

Essential factors in success of all-ceramic restoration

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Abstract

The use of all-ceramic crowns is increasing, and this trend will continue in future too. However, all ceramic systems are not same. They differ considerably in their relative esthetic potential, their physical properties and evidence base relative to longevity. The use of an all-ceramic system does not guarantee outstanding esthetics.

Some all-ceramic systems can provide superior esthetic results compared with metal-ceramic restorations. Zirconia-cored crowns are the strongest all ceramic system and may provide improved esthetic results compared with metal-ceramic crowns. Not all ceramic restorations have been shown to have a life span equivalent to that of metal-ceramic restorations. Clinicians should choose appropriate all-ceramic restorations on the basis of their patients' needs. Currently available evidence indicates that clinicians should not use all-ceramic crowns on molars; in addition, posterior fixed partial prostheses fabricated with all-ceramic materials have a high likelihood of failure. Further clinical trials are needed.

Key words: All ceramic restoration, Esthetic potential, Transformation toughening, Zirconia-cored restorations

Introduction

It is generally accepted that ceramic restorations exhibit excellent esthetic qualities. However, the mechanical shortcomings of such materials include their inherent brittleness and potential to abrade the opposing dentition. Recent developments have attempted to overcome such disadvantages by either the use of increasingly complex technology or by the simplification of existing techniques and/or materials. Patients increasingly are demanding dental restorations that are both esthetic and functional. Manufacturers have introduced numerous all-ceramic alternatives to metal ceramic restorations, and all-ceramic restorations are being marketed to patients and dentists in an aggressive manner.

The diversity of dental ceramics continues to stimulate laboratory and clinical research. Systems such as Dicer and Empress are now established, and data regarding the in vitro and in vivo performance of such restorations have been reported widely. Modifications to several systems have been suggested or introduced to overcome certain disadvantages. The potential of the InCeram system, remains to be exploited to the full. The diversity and sophistication of some of the CAD-CAM systems may prove to be influential in the future¹.

It is safe to state that many dentists are somewhat confused about what these restorations offer in terms of improved esthetic potential, as well as their indications, contraindications and potential life span. In this article, factors that are essential for success when using all ceramic restorations are described. Many of these factors also are essential for success with any type of indirect restoration.

Primary Indications

The primary indications for all-ceramic restorations are improved esthetics and lower cost compared to precious metal-ceramic. Although the physical properties and strength of all-ceramic crowns have improved, no study has demonstrated that they can provide the same length of service as properly fabricated metal-ceramic restorations. Thus, clinicians should use them with patients for whom the esthetics of the restoration are more important than absolute longevity².

The esthetic potential of different all ceramic systems is not equal. When restoring anterior teeth, dentists should use the most esthetic system for which there is a documented evidence base regarding longevity. The criteria suggested by Schärer¹ as an adequate evidence

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base seem appropriate. Those criteria include the need for published independent clinical trials of three to five years' duration, with survival rates of 95 percent or greater. Such a system should have a relatively translucent core, the capability for the technician to build in color intrinsically, and esthetic layers of body and incisal porcelain. Etched and bonded feldspathic porcelain jacket crowns and restorations fabricated with the IPS Empress System (Ivoclar Vivadent, Amherst, N.Y.) meet these specifications.

Restorations with zirconia cored do not have equivalent esthetic potential, and because of their improved physical properties, they are indicated primarily for crowns on premolars and molars and for anterior fixed partial prostheses. With the escalating cost of precious metals, all ceramic crowns are competitive with metal ceramic crowns from a cost perspective. An informal survey of several major dental laboratories indicated that at the current cost of gold, platinum and palladium, all-ceramic alternatives are considerably less expensive, especially when the costs of providing all-porcelain margins in metal-ceramic crowns are factored.

Esthetic success: It is important to understand that simply placing an all-ceramic restoration instead of a metal-ceramic restoration will not guarantee outstanding esthetics. The clinician must accomplish a number of details meticulously to ensure success. One of the most important details is proper tooth preparation, including finish-line geometry^{3,4}.

To attain optimum esthetics and adequate strength, the dentist must achieve adequate reduction to give the ceramist room to create a restoration with excellent esthetics, as well as to achieve physiological crown contours. The clinician must remove a minimal cross-sectional thickness of between 1.2 and 1.5 millimeters of enamel and dentin circumferentially to provide sufficient room for the core and veneering porcelains. These are aggressive preparations, and a biological price may need to be paid for the sake of esthetics.

Pulpal status: In this regard, the clinician must assess carefully the pulpal status of teeth to be restored before preparing them. Many teeth that require crowns have undergone multiple restorative procedures over the years, each of which stresses the pulp and increases the likelihood of eventual pulpal death^{5,6}. If there is any question regarding the viability of the pulp and an all-ceramic crown is to be used, the clinician should perform endodontic therapy before preparing the tooth. Creating an endodontic access cavity through an all-ceramic crown is difficult and often results in a defect that becomes more extensive, eventually requiring fabrication of a new restoration.

The cervical finish line should be a rounded shoulder or deep chamfer at 90 degree to the external angle of the root, and it should be as smooth as possible. The location of the finish line is critical to long-term gingival health. If we assume that achieving an optimum esthetic result is one of the goals of placing an all-ceramic crown, the dentist will, in most situations, place the cervical margins in a subgingival location. Margins need to be placed deeply enough into the sulcus so that minor gingival recession will not expose them, but not so deep that they violate biological width and result in a chronic inflammatory response^{7,8,9,10}.

Clinicians can use the anatomical landmarks suggested by Block¹¹ and Kois¹² as guides for predictable margin placement. The gingival tissues must be brought to a state of optimum health before the dentist determines the final location of the cervical margin and makes the impression. Quality acrylic resin provisional restorations are essential to achieving this¹³, and Sorensen and colleagues¹⁴, Flemmig and colleagues¹⁵ and Sorensen and Newman¹⁶ described useful gingival enhancement procedures.

Patient-related factors: The decision to use an all-ceramic restoration should be made in the context of a number of patient-related factors. The considered factors are:

- What are the patient's esthetic Expectations ?
- Are there complicating Occlusal relationships ?
- What is the Level of parafunctional activity?
- Is the anticipated restoration on an anterior Tooth or a molar ?
- and is it a Single-tooth restoration or a Fixed partial prosthesis ?
- If there is evidence that the patient experiences Nocturnal bruxism ?
- Will he or she wear an occlusal Nightguard every night ?

In ideal circumstances involving anterior single-unit restorations, it is recommended that the dentist choose what I believe is the most esthetic option (IPS Empress System, Ivoclar Vivadent, Amherst, N.Y.). In compromised situations or when restoring posterior teeth or placing a fixed partial prosthesis, the dentist should choose a stronger, zirconia-cored system. It is critical for patients to understand that long-term survival rates for all-ceramic restorations are likely to be lower than those for metal-ceramic restorations, and that they give appropriate informed consent^{17,18}.

Zirconia-cored Restorations

When considering use of a zirconia-cored restoration, clinicians should understand that all zirconia materials

are not the same. A system that mills the zirconia core in the softer "green" state and then sinters it is superior to one that mills the core in the sintered state. This is because the latter requires a robust milling machine and high-temperature milling that will result in near surface damage and defect formation, which will significantly shorten the anticipated life span of the restoration²⁰. Milling in the green state followed by sintering allows lower-temperature milling, and the sintering "heals" any milling induced defects.

Zirconia-based technology in dentistry is in its infancy, and much remains to be learned before dentists use it routinely in practice. There are no published studies with five, ten year data that meet Schärer's criteria³ for restorations on posterior teeth or for fixed partial prostheses¹⁷. The physical properties of the zirconia core are excellent, with their high strength and fracture toughness. In addition, the cores possess a property called "transformation toughening" that prevents defect propagation through transformation from the tetragonal to the mono clinic form. Many clinical trials are being conducted, and the fact that most involve posterior teeth or fixed partial prostheses indicate that the manufacturers of these materials are confident of a high level of success¹⁸.

Current evidence suggest that all-ceramic restorations have an acceptable clinical longevity that accompanies their long-lasting esthetic advantages. Evidences from many clinical studies suggest that clinicians may choose from any all-ceramic system on the basis of patients' esthetic needs for veneers, intracoronal restorations and full-coverage restorations for single-rooted anterior teeth¹⁹.

Only a few systems have been successful for the restoration of molars, and additional clinical factors such as adequate preparation depth and cementation can outweigh materials considerations. In the future, transformation toughened zirconia may stand out as the most successful all ceramic system, irrespective of the clinical indication. Nevertheless, chipping of the veneering ceramic on zirconia restorations continues to be a problem. The evidence provided here should enable clinicians to enter into informed-consent decisions with their patients who desire all ceramic restorations.

Chipping: One problem that has plagued almost all trials of zirconia-cored restorations has been a relatively high rate of chipping of the veneering ceramic. The fracture rate of the veneering ceramic has ranged from 8 to 50 percent at one to two years in these trials, while the reported rate of veneer fracture with metalceramic restorations has been between 4 and 10 percent after 10 years¹⁸. The cause of this chipping is not known, and

both core flexure and bond failure have been suggested. Another possible cause of chipping is the lack of uniform support of the veneering ceramic by the core. A well-established principle for metal ceramic restorations is that the metal core should support a uniform thickness of veneering ceramic and that there should be a maximum of 2 mm of unsupported porcelain. This is accomplished with an anatomical-contour wax-up and controlled cut back.

Veneering ceramic thickness: Laboratories make zirconia cores by scanning the die and then milling a uniform core of 0.3 mm for anterior teeth and 0.5 mm for posterior teeth. Because of the bell-shaped nature of teeth that must be reduced to remove undercuts, uneven thicknesses of the veneering ceramic will result, some of which may exceed the industry standard of 2 mm. The technician can correct this problem before he or she mills the core, but this rarely is done in commercial laboratories. Clinicians should request that the laboratory send them a digital image of the proposed core for approval before milling the core to ensure a uniform thickness of veneering ceramic with adequate core support.

On retrospective analysis of porcelain failures of metal ceramic crowns and fixed partial dentures supported by 729 implants in 152 patients done by Richard P. Kinsel²⁰, and Dongming Lin, within the limitations of their study, the risk of porcelain fracture of an implant-supported metal ceramic crown or FPD was greater than the risk of fracture in the same types of prostheses supported by natural dentition. Fractures, especially major ones, were more frequent when the restoration was in occlusal opposition with another implant-supported single crown or FPD, or when the patient had a bruxism habit. It was also indicated that not using an occlusal device was a significant factor for porcelain fracture.

Cementation

The cementation protocol for all-ceramic crowns can be essential for success. Clinicians can effectively etch feldspathic porcelain jacket crowns and IPS Empress restorations with hydrofluoric acid and bond them in place by using a resin cement. Clinical studies have indicated that this protocol significantly increases their expected clinical life span^{21,22}.

Clinicians can accomplish this with one of two approaches. One approach is to use the immediate dentin sealing concept advocated first by Paul and Schärer²³ and more recently by Magne and colleagues²⁴ and Magne²⁵. With this approach, the dentist seals the dentin with a highly filled dentin bonding agent (such as OptiBond FL, Kerr, Orange, Calif.) immediately after tooth preparation and before making the impression.

Although there is no long-term documentation, another approach is to use a self-adhesive dual cure resin cement and thus avoid the bonding step entirely. This is the simplest approach, although there are some minor concerns regarding potential long-term hydrolysis due to the hydrophilic nature of the self-adhesive cement.

High-strength all-ceramic materials (zirconia and alumina) cannot be etched and bonded readily. This is not really a disadvantage because it permits cementation with more conventional resin-modified glass ionomer cements (such as RelyX Luting Plus Cement, 3M ESPE, St. Paul, Minn.), which are less technique-sensitive. With traditional preparations, which provide mechanical retention and resistance form, adhesive cementation is not needed.

Some authorities have advocated the use of air abrasion and cementation of zirconia-cored restorations with a cement containing specific adhesive monomers (such as Panavia F2.0, Kuraray America, New York City)²⁶ or air abrasion along with tribochemical bonding in order to adhesively cement zirconia restorations. Clinicians should exercise a great deal of caution when taking this advice. First, adhesive cementation is not necessary or critical to improve success rates. Second, the results of studies of air abrasion of zirconia-cored structures have been variable at best^{27,28}.

Air abrasion of the intaglio surface of zirconia crowns can cause a transformation change from the tetragonal to the monoclinic phase, which severely ages the restoration and reduces its life expectancy. The problem is the particle size and it is pressure-dependent, but it is a potentially significant problem and the benefits do not equal the risk.

As a routine part of maintenance, dentists should provide a nightguard to any patient suspected of performing parafunctional activities, such as diurnal or nocturnal bruxism. A hard and soft nightguard (for example, Comfort Zone Bite Splint, Drake Precision Dental Laboratory, Charlotte, N.C.) is preferred. The hard occlusal surface permits precise adjustment of the occlusion, while the soft intaglio surface provides comfort, which improves patient compliance. The dentist should instruct the patient to avoid immersing such splints in solutions containing alcohol and to bring the splint to all recall appointments so that he or she can monitor compliance.

The effect of hydrofluoric acid surface treatment and bond strength of a zirconia veneering ceramic studied by Yada Chaiyabutr, et al, Mass Effective ceramic interface management, such as acid etching and enamel bonding, is considered essential for successful ceramic laminate

veneer restorations. That study demonstrated that not all zirconia veneering ceramics display the same quality of surface roughness after hydrofluoric acid etching and the same bond strength to enamel when used as laminate veneer materials³⁰.

Conclusions

Each system has its own merits, but may also have shortcomings. Combinations of materials and techniques are beginning to emerge which aim to exploit the best features of each. Glass-ceramic and glass-infiltrated alumina blocks for CAD-CAM restoration production are examples of these and it is anticipated that this trend is likely to continue. However, the clinical success of all-ceramic systems will also be dependent on further improvements in resin composite luting cements and dentine bonding agents.

At the same time, the use of all-ceramic restorations is increasing, and this trend will continue. Higher-strength ceramic materials have expanded the indications for all-ceramic restorations; however, at this time, their efficacy is not similar to that of metal ceramic restorations. Simply using an all-ceramic restoration will not ensure predictable esthetic success. Precise attention to detail with regard to tooth preparation, cervical margin design and location, soft-tissue management and impression-making are crucial to success. Proper selection of materials and the ceramist also are essential, as are correct shade matching procedures. Correct luting protocols are important to long-term success. Finally, patients with all-ceramic restorations should routinely use an occlusal nightguard.

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