Glass ceramics

Generally, each glass ceramic is composed of a glass component and a crystal component. The crystal component provides strength. The glass component, typically made of silica or quartz, provides translucency.

Additionally, the selective removal of silica by hydrofluoric acid and subsequent use of adhesive protocols makes it possible for partial-coverage restorations, such as veneers, to remain affixed to the tooth structure without the need for a conventional retentive preparation.<sup>4</sup>

## Common glass-ceramic materials

**Feldspathic porcelain.** Historically, this is the most commonly used glass ceramic. It is used as a layering porcelain for PFMs, as well as for full-contour veneers or porcelain-jacket crowns. Additionally, it can be layered over ceramic cores.

Feldspathic porcelain is applied to a refractory die or platinum foil via a powder-and-liquid mixture. It is then sintered.

Common examples include: Noritake (Kuraray), IPS e.max Ceram (Ivoclar Vivadent) and VITA VM7 (Vita). Flexural strength of feldspathic porcelain typically ranges between 80MPa and 100MPa.

### Leucite-reinforced porcelain.

Although leucite was already a component in several formulations of feldspathic porcelain, manufacturers discovered

that adding a higher percentage of leucite to a ceramic formulation created a material twice as strong as conventional feldspathic porcelain. The flexural strength of leucite-reinforced porcelain restorations is 180MPa.

Leucite-reinforced restorations are fabricated using a lost-wax technique, or can be fabricated via a CAD/CAM protocol, which allows for better marginal fit than traditional feldspathic restorations.<sup>5</sup> Regular applications include veneers, inlays and crowns.

Common examples include Empress Esthetic and Empress CAD (Ivoclar Vivadent) and Authentic (Jensen Dental).

**Lithium disilicate-reinforced.** Although Empress proved to be a popular material, it was too weak for use in anterior bridges or posterior crowns. Empress2, which incorporated lithium disilicate in the crystal phase, was created to address these issues.

In 2005, Ivoclar Vivadent refined the processing of the lithium disilicate, and created IPS e.max Press and IPS e.max CAD. With a flexural strength of 360MPa to 400MPa, the material is used for posterior crowns and anterior bridges (up to the second premolar). Additionally, it is formulated to have varying levels of translucency or opacity, and can be adhesively bonded.

Lithium-disilicate restorations offer roughly 56 ingot or



Table 1

Material	Type	Flexural strength (MPa)
Feldspathic	Glass	90–120
Leucite-reinforced	Glass	180
Lithium disilicate-reinforced	Glass	360–400
Densely sintered aluminum oxide	Oxide	650
Zirconia	Oxide	720–1200

block choices, and include high-translucency or high-opacity options.

## Oxide ceramics

Oxide ceramics have higher flexural strengths than glass ceramics.<sup>6</sup> They contain no silica and therefore tend to be more opaque than glass ceramics, although the development of a more translucent oxide ceramic is certainly on the radar of today's manufacturers.

While universal primers have improved the reliability of adhesive protocols, as a whole the bond strength of oxide ceramics tends to be lower than that of glass ceramics.<sup>7</sup>

**Densely sintered aluminum oxide.** It's currently marketed as Procera Alumina (Nobel Biocare). Though it has a high flexural strength of 657MPa, the material is used as a core and is overlaid with feldspathic porcelain. It is indicated for posterior three-unit bridges, and is not available in a monolithic formulation.

**Zirconia.** Available as either a layered (e.g., Lava, 3M ESPE) or monolithic (Brux-Zir, Glidewell Laboratories; Zenostar, Ivoclar Vivadent) restoration, zirconia has the highest flexural strength of any of the all-ceramic materials available today.<sup>8</sup>

It is indicated for posterior crowns and bridges, particularly in the monolithic form. Although it's still not as translucent as glass ceramics, the incorporation of the cubic phase of zirconia offers a promising avenue to increase the material's translucency. It should be noted that cubic zirconia does have an approximately 20 percent lower flexural strength than traditional yttria- or ceria-stabilized zirconia formulations.<sup>9</sup>

Table 1 lists the material type and flexural strengths of the glass and oxide ceramics that have been discussed.

## Shade selection

When choosing a shade for an oxide ceramic, as is done



Fig. 2



The clinical outcome resulting from the use of a translucent material over a dark metallic post.

Fig. 3



Preoperative situation: patient presented with failing anterior restorations.

Fig. 4



Communicating the shade to the laboratory via photograph.

Fig. 5



The final result. A low-translucency ingot was used.

with PFM restorations, only the desired final shade needs to be determined. This is due to the inherently opaque nature of the oxide materials.

With glass ceramics, four variables will influence the final desired shade:

**Shade of preparation.** Commonly referred to as the “stump” shade, this is the color of the prepared tooth. Preparation shades closer to the desired final color can allow for a more translucent material to be used.

**Shade of cement.** A more opaque or more heavily chromatic cement can mask a darker preparation more effectively than a translucent resin cement.<sup>10</sup>

**Material thickness.** As material thickness increases, it can better mask a darkened stump than an equivalent material made with less buccal-lingual thickness.<sup>11</sup>

**Material properties.** The amount of translucency or opacity in endodontically treated teeth with metal or dark posts can create a graying-out of the restoration, especially if a translucent ingot or block is chosen to fabricate the restoration (Fig. 2).

The following cases discuss material selection when dealing with factors impacting the success of glass ceramic restorations.

## Case presentation No. 1

The patient is a 43-year-old male in good general health who presented with caries and failing composite restorations on #8 and #9 (Fig. 3). It was decided that the anterior teeth would be restored with lithium-disilicate pressed veneers.

The patient was anesthetized and the failing restorations were removed. A defect-oriented preparation was completed.<sup>12</sup>

After impressions with a polyvinyl siloxane material (Aquasil Ultra, DENTSPLY Caulk), photographs with shade tabs were taken (Fig. 4).

The desired final shade was A2. The stump shade was determined to be A3. Because the desired final shade was close to the final shade, a more translucent

ingot could be used, which would allow some reflectance of the underlying tooth structure.

A low-translucency ingot was selected for the veneers, because the large interproximal area between the central incisors needed chromaticity, and might have looked too gray had a high-translucency ingot been selected.

The restorations were treated with a ceramic primer (Interface, Apex Dental) and adhesively luted with a light-cured resin cement (NX3, Kerr). The patient was pleased with the final results (Fig. 5).

## Case presentation No. 2

The patient is a 39-year-old female in good general health. She had an existing PFM restoration on #8 and a failing feldspathic veneer on tooth #9 (Fig 6). Note that although both restorations were shade

Commonly referred to as the “stump” shade, this is the color of the prepared tooth. Preparation shades closer to the desired final color can allow for a more translucent material to be used.

A2, and quite possibly were fabricated using the same feldspathic porcelain, differences in the overall shade can be noted. This is due to the reflectance, or lack thereof, from the underlying structures (more opaque and metal from PFM #8, natural tooth from tooth #9).

After endodontic therapy on #9 and the removal of both restorations, it was noted that #8 had an existing, well-functioning cast post (Fig. 7).

Although attempting to remove a cast post and replacing it with a fiber post and composite build-up is an option to block the dark color, it does possess risks such as root fracture.<sup>13</sup>

A clinician has several options when faced with the prospect of trying to block out a dark color on a restoration:

- oxide ceramic or PFM
- deeper preparation
- replacement of metal post with fiber post
- more-opaque composite
- opaque cement
- opaque ingot

For this case, after discussion with the laboratory, a medium-opacity pressed-lithium disilicate ingot was selected for both teeth.

Because of concerns about the efficacy of light-curing through an opaque material, a dual-cure resin adhesive was used to cement the restorations.<sup>14, 15</sup>

Note that the immediate postoperative result reveals no show-through of the metal post in #8, and a uniform appearance of both front teeth (Fig. 8).

## Conclusion

A great many all-ceramic options are available to the clinician. The proper selection of materials will help prevent any untoward clinical or esthetic failures. Additionally, when using glass ceramics, the factors influencing the final shade of a restoration must be considered and managed in an appropriate manner. ■

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Fig. 6  
Preoperative situation: the patient presented with a PFM restoration on tooth #8 and a feldspathic porcelain veneer on #9.



Fig. 7  
A preparation photo. Note the metal post on tooth #8.



Fig. 8  
Final result: a medium-opacity ingot was selected. Note the uniformity of the final shade.

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1. Which glass ceramic has the highest flexural strength?
  - A) Feldspathic porcelain
  - B) Zirconia
  - C) Lithium disilicate-reinforced
  - D) Leucite-reinforced
2. Which component of a "glass ceramic" gives the material its strength?
  - A) Silica
  - B) Crystal
  - C) Silane
  - D) Block
3. Which of the following is an "oxide ceramic"?
  - A) Densely sintered aluminum oxide
  - B) Lithium oxide
  - C) Feldspathic oxide
  - D) Oxidinium
4. Which of the following materials has the highest flexural strength?
  - A) Lithium
  - B) Leucite
  - C) Feldspathic
  - D) Zirconia
5. Zirconia is available as either a layered or monolithic restoration.
  - A) True
  - B) False
6. Which restoration is *not* indicated for lithium-disilicate-reinforced restorations?
  - A) Veneers
  - B) Posterior bridges
  - C) Anterior crowns
  - D) Anterior bridges
7. Which of the following is a strategy to block the color of a dark or discolored underlying preparation?
  - A) Use of an oxide ceramic
  - B) Deeper preparation
  - C) Opaque ingot/block
  - D) All of the above
8. Regarding glass ceramics, which of the following will influence the final shade of the restoration?
  - A) Material thickness
  - B) Cement shade
  - C) Shade of the preparation
  - D) All of the above
9. An "LT ingot" is an abbreviation for low-transparency ingot.
  - A) True
  - B) False
10. What is the flexural strength of e.max Press?
  - A) 520 MPa
  - B) 400 MPa
  - C) 360 MPa
  - D) 657 MPa

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## Material Classification and Shade Selection

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