How to achieve long-term stability on bonding zirconia/alumina structures?

Renato Savi de **CARVALHO***

Nothing seems to be more frustrating for dentists than the often recurrent displacement of an indirect restoration. Such clinical setback leads to self-criticism about their professional skills, which may also be silently questioned by their patients at the same time and raise serious concerns. For this reason, questions about which cementing techniques and agents are more appropriate for each particular clinical situation have always been raised during the phase of crown and prosthesis cementing. The desire to make retention last and to ensure that they are kept attached to the posts has led several authors and clinicians to constantly seek procedures and materials that are more reliable and adequate for that purpose.

Both dentists and the dental industry systematically seek alternatives to optimize esthetics in dental treatments. This is confirmed by the interest in adhesive systems and techniques that may ensure a better performance of composite resin restorations, or the special attention that has been paid to gingiva surrounding prosthetic crowns, either supported by implants or not. This latter has even gained the status of pink esthetics and is currently the focus of special attention.

The demand for better esthetic results is growing, and the use of densely sintered oxide-based structures, particularly alumina and zirconia, as replacements for metal copings in the traditional metal-ceramic crowns is irreversible. Such change has effectively translated into a substantial esthetic gain, so that it has become the first choice when the aim is to have crowns and restorations that respond to esthetic appeals. This is a fact! However, at the last moment of crown placement, questions about the ideal way to cement crowns haunt most of those that use such technology. The relevance of this question deserves a more profound analysis.

How to cite this article: Carvalho RS. How to achieve long-term stability on bonding zirconia/alumina structures? Dental Press Implantol. 2012 Oct-Dec;6(4):38-52.

» The author reports no commercial, proprietary or financial interest in the products or companies described in this article.

Contact address

Renato Savi de Carvalho
Av. Rio Branco, 19-45 – Bauru/SP – CEP: 17.014-037 - Brazil
E-mail: renatosavi@uol.com.br

Submitted: November 8, 2012
Revised and accepted: November 25, 2012

* MSc in Implantology, USC (Bauru/SP). PhD in Restorative Dentistry, FOB-USP.

Ceramics in dentistry

Characteristics such as biocompatibility, resistance to wear, action of chemical agents, chemical and color stability, thermal expansion coefficient similar to that of dental structure and, mainly, satisfactory esthetic results soon made ceramics the material of choice in the restoration of teeth when using indirect methods. Since 1774, when Duchateau and Chemant devised and produced the first total prosthesis with porcelain teeth, much has been studied to improve prostheses and to expand the use of porcelain in dentistry.

About one century later, in 1886, the first full porcelain crown was manufactured, which gave rise to an era of contradictions between optimism and uncertainties that has lasted until today, when the ideal way to manufacture and cement a ceramic crown seems not to have been defined yet. Introduced by Land and Taggart, and called "jacket crowns", these exclusively ceramic restorations reinforced by alumina and feldspar, or those cast using refractory dies, often failed because they had an inadequate marginal fit, low mechanical resistance and little technical sensitivity, as there was no supporting structure over which the porcelain cover could be applied.

In 1962, conventional crowns and prosthesis with a metal structure as support for the ceramic cover were designed by Weistein. Called metal-ceramic restorations and used almost exclusively with zinc phosphate cements, they have reduced the difficulties in this area and achieved its best performance in the last decades, with extremely satisfactory results that ensured their good acceptance and use until today. However, cases of allergy to metals, reported even for pure gold,[1] gingival reactions and, mainly, the request made by patients and professionals for better esthetic solutions were the trigger to seek ways to eliminate metal structures or replace them with nonmetallic materials.

McLean and Hughes, in 1965, described the manufacture of crowns using aluminized porcelain (conventional feldspar porcelain that incorporates 50% of aluminum oxide) over a platinum plate or refractory die. As they did not have a metallic appearance, these crowns were a real esthetic advance.

The history of ceramics evolution also features more or less successful attempts to manufacture metal-free crowns using milled ceramics, injected and infiltrated with glass.

Based on the functional success achieved by metal-ceramic prostheses, it was clear that the presence of a supporting structure was fundamental for the good performance of esthetic porcelain covers and, in consequence, of all restorations. Its elimination would simply represent a regression to a time of high failure rates.

In 1991, using CAD-CAM technology, the Procera™ crowns were released. Supported by alumina and, more recently, also zirconia structures — respectively produced using the process of aluminum oxide (Al_2O_3) and zirconium (ZrO_2) sintering — they represented an important contribution for the resolution of previous difficulties. They satisfactorily replaced the metal base even in areas submitted to high masticatory forces.[2] Since then, over 8 million of these crowns have been manufactured all over the world.

With a flexural strength of over 680 MPa, translated into success rates of over 95% after 5 to 10 years, the alumina and zirconia structures covered with porcelain have led the search for esthetic and functional excellence. This type of restoration successfully replaces the traditional crowns based on metal cast copings, and they provide precise marginal fit and mechanical resistance without impairing esthetics.[3,4]

When such a stage of evolution is achieved, dentists understandably want to also make sure that their restorations remain functional for a maximum length of time. Therefore, previous studies were consonant with those that aimed at improving adhesive cementation. The clinical use of fixed prostheses retained by means of adhesive systems depends on stable and durable bonding between resins and ceramics. Therefore, the wish to develop esthetic prostheses that may be both cemented and bonded has become stronger and motivated the search for the ideal cementing technique and agent.

The structure obtained by dense sintering of oxides (aluminum and/or zirconium) may add relevant esthetic and mechanical proprieties to the crown. However, it also compromises its adhesive cementation, performed after the internal side of the restoration has been treated with hydrofluoric acid and silane or an adhesive agent, common in pure ceramic restorations, because that acid, as any other acid, is inefficient when used with densely sintered alumina or zirconia.

Is it possible to use etching with alumina or zirconia?

Alumina and zirconia are materials obtained by compacting metal oxides under high temperatures. This process, called industrial sintering, produces a structure composed of almost only these oxides (Fig 1) and, differently from feldspar porcelain, free of silica. If there is no silica available to be removed during the interaction with acid — which should produce an irregular surface due to the exposure of non-etching crystals —, acid etching of this material is ruled out. The absence of silica also compromises silanization, because the silane agent, with its chemical affinity for silica, cannot establish any molecular connections.

Because etching, as well as silanization, is not possible, the bonding of these crowns to resin cements is very likely compromised. This hypothesis has been confirmed and seems to be, up to the moment, the issue that has raised questions and set limitations to the ideal cementation for this type of prosthesis. After the displacement of crowns manufactured with this material, resin cement often remains on the prosthetic retainers, and no cementing agent remains on the internal surface of the displaced restoration, at least according to superficial clinical examinations.

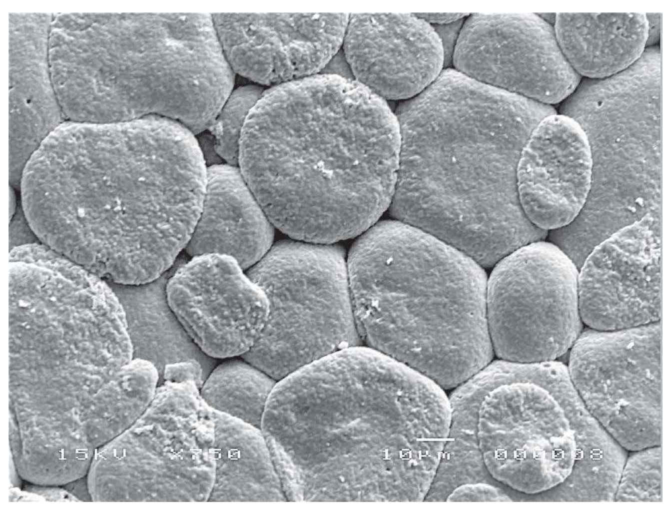

Figure 1 - SEM image of the inner face of a Procera® coping obtained by sintering of metal oxides. It is possible to observe the granules compacted by the industrial sintering with high pressure and temperature, as well as the absence of a vitreous phase (silica). (Source: Carvalho,[6] 2009).

As they have different structures, it is, in theory, impossible to replace metal with ceramics without reducing the mechanical resistance to fracture. Therefore, to obtain dental ceramics with greater resistance, the industry has invested in two directions: Improvement of their intrinsic quality by means of incorporating aluminum oxide to feldspar; and development of porcelain supports in a substrate that adds resistance to it.

Ceramics used in dentistry have different structures, characteristics and applications, and may be divided, for better understanding, into:

a) Base ceramics: Composed by oxides (aluminum, magnesium or zirconium) that have a high mechanical resistance, but an extremely unfavorable esthetic appearance.
b) Leucite-reinforced ceramics or lithium disilicate-reinforced ceramic: Its mechanical resistance is lower than that of base ceramics, but it may, after the application of esthetic coating, look like natural teeth.
c) Porcelains: They have the best esthetic result but the worst mechanical resistance. Essentially composed of feldspar, they have a high elasticity modulus and low tenacity, characteristics that translate into absence of deformation in face of application of a load and little resistance to crack propagation.

Methods available for the manufacture of ceramic restorations

Different methods are available to produce ceramic restorations in the laboratory. They are classified into three categories: Milling, pressing and sinterization.

Two or more methods may have to be associated depending on the type of clinical results expected. The Procera™ crowns, either based on alumina or zirconia, are good examples of the successful association of two methods. In the case of a fully ceramic crown, ceramic copings (base) may be produced by milling followed by industrial sintering of some metal oxide that will be later coated with feldspar porcelain using the bake technique.

Milling requires the drilling of a ceramic block until the shape desired for the restoration is obtained. Two techniques can be used for that: CAD-CAM and the pantographic technique. Milling requires the use of sophisticate equipment and micro-cameras for intraoral imaging of cavity preparation and milling units.

Moreover, the fit of prosthetic restorations produced using this technique is not precise. Therefore, milling has been the least used technique to manufacture ceramic elements directly in the clinic, and its use has been limited to the industrial production of copings, with quite interesting results in terms of dimensional accuracy and fit.

Pressing is similar to the system used to obtain metal restorations by investment casting, in which a wax pattern is included in a ring with refractory material and taken to the oven for evaporation and creation of a counter model. After that, the ring is placed in a special ceramic oven where ceramic tablets are melted and injected into the empty space. After the removal of the coating, the restoration is rough and non-esthetic, and should receive color and surface finishing.

For that purpose, two techniques can be used: Makeup or stratification. In the first, dies are applied to the external surface of the restoration and baked in a porcelain oven. The second consists on the application of feldspar porcelain over the pressed structure after it is partially waxed to cover the edges, but leaving space so that the coating porcelain can be added to give it an esthetic shape.

In the pressing technique, leucite-reinforced porcelain may be used (in case of units) and lithium disilicate-reinforced ceramics (that have greater flexural resistance, and is good for units or small fixed prostheses). When compared to the restorations manufactured only with feldspar porcelain, pressed restorations have a higher intrinsic mechanical resistance and can also undergo acid etching, which ensures excellent bonding to the resin cementing agent.

Sintering is defined as the process that can convert a porous material into a dense and strong material by means of transformations at high temperatures. To produce ceramic restorations, there are three techniques that use sintering: Baking, infiltration and industrial sintering under high pressure and temperature.

In the same way, the infiltration technique also produces ceramic copings with high mechanical resistance based on the compaction of metal oxides (aluminum, zirconium or magnesium). These copings produced using either technique (infiltration or industrial under high pressure and temperature) are called base ceramics and should be coated with esthetic coating materials, such as feldspar, aluminum or low fusion porcelains, which, once taken to the baking oven, will give an anatomic and esthetic form to the restoration.

Ceramic crowns should not, therefore, be understood to be produced exclusively by means of porcelain bake. Equivocally, this idea gained force because bake is the oldest and most versatile method to produce ceramic restorations. Bake should be understood as the addition of porcelain (powder + liquid) over a structure or base (refractory, ceramic or metal coping) and later baking in an oven specifically for that purpose. This method ensures excellent shape and esthetics, because a wide combination of porcelains, with different hues and optical characteristics may be used in successive stratifications.[5]

Treatment of the inner surface of the restoration

It is common sense among those that defend adhesive dentistry that there are three ways to bond different structures: Physical, chemical and physical/ chemical. It is understandable, therefore, that clinicians and researchers attempt to expand, as much as possible, the nature of bonding combining these three modes.

The creation of micro-porosities or roughness on the inner surface of ceramic restorations, similar to those observed in tooth tissue after acid etching, went from speculation to primordial objective when the purpose was to bond resin to ceramics. Success, credibility and clinical and scientific confirmation were achieved when purely ceramic restorations, basically composed of feldspar porcelains containing a vitreous (silica) and a crystalline phase, started receiving hydrofluoric acid etching.

The silica selectivity for this type of acid produces hexafluorosilicate, removed by water rinsing. This exposes the crystals of the crystalline phase (Fig 2) and, consequently, creates some superficial roughness, similar to a honeycomb, extremely useful for the micromechanical inclusion of a resin, and, consequently, a physical bond.

Associated with this technique, a bifunctional component (silane) is applied. It can bond to the vitreous phase of porcelain by means of chemical bonds and to the organic phase of the resin, which ensures even better adhesive properties to the porcelain/resin combination. Its chemical strength, in addition to the mechanical interweaving mentioned before, also acts upon its adhesive interface.

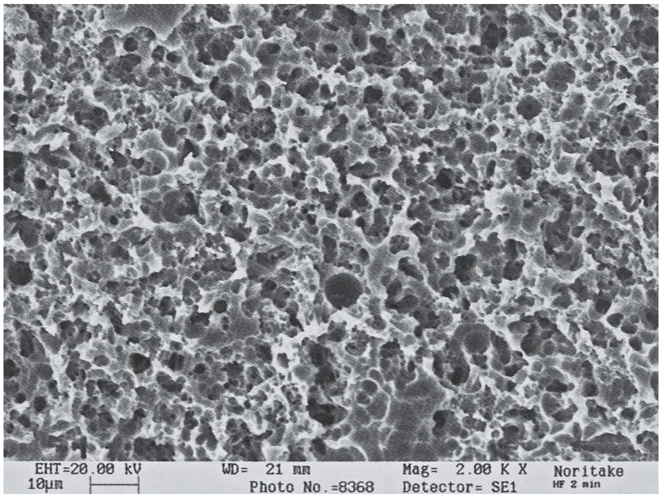

Figure 2 - Feldspar porcelain surface after fluoride acid etching. (Source: Carvalho[6], 2009).

The combination of these two patterns of adhesiveness (physical and chemical) occurs spontaneously because of the fluidity of silane that permeates and infiltrates the spaces and pores left in the ceramic surface after acid etching. This produces an interesting microstructural and chemical weaving with the silica remaining in porcelain, as well as with the organic portion (methacrylate groups) of resin cements.

How to produce irregularities in densely sintered zirconia?

According to the previously described principle of reliability of physical, chemical and physicochemical connections, we have tried to reproduce similar micro-retention on ceramic restorations based on densely sintered oxide structures. However, the lack of a vitreous phase that may be partially removed by acid interactions (the best known and most important way to create micro-retentions on ceramic surfaces) in this type of ceramics precludes the creation of micro-rugosities and blocks the chemical connections with silane and adhesive agents. Therefore, other ways of creating roughness on the surface of dense, highly crystallized ceramics, have been sought, and the methods developed have basically focused on physical attacks to its structure.

Mechanical abrasion due to aluminum oxide particle acceleration against the alumina structure has been studied by several authors.[7,8] Developed in the 40s as an alternative to low speed engines (the first high speed engine appeared in the end of the 50s), this type of blasting, often using aluminum oxide grains with diameters of 50 or 100 µm and hardness close to that of alumina crystal found in ceramic structures, creates roughness similar to that left by the hydrofluoric acid on feldspar porcelains and facilitates resin penetration and bonding. As an alternative to this type of etching, abrasion by spraying of 1 to 3 µm synthetic diamond particles has been tested, and produced even more marked rugosities on densely sintered alumina. When associated with a silane agent that may infiltrate these porosities, although a chemical connection is not established because of the lack of silica, it seems to be an interesting technique to increase the strength of union between resins and densely sintered alumina.

This method of creating surface roughness in ceramics has also found opposition in those that classify it as innocuous or blame it for the generation of micro-cracks and, consequently, structural weakening. Moreover, in some cases, it may compromise an area previously adequate for bonding, such as in the case of unprocessed Procera™ crowns, because it smoothens the surface instead of producing micro-retentions.[9]

Some authors have tested the addition of silica to alumina structures to create a "chemically favorable" environment for silane to interact before cementing with resin agents. This incorporation of silica is possible when using a specific equipment, so that the structure of alumina may be blasted with aluminum oxide grains coated with silica at a high speed. Some reports demonstrated that, as a result of this impact, the silicate particles of aluminum oxide may penetrate over 15 µm into the ceramic or metal substrate. After coating with silica, the alumina surface may become chemically more reactive to the silane agent, which may ensure bonding where it was not possible before.

Moreover, the micro-topography of the ceramic surface may be affected, having more or less rugosities, which is also relevant to ensure penetration and physical adhesion of fluid resins.[10]

Chemical bonding between resins and ceramic surfaces may also be obtained by using plasma sprays. Plasma is a gas partially ionized in a high power generator containing ions, electrons, and neutral particles. The ionization of ceramic surfaces for adhesion may confer it better chemical reactivity, very likely due to the establishment of more than one type of electronic and covalent connections.

The incorporation of low fusion porcelain granules (porcelain pearls), either silanized or not, to the alumina surface may also generate interesting roughness for the mechanical infiltration of resin cements. This structural change of the alumina and zirconia surface has been tried in some studies, and results have been extremely satisfactory, because granules promoted micro- and macro-mechanical infiltration of the resin. Observations after shearing tests revealed that the pearls remained bonded to the ceramic surface after the adhesive fracture of the resin. When this technique is used, the porcelain granules should be applied only during the last bake or during glazing, and the thickness of the layer should not be greater than 5 µm, which might lead to poor adjustment or difficulties in the fit to the prosthetic retention.

The cementing agent

Cavity and coronal preparations should be adequate for retention and resistance, but the success of fixed prostheses is strongly dependent on the cementing procedure, and dental cements play important role in the success of indirect restorations.

Together, the loss of retention and the displacement of prosthetic crowns are the second most frequent cause of failure of this type of treatment. Moreover, cements should act as a mechanical barrier to the penetration of fluids and oral microorganisms into the interface between restoration and prosthetic retention. Therefore, cements should bond different materials and interact with both surfaces that they contact. Bonding here may be mechanical, chemical or a combination of both.

An ideal cement should, moreover, support tension and compression strengths; be resistant to fracture; have good fluidity over the structures with which it interacts; have adequate viscosity and film thickness, so that it does not compromise the placement of the restoration; not disintegrate in the oral cavity; be biocompatible, and to ensure enough working time for the operator during handling.

Historically, a large part of the high-resistance ceramic restorations have been cemented to their retentions using zinc phosphate or glass ionomer cements. The first has been clinically used for about one century, whereas the latter approaches its forth decade, time that grants them credentials as agents and confirms their clinical success in the middle and long runs. Their use requires mechanical retention because these water-based cements work, primarily, by frictional retention. When it is compromised, adhesive bonding systems are recommended.

In the last decade, resin cements have been the first choice because of some advantages: Adhesiveness to several substrates, low solubility, biocompatibility, satisfactory esthetics, thin film, good marginal fit and reinforcement to restoration. In addition, zinc and ionomer cements have low resistance to shearing, compression and traction. Its use should be avoided to cement ceramic restorations that have no metallic or ceramic structures for reinforcement. Therefore, resin-modified cements have been intensively studied to select characteristics and commercial brands that may have more advantages.

Bonding similar to that obtained between "resin and tooth tissues" is expected between a resin cement and ceramics, a connection in which monomers penetrate the tooth matrix that has been prepared and later polymerized to promote micromechanical bonding by means of formation of a hybrid layer. In a similar way, the inner surface of ceramic restorations should be prepared to optimize its interaction with resin agents. This previous preparation is the most important step to ensure the longevity of adhesion between two materials. However, though secondary, there are particular characteristics of the cement agents, their monomers and bonding agents that may affect the occurrence and maintenance of the adhesive phenomenon.

Adhesive stability for densely sintered ceramics may also be obtained by using adhesive systems or cements with 4-meta or methacryloyloxydecyl dihydrogen phosphate (MDP). By means of chelation, the phosphate ester radicals form a chemical bond to metal oxides (major components, almost exclusive, in this type of ceramics), such as chromium, titanium, zirconia and alumina, which increases their adhesive strength.

Some cements that have these components are available in the market. Panavia F™ (Kuraray Medical Inc, Okayama, Japan) is the best known adhesive cement resin that contains MDP. Shearing strength studies of this material showed its superiority to other conventional Bis-GMA compounds without this adhesive monomer.

Final considerations

As discussed above, resin cements establish three types of bonds with ceramics: Physical, chemical and physical/chemical. For resin cements to establish a physical bond with the ceramic surface, this surface should have some type of irregularity for the resin to penetrate before polymerization and to ensure the micromechanical weaving of the two materials after polymerization. Chemical adhesion is achieved by the interposition of silane, a bifunctional component that can bond, by covalent connections, to the silica in the porcelain and the methacrylate groups found in resin cements. The sum of these two phenomena promotes the third type of union: Physical/chemical.

Dense and highly crystallized ceramics, obtained by sintering metal oxides, do not have a vitreous (silica) phase and, therefore, acid etching or chemical bonding with silane agents cannot be used, which adds importance to their surface texture as a form to provide sites for the mechanical micro-retentions of the cement. Several studies have attempted to find out which ceramic surface treatment better prepares it to interact with resin cements.

Spraying with Al_2O_3 particles has been the method of choice to create irregularities on high resistance ceramics. This technique substantially affects adhesive bonding strength by producing irregularities that favor resin incorporation and increase the energy of the area surface. Although not accepted by some authors,[11] who found cracks and breaks that may result in ceramic fragility after blasting, this technique has proven to be, up to the moment, the best and most frequently used way to roughen dense ceramics. When associated with a resin cement, a material that might seal such cracks and restore the strength to its structure, this technique does not seem to be definitely contraindicated.

Plasma spray use, the increase in low fusion porcelain pearls, silicatization, and roughening using diamond points are some other techniques, though less usual. Each has its own tools, degree of complexity and demand, and all prepare ceramics for adhesive cementation, in an attempt to make it rough or chemically ready for adhesion. Of these, silicatization has been the most frequent, and has been used based on results still unstable. Silica layers are created on the surface of alumina, which enables their silanization. However, the instability of the silane agent, which often reacts while still in its container, together with unfavorable clinical conditions for the use of this product, has raised questions about this technique. Silane comes from the automobile industry, where, after application, products remain in a light oven for some hours for evaporation of its unstable components. Similar results should not be expected when it is used in dentistry, under conditions that are far from ideal.

Metal oxide grains united by industrial sintering have small gaps between each other. Therefore, before cementation, internal blasting of prosthetic crowns manufactured according to this technique or using this material may be unnecessary. In a comparison of pros and cons, we believe that it makes sense not to run the risk of a possible micro-crack or weakening of the structure in the attempt to roughen the surface by using particle blasting when the product already has this characteristic. The attempt to produce a rough surface may induce the weakening of the structure, which seems to be a very high price to pay for a benefit that is already there.

The application of a phosphate primer, which contains methacrylate agents with crossed connections, to alumina surfaces before the application of a resin cement may promote an increase in retention strength.[12] This finding may be explained by the fact that this primer has a better wettability (more fluid) than resin cements (more viscous). The irregularities found on unprocessed alumina or zirconia are better filled by using a combination of primer and resin cement than by applying cement alone. This better filling favors, above all, the physical micromechanical interaction between resin and ceramics, reduces surface tensions in the substrate and increases surface energy, which results in increased retention forces.

It is clear that irregularities on alumina or zirconia are innocuous if they cannot be adequately infiltrated by cement. The analysis of microscopic images of alumina and zirconia structures after cementing followed by shearing confirms that cement, alone, is not capable of permeating the micro-spaces found in the structure, which explains the need of using a primer with greater fluidity. The infiltration of a primer is so intense that scanning, even after shearing tests, did not show any gaps between grains filled with this component (Fig 3).

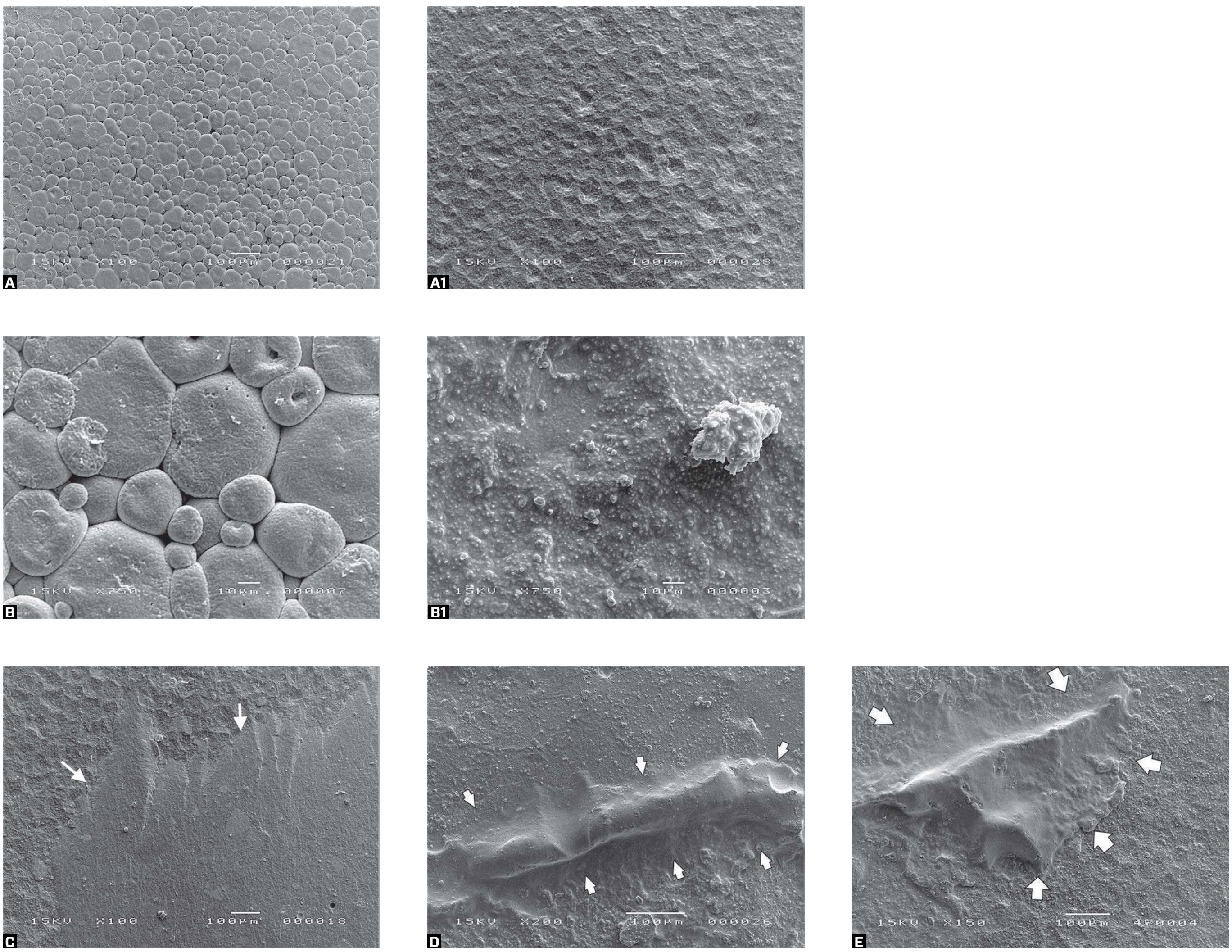

Figure 3 - Comparisons between **A** – **A1** and **B** – **B1** provide a visual analysis of alumina, either infiltrated or not by primer, under two magnifications. Alumina surface in Figures **A1** and **B1** do not have the same pattern of roughness or porosity because they remain infiltrated by primer even after shearing test of cement, to which all surfaces were submitted (magnifications: **A** and **A1** = 100X; **B** and **B1** = 750x. In **A** and **B**, there was total displacement of cement and repeated evidence of grains and inter-grain spaces.
C, D and **E**) Portions of resin cement adhered to alumina surface after shearing test (white arrows) show cohesive fracture. Exposed alumina surface, where there was cement fracture, remains infiltrated, and primer lost its irregular porous aspect, with gaps. Even after resin cement displacement, primer remains bonded to alumina surface. (SEM. Source: Carvalho,[6] 2009).

The affinity of phosphate primer with oxides also has great relevance for adhesion. Inadvertently, some professionals that work with dental prosthesis "classify" alumina (zirconia) as a type of ceramics, very likely due to their white-yellowish appearance. Densely sintered alumina is composed of 99.5% of metal oxides (aluminum), and this type of primer establishes chemical connections by chelation, and oxides promote a chemical increase in the strength of the union between porcelain and the resin cement.[13] Blatz et al[14] confirmed this finding in a study that classified non-phosphate agents as inefficient when the purpose is adhesion to alumina.

Clinically, after the displacement of crowns manufactured with densely sintered alumina or zirconia, cementing agents can be seen still adhered to the prosthetic retention, but not to alumina (Fig 4). This is usual when dental tissues, such as dentin and, mainly, enamel, are part of the substrate for retention. The possibility of roughening such structures for later penetration of fluid resin ensures some relative stability to the adhesive interface.

Full crown preparations on natural teeth have almost 100% of their area made up of dentin, a mineralized and humid tissue characterized by collagen. The formation of a hybrid layer of resin remains a source of concern because of the variable results obtained since tests started in adhesive dentistry. It is even more critical in healthy teeth, which, in addition to increased humidity, also naturally have internal pulp pressure, a force that pushes fluids to the union line. These fluids compete with the adhesive agent for the occupation of spaces left by acid etching.

It is a consensus that the place of choice for resin adhesion is enamel, and not dentin. Therefore, a disturbing

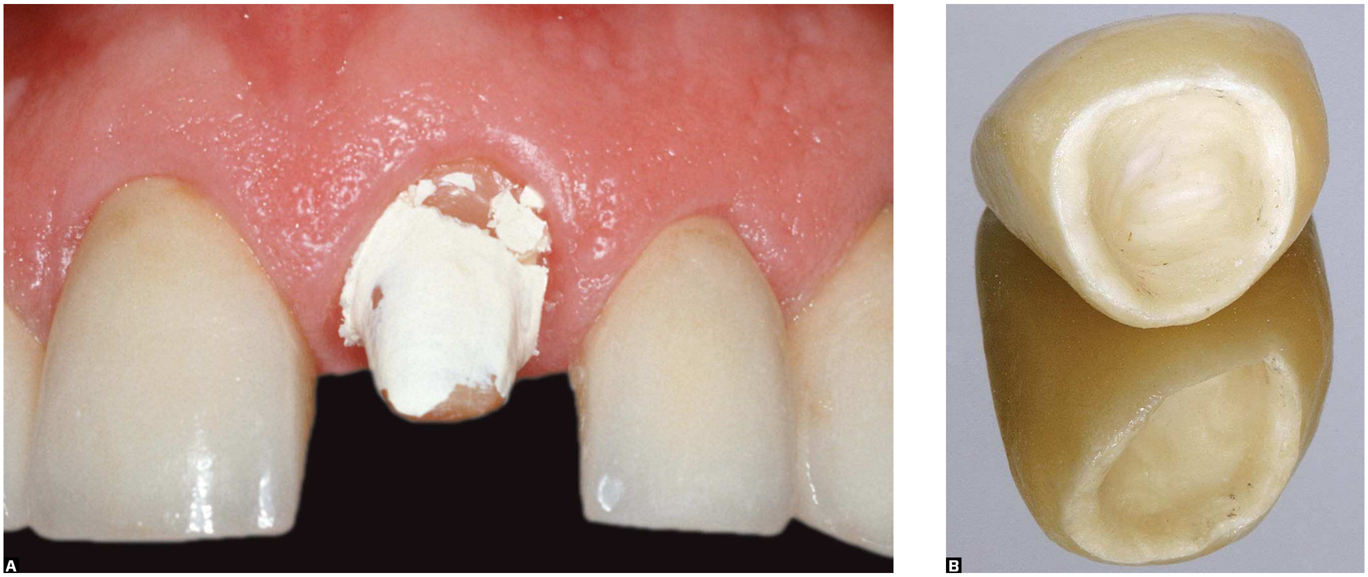

Figure 4 - **A)** Ionomer cement adhered to the prosthetic retainer (dentin) after displacement of an all-alumina ceramic crown (Procera AllCeram™). **B)** Inner area of crown after separation. Macroscopic aspect shows no remaining cement adhered to alumina (clinical case by Francischone CE).

question is raised. How does dentin, which is humid, is better than alumina, a structure that is free of humidity, in terms of strength of adhesion to resins? The explanation seems to lie not only on the greater facility to create roughness in the first one, but also on the attention assigned to the next step of infiltration of some types of fluid resin, a fact that grants some privilege to the diffusion and combination of adhesive agents in its interstice, a procedure that is sometimes overlooked in the second one.

The correct and complete filling of porosities in alumina and zirconia is fundamental to determine their adhesive success. If, after cementation, such irregularities, mainly those located close to the crown margin, remain without cement (or adhesive primers), they will be filled by oral fluids that may promote hydrophilic degradation.

This phenomenon, in addition to the already mentioned crown displacement, may also result in the incidence of caries in the retention structure and changes in the color of the restoration. Because it does not have a gray-metal infrastructure to mask die infiltration, this restoration is more vulnerable to it (Fig 6). Therefore, it is important to increase wettability and filling by the primer to reduce water infiltration into the interface and minimize, therefore, the effects of this type of degradation. Clinical observations confirm greater rates of fracture of the cement-alumina interface than of the cement-prosthetic retention interface.

When repeating the cementation of alumina or zirconia crowns that were displaced by any reason, several use internal blasting with aluminum oxide particles even when all the cement remains adhered. Such blasting is, usually, a repetition, because most times it was already performed at the time of the first cementation. They use this procedure whenever the problem occurs, without concerns about making it weaker and not even questioning the real cause of the displacement. If displacement is repeated, the same techniques used in the previous cementation will most likely be inefficient again.

When the cement remains in the retentions, the crown will probably be as clean as when it arrived from the laboratory. In such case, the application of cleaning agents seems to be more sensible, conservative and better indicated, as it is necessary to remove only saliva and minor impurities. As long as there are no infiltrations, when any type of fluid resin is used, the alumina structure will remain the same, even after contact with resin cements, as shown in Figures 3B and 4B. To submit them again to procedures that are somehow aggressive does not seem to be the best choice. We should, instead, infiltrate them with adequate primers and review other relevant prosthetic aspects.

Resin cements certainly have better proprieties than purely ceramic crowns, but conventional cementation may also be used successfully as long as there is some structure for support and application of porcelain coatings, as well as some frictional retention for preparation. A prosthetic crown is not retained only by its adhesion to the cementing agent. This idea erroneously overestimates the role of cement in the maintenance of a restoration, and may lead to negligent clinical procedures and failure. Care should be taken when extrapolating in vitro results to clinical conclusions. Several other relevant aspects are involved in clinical cases, such as preparations, contact surfaces and occlusal balance, which should be taken into consideration when defining the success of restorative treatments.

Figure 5 - **A**) Clinical aspect immediately after cementation of two metal free crowns with alumina infrastructure coated with feldspar porcelain in teeth #12 and #22 (zirconia posts over osseointegrated implants). There is good color harmony when compared with natural neighboring teeth. **B**) Six years' follow-up: Visible color change of ceramic crowns, which have a grayish hue. **C**) Proximal view of tooth #22 crown immediately after cementation (original color). **D**) Change of color of tooth #22 crown six years later.

Figure 5 - (continuation) **E**) Detail of lingual aspect, where, in addition to darkening, there is pigmentation on the margin of the crown, probably due to penetration of oral fluids into alumina/cement interface, an area not adequately filled with the cement. **F**) Image captured without any artificial light (no flash) shows more evidently the color difference (clinical case by Francischone CE).

Our culture loves isolated explanations based on two opposed ideas — such as God and the devil, black and white, good and bad, smooth and rough, and right and wrong — to justify our own mistakes or to mask what we do not properly understand. This is part of our contradictions, and it may impair the coherence of our analysis about the ideal way to cement prosthetic crowns.

REFERENCES

1. Björkner B, Bruze M, Möller H. High frequency of contact allergy to gold sodium thiosulfate. Contact Dermatitis. 1994;30:144-51.
2. Snyder MD, Hogg KD. Load-to-fracture value of different all-ceramic crown systems. J Contemp Dent Pract. 2005 Nov 15;6(4):54-63.
3. Galindo ML, Hagmann E, Marinello CP, Zitzmann NU. Long-term clinical results with Procera All Ceram full-ceramic crowns. Schweiz Monatsschr Zahnmed. 2006;116:804-9.
4. Walter MH, Wolf BH, Wolf AE, Boening KW. Six-year clinical performance of all-ceramic crowns with alumina cores. Int J Prosthodont. 2006;19(2):162-3.
5. Conceição EN. Dentística: Saúde e estética. 2ª ed. São Paulo: Artmed; 2007. p.596.
6. Carvalho RS. Efeito de um agente primer e de ciclos térmicos para cocção de porcelana na resistência de união adesiva entre alumina e cimento resinoso [tese]. Bauru (SP): Universidade de São Paulo; 2009.
7. Atsu SS, Kilicarslan MA, Kucukesmen HC, Aka PS. Effect of zirconium-oxide ceramic surface treatments on the bond strength to adhesive resin. J Prosthet Dent. 2006;95(6):430-6.
8. Ayad MF, Fahmy NZ Rosentiel SF. Effect of surface treatment on roughness and bond strength of a heat-pressed ceramic. J Prosthet Dent. 2008;99(2):123-30.
9. Derand T, Molin M, Kleven E, Haag P, Karlsson S. Bond strength of luting materials to ceramic crowns after different surface treatments. Eur J Prosthodont Restor Dent. 2008;16(1):35-8.
10. Xie H, Wang X, Wang Y, Zhang F, Chen C, Xia Y. Effects of sol-gel processed silica coating on bond strength of resin cements to glass-infiltrated alumina ceramic. J Adhes Dent. 2009;11(1):49-55.
11. Borges GA, Sophr AM, de Goes MF, Sobrinho LC, Chan DC. Effect of etching and airbone particle abrasion on the microstruture of different dental ceramics. J Prosthet Dent 2003;89(5):479-88.
12. Carvalho RS, Francischone CE, Medina-Valdívia JR, Francischone Jr CE. Materiais adesivos e restauradores sobre implantes: alumina e zircônia. In: Pedrosa SF, organizador. Pro-Odonto Implante. São Paulo: Artmed; 2010. p. 93-148
13. Yoshida K, Tsuo, Atsuta M. Bonding of dual-cured resin cement to zirconia ceramic using phosphate acid ester monomer and zirconate coupler. J Biomed Mater Res B Appl Biomater. 2006;77:28-33.
14. Blatz MB, Sadan A, Blatz U. The effect of silica coating on the resin bond to the intaglio surface of Procera AllCeram restorations. Quintessence Int. 2003;34:542-7.