A Prosthodontist's Anecdotal Approach to Choosing a Material for Crown Construction

by Dr. Izchak Barzilay, DDS, Cert. Prostho., MS, FRCD(C)

Description

In this CE article, a prosthodontist gives his criteria as to what material to use for crowns in specific situations. Understanding the inherent strengths and weaknesses of the different materials and what clinical situations are best for each are thoroughly discussed. The various types of ceramic materials are highlighted in terms of how and when to use them.

Objectives

1. Learn the various types of materials used for crowns.
2. Learn the uses and contraindications of each type of material.
3. Learn the proper way of cementation or bonding of each type of material.
4. Learn the keys in preparation design for successful ceramic-type crowns.

You know, it is hard to decide which material to use when we plan any form of crown and bridge treatment. There are so many materials on the market that it can be very confusing. You need to understand the inherent strengths and weaknesses of the different materials and the clinical situation that you are looking to treat. Sometimes it is best to break down the materials into their characteristics (aesthetic and mechanical) in order to help categorize them and therefore allow us to make better treatment choices.

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Crown and bridge materials have gone through a rapid evolution over the past century. There was a time when metals were king and you placed an aesthetic material on metal only in the most aesthetic-conscious patients. This was the time of the gold crown, the partial crowns (3/4, 7/8, pin ledge retainers, etc.) and the gold acrylic crowns. These restorations were conservative for their time yet left much to be desired from the aesthetic perspective. The restorations did well over time and there are still many of these restorations that can be seen surviving in some of our older patients. During this time, situations needing highly aesthetic restorations made use of the porcelain jacket crown. This restoration was highly aesthetic however lacked in strength. It was limited to the anterior part of the mouth and often fractured due to its inherent weakness and the inability to bond the restoration to increase strength (nor did we have the knowledge of bonding and its benefits). It was under this environment that the combined restoration (the all metal and the ceramic) came about. The porcelain-fused-to-metal (PFM) restoration was developed. It used the strength of the metal core with laminated porcelain over top. Much work went into the connection of the materials and new metals were developed that allowed for this to happen. The aesthetics were improved upon by development of new methods to color the metal before porcelain application. As the prices of noble metals increased, newer less expensive metals were developed that could also be used for this application (non-precious or base-metal alloys). This level of dentistry was the mainstay for many years.

The need for aesthetic restorations pushed the industry to develop new all-ceramic materials. The concept of all-ceramic materials meant that no obvious metal- or metallic-like material was used in the restoration. Early versions of this were not very successful clinically (Dicor, Cerestore) which led many to avoid its use. But more recent advances in the technologies of design and manufacturing made manufacturing of all-ceramic restorations easier, more precise and clinically, the newer materials were stronger. This type of restoration has become very popular and it currently takes on the form of two designs – the laminated design and the monolithic design.

The laminated design uses some type of high-strength ceramic core and then laminates this ceramic core with an overlay of porcelain. The monolithic design makes use of one material that makes up the complete restoration.

Laminated ceramic (non-metal) designs are an extension of the gold acrylic crown and the porcelain-fused-to-metal restoration. They use the concept that the underlying material can be made to fit well to the preparation and then the overlaying material gives the aesthetics that is needed. Sometimes the underlying structure is brought out to support the occlusion or if this is not needed, then the overlaying material is used to support function and aesthetics by being the functional surface (occlusal surface). It is important to remember than when dealing with laminated designs, the two materials must be able to work together and stick to each other so they don't separate. They must be compatible with each other both functionally and aesthetically. Over the years there have been many recorded mismatched materials from functional and aesthetic perspectives. When this occurs, failure of the restoration often occurs. The most commonly used laminated all-ceramic designs used today are based on zirconia substructures that are laminated with either feldspathic porcelains or other higher strength ceramics (Figs. 1a and 1b). These restorations are highly aesthetic and are quite functional in most situations. The issues that arise from these materials are the fact that the weak link (clinically) is the strength of the overlying porcelain. It is subject to chipping and fracture when it does fail. This does not happen very often but is a nuisance when it happens and needs to be dealt with. The aesthetic quality of these materials is very high since the experienced dental technician can layer porcelains of different aesthetic quality over the core and create very beautiful restorations. These material combinations can also be used in the implant application for both the cemented as well as the screw-retained restoration (Figs. 2a, 2b, 2c). One must remember

Fig. 1a


Fig. 2a

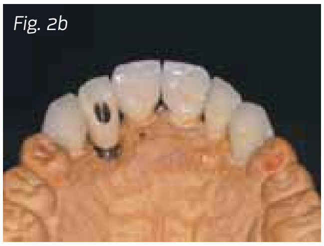

Fig. 2b


Fig. 2c


Fig. 1b


Fig. 1a: Pre-treatment photograph of patient with amelogenesis imperfecta.
Fig. 1b: Post-treatment photograph of patient with all-ceramic zirconia-based laminated crowns anteriorly and full gold crowns posteriorly. The gold restorations support occlusion without risk of fracture. The anterior crowns are both aesthetic and functional.
Fig. 2a: All-ceramic restorations fabricated for the anterior maxillary teeth. Note the implant in the upper right lateral incisor site.
Fig. 2b: An access hole has been created in the ceramic restoration so that it can be bonded to the metal abutment which then provides for a screw-retained restoration yet the same ceramic is used for all restorations in the area.
Fig. 2c: Final restorations in place.

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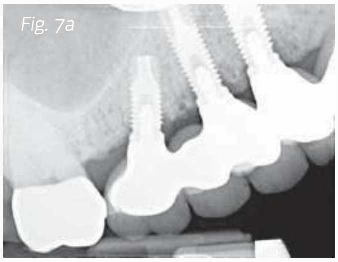
however that in the implant scenario, occlusion on the restoration becomes very important since the ligament is absent and there is little shock absorption present in the system. One would guess that the implant situation might present itself with more ceramic fractures for this reason. Of course, a fracture of ceramic material in the implant situation alerts the clinician that there might be a need for occlusal adjustment (Fig. 3).

Monolithic ceramic designs began with the porcelain jacket crowns. Today monolithic restorations are commonly being manufactured using CAD/CAM concepts and most commonly take the form of lithium-disilicate-based materials or full zirconia-based materials. Several materials can also be pressed to contour and there are many that use these methods to create their crowns. The monolithic material has the inherent quality of not involving lamination so there is one less interface to deal with. This makes the crown stronger and more resistant to some of the surface fractures that occur with laminated crowns. The perceived downside of this type of restoration is its aesthetic quality. The zirconia-based restoration started off as a stark white color with no translucency and a highly opaque quality (Fig. 4). Over time, methods were developed where this material can be stained and colored so its aesthetic value has improved. It, by no means, matches the aesthetics of the laminated restoration since no overlying porcelain is used to enhance the aesthetic quality of the restoration (Figs. 5a and 5b). The all-ceramic lithium-disilicate material was originally manufactured for a pressed method, which made its shade limited since once again there was no overlying porcelain. It can be stained but this is just a surface stain. Now, with the use of the milling process, the material can be milled in its pre-crystallized state. This mills out the material in a hardness that is close to the hardness of standard ceramics. This can then be adjusted for shape and contour and can also be infused with stains before it is crystalized. This gives a much deeper and richer color to the restoration. Once the material is crystalized, it can then be further stained if needed. The final outcome is an aesthetic material that is hard and resistant to fracture. These CAD/CAM restorations can be used in the anterior as well as the posterior parts of the mouth (Fig. 6). The lithium-disilicate material can be bonded using conventional bonding methods that relate to porcelain. Zirconia cannot be bonded to with predictability so it is more limited in its applications (no veneers or short crown preparations). Clinically, these materials also have very different radiographic appearances. The lithium-disilicate material is radiolucent and easily evaluated while zirconia takes on the appearance of a metal on radiographs (radio opaque) (Figs. 7a and 7b).



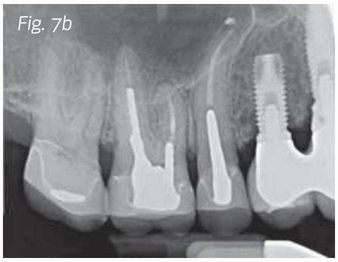


Fig. 3: A maxillary arch showing many different types of restorations. A fracture is noted in the right first molar disto-lingual area suggesting a week ceramic that is also possibly unsupported. Note that other restorations include a full contour zirconia crown (upper right second molar), PFM-based restorations in all other areas and a repair veneer in the upper left lateral incisor site.

Fig. 4: A highly opaque full contour zirconia-based crown (same as in Fig. 3)

Fig. 5a: A full contour three-unit zirconia-based bridge is stained to enhance its appearance but leaves much to be desired.

Fig. 5b: Radiograph of the zirconia restoration giving a look much like metal.

Fig. 6: Full upper reconstruction done with monolithic lithium-disilicate with added stain in the anterior area.

Fig. 7a: Radiograph showing a full contour zirconia-based restoration on the upper right second molar. This shows the radiopacity of the restoration blocking out any underlying tooth structure.

Fig. 7b: Radiograph showing the translucent effect in radiography of the lithium-disilicate crowns. All underlying tooth structure can be visualized.

With the knowledge of how these materials work, how do you decide which material to choose and when? This is the issue that we are all faced with on a regular basis.

As a prosthodontist, I need to choose specific materials for all my patients based on the patients' functional needs as well as their aesthetic demands.

1. Need for a full-coverage crown in the posterior part of the mouth (non-aesthetic zone – second molar). My first choice here is the gold crown due to its strength, kindness to the opposing dentition and minimal requirements for tooth reduction. Oftentimes a crown in the second molar region is short occluso-gingivally and as such might require additional retention from grooves or pin preparations. Gold lends itself well to this need. Gold can also be bonded if one needs the added "cementation comfort" of bonding the restoration as part of cementation. In this case the metal crowns internal surface is air abraded and then a metal bonding cement (Metabond) is used. Gold works well in all situations of occlusal forces; from light to heavy load. It is the best universal functional material. Its drawbacks are only its color and its cost (Fig. 8).

Table 1 – Cement Choices and Methods for All-ceramic Materials

Crown Material	Crown Treatment	Prep Treatment	Cement	Alternate Cements
PFM/Gold where bonding is required due to limited preparation design	Air abrasion (Al2O3 blasting) to help with bonding	Pumice (lab), dentinal etching with citric acid and ferric chloride	Metabond	Panavia (follow manufacturer's instructions)
PFM/Gold where bonding is not required due to adequate preparation design	Air abrasion to clean surface	Pumice (lab)	Maxcem Elite RelyX Unicem2	Any cement can be used
Lithium-disilicate where bonding is required due to limited preparation design	Air abrasion, HF etching, silanation	Pumice (lab), etching of dentin and enamel, priming and bonding as indicated	Maxcem Elite RelyX Unicem2	
Lithium-disilicate where bonding is not required due to adequate preparation design	Clean surface with ethyl alcohol and dry	Pumice (lab)	Maxcem Elite RelyX Unicem2	Any cement can be used
Zirconia where bonding is required due to limited preparation design	Air abrasion	Pumice, etching of dentin and enamel, bonding resin as per manufacturer	Panavia	Metabond
Zirconia where there is adequate tooth preparation height	Air abrasion	Pumice (lab)	Maxcem Elite RelyX Unicem2	Any cement can be used
All-ceramic crown cemented to an all-ceramic implant abutment	Clean surface with ethyl alcohol and dry	Clean surface as preferred	Maxcem Elite RelyX Unicem2	Any cement can be used as long as aesthetics are maintained
All-ceramic crown cemented to a titanium abutment	Air abrasion	Surface treatment based on surface configuration	Metabond Opaque	Opaque cement is needed
PFM-based crown cemented to a titanium abutment	Air abrasion	Surface treatment based on surface configuration	Improv Maxcem Elite RelyX Unicem2	Any cement can be used as per clinical requirements

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2. Need for full coverage crown in the posterior part of the mouth (patient does not want any show of metal in the mouth) where the patient exhibits a high occlusal load. This is the patient who has broken down their posterior teeth over the years and exhibits the ability to produce high occlusal forces. This patient is the one who breaks restorations and/or teeth on a regular basis and might not be very compliant with your constant requests for nightguard use. In this type of case, use of a ceramic monolithic material is called for. For reasons of strength, a full-contour zirconia-based crown is needed. One must remember that the crown will look opaque but will be quite strong as long as the preparation design allows for adequate occlusal reduction. The material cannot be etched and as such cannot be truly bonded to tooth structure. According to published reports, cementation is best achieved with Panavia. In the opinion of this author, Metabond is also wonderful cement for this crowns material. Tooth preparation needs to be idealized for retention and resistance form since posterior teeth are generally lacking in height and the zirconia-based material cannot be adequately and predictably bonded to.

Fig. 8

Fig. 8: The classic full gold crown still serves as one of the best restorations available. From a functional point of view it may still be considered the "gold standard."

3. Need for full-coverage crown in the posterior part of the mouth (second molar) where the patient exhibits a lighter occlusal load. This is the patient who does not seem to exhibit that much force posteriorly but wants an aesthetic restoration. In this situation, use of monolithic lithium-disilicate is ideal since it can be bonded during cementation and is very strong. It is also much more aesthetic in its appearance (when compared to monolithic zirconia) and can be stained more readily than zirconia.

4. Full coverage crowns on all other posterior teeth (first molars and both premolars) where aesthetics are crucial. This case needs lithium-disilicate for its strength and aesthetic quality. The material is quite lustrous and strong. When possible I prescribe the milled version of this material so that colors can be more deeply embedded into the surface.

5. Full coverage for the anterior teeth. Due to lower stress levels in this part of the mouth in most patients, a layered ceramic could be considered for its aesthetic quality. Either a zirconia core or a lithium-disilicate core can be used and porcelain can be laminated to it. If it is felt that forces are heavy in anterior guidance or in lateral excursion, then one might consider making the crown out of the core material and extending the core material to the occlusal surface and the laminating porcelain to the non-fuctional regions of the crown for aesthetic enhancement. If the preparation is short, then bonding during the cementation protocol is a good idea and would direct one toward the use of lithium-disilicate to assure adequate bonding cementation.

Based on the breakdown listed here it is quite evident that I do not use PFM restorations very often anymore for single crown restorations. If I need to match an existing PFM crown in an area of lower force, a new PFM is acceptable; otherwise an all-ceramic crown has become the workhorse in our practice.

For an all-ceramic crown to work well and fit properly, one must prepare the crown to ideal preparation design. There must be adequate occlusal reduction (this is the key) and the margins of the preparations must be clear and easily read. Whether you choose to use a chamfer-like preparation margin or a shoulder-like margin, it must be clean and smooth so the material can be made to fit the margin. Metals are much more forgiving when they are cast to fit a margin that is less than ideal. A milled crown needs a clean smooth margin of adequate depth so that the mill can produce the crown with proper shape and fit. A zirconia-based crown margin is more forgiving in its manufacturing when compared to the milled lithium-disilicate. One must remember these issues when preparing teeth. If I find that I am not able to adequately prepare a tooth margin for milled in-house CAD/CAM, then I choose either pressed ceramic (monolithic lithium-disilicate in non-aesthetic areas or monolithic zirconia if preparation height allows for it) or a laminated all-ceramic where the core is pressed and additional porcelain is added to it.

What choice do I make in my production of an implant-based crown? Where aesthetics is important, and low to medium occlusal load is present, a zirconia-based abutment is made and a cemented crown (zirconia or lithium-disilicate core with laminated porcelain over top) is placed using conventional implant cementation protocol. If a screw-retained crown is chosen, either porcelain can be added directly to the zirconia abutment or a separate crown can be manufactured with a screw access hole and it is cemented to the abutment extra-orally once complete (Figs. 9a-c). The full restoration can then be secured to the implant using the conventional screw-in approach. In cases of high stress, a monolithic crown is needed rather than the layered crown. This can be manufactured from either zirconia or lithium-disilicate based on the aesthetic need. This can then be cemented or connected to either a zirconia abutment or to a titanium abutment. In the highest stress situations, a monolithic abutment and crown can be made from either zirconia or from metal and screwed in on top of the implant. This approach makes use of the fewest number of materials, has the least number of interfaces and stands the best chance of survival (Fig. 10).

How do I treat the different materials when it comes to cementation?

One must remember that there are many materials that can be used to cement a crown to either a tooth or to an implant. Once must consider what we are trying to do. Is this an interim cementation? What is the crown preparation like? Is there enough retention and resistance form in the preparation? Is the crown preparation in tooth structure or is there build-up material (composite resin, amalgam, cast post and core metal, etc.) present? What is the crown made of and do I need to bond to it? How difficult is clean up?

It is difficult to characterize and give strict guidelines since clinical experience plays a big role in how one decides which cement to use and under what conditions one chooses and uses particular cement. In a busy practice, one wants to minimize the number on materials that one uses so that simplicity rules. Table 1 (on page 37) suggests several choices in cement materials and methods when it comes to all-ceramic materials. It, by no means, is the only option. If preparation is adequate, and there is retention and resistance form, one can cement any strong material with virtually any cement. Metal, zirconia and lithium-disilicate can all stand on their own and as such they can be cemented with luting cements. In these cases any cement can be used. It has been our practice to use self-etch self-bond cement that simplifies the process by not requiring added steps. For this we use either Maxcem Elite (Kerr) or RelyX Unicem2 (3M). If bonding is needed due to lack of preparation, then one must look closely at the crown material as well as the preparation substrate and use cement that bonds to both materials.

All-ceramic materials are here to stay and it becomes up to us to choose the proper material and the clinical application presented to us. This field will continue to evolve and will give us much to think about. ■

Fig. 9a: A radiograph showing a zirconia-based abutment for an implant with a lithium-disilicate crown that has been bonded to it.
Fig. 9b: Occlusal view of the restoration on the master cast showing the aesthetic quality of the stained monolithic lithium-disilicate.
Fig. 9c: Lateral view showing the restoration and part of the underlying abutment.
Fig. 10: A recently made full contour zirconia-based screw-retained implant restoration without any laminating porcelain.

Author's Bio

Dr. Izchak Barzilay received his DDS from the University of Toronto in 1983, a Certificate in Prosthodontics from the Eastman Dental Center in Rochester, New York, in 1986, and a MS from the University of Rochester in 1991. He is currently Head of the Division of Prosthodontics and Restorative Dentistry at Mt. Sinai Hospital, Toronto, Ontario; assistant professor, University of Toronto, Toronto, Ontario; adjunct assistant professor, Division of Prosthodontics of the Eastman Department of Dentistry, University of Rochester, Rochester, New York; Prosthodontic Examiner – Royal College of Dentists of Canada; past president of the Association of Prosthodontists of Canada: past president - Ontario Study Club for Osseointegration.; advisory board - Toronto Implant Study Club; Editorial Council – Spectrum, and is in private practice limited to prosthodontics and implant dentistry in Toronto, Ontario. He has published on various topics including immediate implants, bonding plastics to various metals and other material and implant-related topics. He has been awarded the Tylman Award (American Academy of Crown and Bridge Prosthodontics), Prosthodontics Research Award (International Association for Dental Research), Buonocore Award (American Association for Dental Research Rochester Chapter), the Essay Award (American College of Prosthodontics), the International Journal of Oral and Maxillofacial Implants-Best Paper-1996 and the A.B. Hord Master Teacher Award (University of Toronto). Dr. Barzilay holds fellowships in the Academy of Prosthodontics, Academy of Osseointegration, Royal College of Dental Surgeons of Canada, Pierre Fauchard Academy and the Academy of Dentistry International. He can be reached at 461-322-6862 or ibarzilay@buildyoursmile.com.

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1. Which of the following are problems associated with gold crowns?
   a. Cost of metal
   b. Not aesthetic in the anterior region
   c. All of the above

2. Recent advances in the technologies of design and manufacturing of all-ceramic restorations make them…
   a. easier to construct.
   b. more precise in fit.
   c. clinically stronger.
   d. All of the above

3. Laminated ceramic crowns…
   a. use the concept that the underlying material can be made to fit well to the preparation and then the overlaying material gives the aesthetics that is needed.
   b. are an outdated concept.
   c. rely on acrylic facings.
   d. are better cemented than bonded.

4. In laminated ceramic crowns…
   a. the underlying structure may be brought out to support the occlusion.
   b. the overlaying material may be used to support function and aesthetics by being the functional surface (occlusal surface).
   c. the two materials must be compatible with each other to prevent delamination and fracture.
   d. All of the above

5. Currently monolithic ceramic crowns are made of…
   a. lithium-disilicate.
   b. zirconia.
   c. acrylic.
   d. a and b

6. Since monolithic materials have the inherent quality of not involving lamination…
   a. there is one less interface to deal with.
   b. this makes the crown stronger and more resistant to some of the surface fractures that occurs with laminated crowns.
   c. generally does not match the aesthetics of the laminated restorations since there is no overlying porcelain.
   d. All of the above

7. Lithium-disilicate…
   a. can be pressed.
   b. can be milled.
   c. can be bonded by conventional means.
   d. All of the above.

8. Which of the following is false?
   a. Zirconia can be used in the posterior region in patients that can produce high occlusal force.
   b. Zirconia bonds as well as lithium-disilicate.
   c. Zirconia tends to look opaque.
   d. Retentive preps are needed with zirconia.

9. Which of the following is false?
   a. Bonding makes lithium-disilicate less likely to break in the mouth over cementation.
   b. Lithium-disilicate tends to be quite lustrous and strong.
   c. Lithium-disilicate works almost as well (and looks nice) when not crystallized.
   d. A layered ceramic could be considered for its aesthetic quality in the anterior region of the mouth.

10. True or False: Monolithic materials are to be avoided in bruxers.
   a. True
   b. False

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