

Surface Treatment of All-ceramic Restorations: A Literature Review

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Abstract

Tooth tissues do not possess any natural affinity to dental ceramics. The studies done in the past indicate that the adhesive system seems to be a valid option for all ceramic prosthesis cementation, since it has several advantages over conventional cementation methods. Hence, proper pre-treatment and adhesive resin composite cements are vital when bonding ceramic materials to the tooth. However, the adhesive technique is a very recent procedure and clinicians should have a more detailed knowledge about the technique and related materials so that they can use them in their day-to-day clinical practice. The clinician should always keep in mind the characteristics of materials they are working with, so that they can select the best technique and the best cement for each clinical situation. This review aims to present some aspects of dental ceramics surface treatments, which involve the related physical and mechanical properties, as well as new technologies.

Keywords: Acid etching, Acid resistant ceramics, Acid sensitive ceramics, Blasting, Silanization, Silicatization

INTRODUCTION

There is an increasing search for aesthetic treatments in dentistry, which has led to a great interest in the developments of new materials and techniques to supply such demand. In this context, materials such as adhesive systems, composite resins, resin cements, and dental ceramics have been increasingly improved.^[1] Ceramics are biocompatible and inert materials and have a high degree of intra-oral stability. They are the material of choice when esthetics is of importance, as they have the ability to simulate the tooth structure successfully. The predominantly glass-based ceramics, that is, the fieldspathic porcelain is most commonly used as veneers in PFM restorations. Being the weakest of all types, they are used only in the bilayered restorations, where esthetics is of concern. On the other hand, the highly glass based ceramics – such as leucite and lithium disilicate are considered for use as inlays and onlays and also anterior and posterior crowns, due to their good mechanical properties. Zirconia, which is a polycrystalline based ceramic possesses excellent mechanical properties by virtue of which, it can be used as monolithic restorations in the posterior region and as a core material in bilayered restorations. The success of these restorations starts and ends at the restorative tooth interface. A successful bond between the tooth structure and the restoration reinforces the

tooth structure, biologically preserves the tissues, seals the dentinal tubules, and provides long-term functional success. Proper conditioning of the ceramic surface helps maintain durability of the restorative procedure.^[2,3] Conditioning that has good adhesive strength results for one ceramic may not show the same results for other ceramics. In this way, each ceramic system presents different conditioning protocols. The micromechanical and chemical bonding to the ceramic substrate depends on its physical properties and chemical composition. Therefore, its chemical constituents will define the most effective treatment method from the adhesive point of view.^[3,4]

Based on the foregoing, this literature review proposes to present some aspects of dental ceramics, which involve the related physical and mechanical properties, as well as new technologies. Having a better understanding of the recent procedures and techniques of adhesive cementation will help improve oral rehabilitation with fixed prosthesis.

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CLASSIFICATION OF CERAMICS ACCORDING TO ACCORDING TO ACID SENSITIVITY

Acid-resistant ceramics

Ceramics containing high crystalline content (aluminum oxides and/or zirconia) are named “acid-resistant” and they possess superior clinical performance to acid-sensitive ceramics. This increase in mechanical strength is due to an increase in the crystalline phase of the ceramic and a decrease in the glassy phase. When the preparation designs have a good retention and resistance form, non-adhesive cements or moderately adhesive cements can be used for their cementation. On the other hand, when the retention and resistance form is compromised, adhesive cementation with surface treatment of the ceramic material will increase the durability and reliability of such restorative materials.

The surface treatment for the tooth substrate remains the same, while that for the silica based and high strength ceramic varies greatly. Various surface treatments used for zirconia are depicted in Figure 1. Used as infrastructure for all ceramic restorations, they are ceramics that suffer little or no surface degradation by the action of hydrofluoric acid, enabling a limited micromechanical bonding by the conventional method. However, recently various acid solutions have been proposed to etch zirconia, based on hydrofluoric acid and nitric acid applied at a temperature of 100°C. In a study done by Xie^[5], good results were obtained with hot etching and application of 10-MDP primers. In another study^[6], an experimental acid solution (800 ml of ethanol, 200 ml of 37% HCl, and 2 g of ferric chloride) is tested. It proved to be able to dissolve the surface of zirconia and guaranteed good adhesion. Although these techniques seem, in some cases, able to promote good adhesion,^[5-7] it must be evaluated by the possible negative effects of the use of these methods, which are linked mainly to clinical safety.^[7]

At present, the two most commonly used methods are based on grit-blasting, either using alumina powder or silica-coated alumina particles (tribochemical silica-coating). Despite the benefits highlighted above of grit-blasting as a pretreatment of zirconia, this physical pretreatment, which depends mainly on the applied pressure^[8] but to a lesser extent on the application angle,^[9] may introduce surface flaws that can, if at critical locations and under excessive stress, affect the long-term performance of the restoration. If no pretreatment or grit-blasting using alumina powder is used, an adhesive resin composite cement system that contains 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP) should be used. Adhesive resin composite cements or ceramic primers containing 10-MDP are indicated because 10-MDP, the most promising functional monomer, forms a relatively stable chemical bonding with the demineralized tooth (through reaction between the hydrophobic 10-MDP parts with collagen) and with zirconia (through reaction between the phosphate ester groups of 10-MDP with the hydroxyl groups on the passive zirconia surface) (Figure 1).^[10,11] The 10-MDP to collagen complexation may contribute to the generally well-performing 10-MDP-based self-adhesive cements.

The currently available primer systems for zirconia include – Monobond Plus (Ivoclar Vivadent), Clearfil Ceramic primer (Kuraray), Primer (Shofu Dental), Metal/Zirconia Primer (Ivoclar, Vivadent), and Z prime Plus (Bisco). It is recommended to also use air-borne particle abrasion with small aluminium oxide particles before application of a ceramic primer, to further increase the bond strength of composite resins to high-strength ceramics.

Acid-sensitive ceramics

Acid-sensitive ceramics are those in which the hydrofluoric acid degrades its surface, enabling the micromechanical

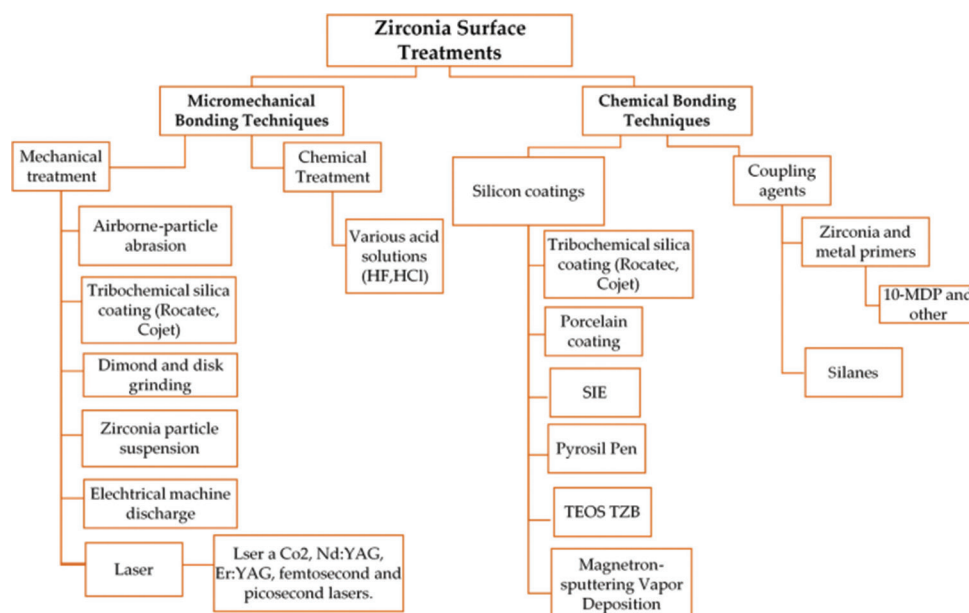


Figure 1: Surface treatment options for zirconia

bonding with resinous cements and the chemical bonding with resinous cements and the chemical bonding using silane coupling agents.

By virtue of its fine optical and esthetic properties, silica-based ceramic restorations are widely used for porcelain laminate veneers, inlays and onlays, and full coverage crown restorations. Being a brittle restorative material, it derives its strength from the adhesive bond of definitive restorations and the supporting tooth structure. It is therefore essential to do the surface treatment to ensure long-term clinical success. It is important not to place an excess or thick layer of silane as additional layers of hydrolysed silane will not bond to the porcelain surface and can result in a less than optimal porcelain bond.

In this category, some ceramics are recommended for partial inlay, onlay and laminate veneer restoration, such as feldspathic ceramics, leucite-enhanced feldspathic ceramics (IPS Empress), and lithium disilicate (IPS Empress II) ceramics.

CERAMIC SURFACE TREATMENT OPTIONS

Conditioning with hydrofluoric acid

The chemical process of conditioning with hydrofluoric acid causes a reaction with the glassy phase of leucite-reinforced ceramics, resulting in hexafluorosilicate. These silicates are removed by the jet of water forming a honey-comb surface that is ideal for the cement micromechanical retention.^[12] This is the surface treatment of choice for ceramics with feldspar or vitreous silica in a 2.5–10% of hydrofluoric acid for 20 s to 3 min, and subsequent application of silane.^[13] The 10% hydrofluoric acid conditioning is designed for 2 min. The hydrofluoric acid conditioning in leucite and feldspathic ceramics has been well studied and has confirmed the effectiveness of the treatment in this type of ceramic.^[14]

Hydrofluoric acid conditioning does not exert any effect on systems with high alumina content, such as the aluminized and zirconia based ceramic system. This may be due to low content of glassy phase and silica in them.^[15]

Blasting with aluminium oxide

Blasting is a method that consists of taking certain substances against the internal surface of the restoration that are capable of creating roughness. Aluminum oxide is the longest used substance for this purpose.^[15] This surface treatment consists of blasting with aluminum particles of about 50 µm in diameter at a pressure of 80 lbs/in² for 15 s to cause micro-retentions. It is one of the available methods for increasing the bond strength between ceramic restorations and cement resins. This treatment generates superficial irregularities in the ceramic surface, helping the interaction with cement.^[16]

It is advisable to work with smaller particles and, if necessary to increase the pressure as a way of achieving greater effectiveness, especially if the yttria-stabilized zirconia ceramic, since large shocks on this ceramic surface lead to its structural modification, which can compromise its resistance to deformation.^[15,16]

Silanization

In dentistry, silane coupling agents have several applications. They can be used as surface pre-treatment for ceramic adhesion to a composite of dental restorations, in intraoral repairs of ceramic surfaces or resins, and to attach a bionic layer to titanium implants.^[15]

Silane is a bifunctional molecule that on the one hand reacts with the organic matrix of the resin cement through the organic functional radical and on the other hand interacts with vitreous components of the glass ceramic (SiO₂) by means of the inorganic radical.^[13] As the silane will react with the hydroxyl group of the porcelain surface, it allows for the chemical adhesion by making it more reactive to the composite.

This bonding agent must be used in the ceramic with a disposable brush for 1 min. Then, it must be air-dried using a triple syringe for five seconds before applying the adhesive system.^[13] To simulate the reaction between the silane coupling agent and the inorganic surfaces of the ceramic, the reaction can be catalyzed by heating the silane agent. This thermal treatment allows for the silane agent to increase the bond strength between the resin cement and the ceramic.^[16]

Silicatisation

The use of silica before cementation involves the following steps: First, surface blasting with aluminium oxide (110 µm); second, deposition of aluminium oxide modified by silicon acid (30 µm or 100 µm); and third, silanization. This process will lead to the imbibition of silica particles by the ceramic, making its surface micro-retentive and chemically more reactive to the resin cement through the silane coupling agents.^[12]

The protocol for the blasting system is made at a distance of 10 µm and perpendicular to the surface for 20 s at a pressure of 2.8 bars, after which the silane is applied for 5 min.^[17,18]

The association of silanization, silicatisation, and cementation with MDP resin cements (phosphate monomer) provides high bond strength values for acid-resistant ceramics (alumina and zirconium oxide, and densely sintered alumina oxide-based structures).^[10]

CONCLUSION

Given the variety of cements available, dental surgeons cannot choose one type of cement for all cases. They should always keep in mind the characteristics of the material; they are working with, so that they can select the best technique and the best cement for each clinical situation. The previous preparation for the restoration and the tooth surface to be cemented is extremely important steps when using the adhesive cementation technique. Adhesive strength of the restoration is not only dependent on the properties of the resin cement, but also on the treatment of dental and interior surfaces of the restoration. In this context, it should be remembered that the application of silane after the surface treatment has proven to be an important factor that will increase considerably the bond strength between the tooth and the restoration.

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