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Perspective

Contemporary adhesive cementation: the challenge of bonding to new CAD/CAM restorative materials.

Fernando Grandon[1,2] & Michael Wendler.[1,2]

Affiliations: [1]Departamento de Odontología Restauradora. Facultad de Odontología; Universidad de Concepción, Chile. [2]Programa Odontología Estética Adhesiva. Universidad de Concepción, Chile.

Corresponding author: Fernando Grandon. Roosevelt 1550, Concepción, Chile. Phone: (56-41) 2204481. E-mail: fgrandonv@gmail.com; fgrandon@udec.cl

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It is hard to imagine going about our day-to-day activities without the help of a computer or smart phone. In the same way, CAD/CAM technology (computer-aided design/computer-aided manufacturing) has revolutionized routine restorative and implant procedures, with a cross-sectional reach into several different areas. Thanks to the sophistication of both the design programs and the new available alternatives in milling equipment, it is possible to achieve partial or complete ceramic restorations designed and processed even without the participation of the dental laboratory, following a fully digital workflow.[1] As a consequence, the development and production of materials for CAD/CAM restorations is one of the fastest growing fields in dentistry. The ideal industrial environment in which these materials are produced has allowed high quality standards, difficult to achieve using conventional laboratory methods,[2] and thus ensuring better mechanical properties and high clinical performance.

Nonetheless, each type of material is unique in terms of its composition and microstructure, so choosing the appropriate cementing agent for each substrate and clinical situation can be a difficult and confusing task. Therefore, a thorough understanding of the characteristics of the specific ceramic or polymer to be used is of main importance. The type of surface treatment, as well as the cementing material must be chosen rationally using an approach based on scientific evidence and clinical knowledge. An inappropriate cementing protocol can negatively impact the result and longevity of the rehabilitation procedure.

Most modern dental ceramics can be approached using two basic adhesion principles: micromechanical retention and chemical bonding. Reinforced glasses (also know as porcelains) and contemporary glass-ceramics are susceptible to etching procedures with hydrofluoric acid, which has contributed significantly to their high clinical success rates.[3] This is due to the dissolution of the vitreous matrix by the hydrofluoric acid on the surface of the ceramic, generating irregularities that allow the microretention of the resinous cementing agent. The effectiveness of this procedure is enhanced by the subsequent application of silane coupling agents, which increase the wettability and favor chemical bond between the silica-rich ceramic surface and the composite resin cement.[4]

Although these procedures are routinely used in leucite- and feldspathic-reinforced glasses, as well as in lithium silicate and disilicate glass-ceramics, they are completely inefficient for the surface treatment of polycrystalline

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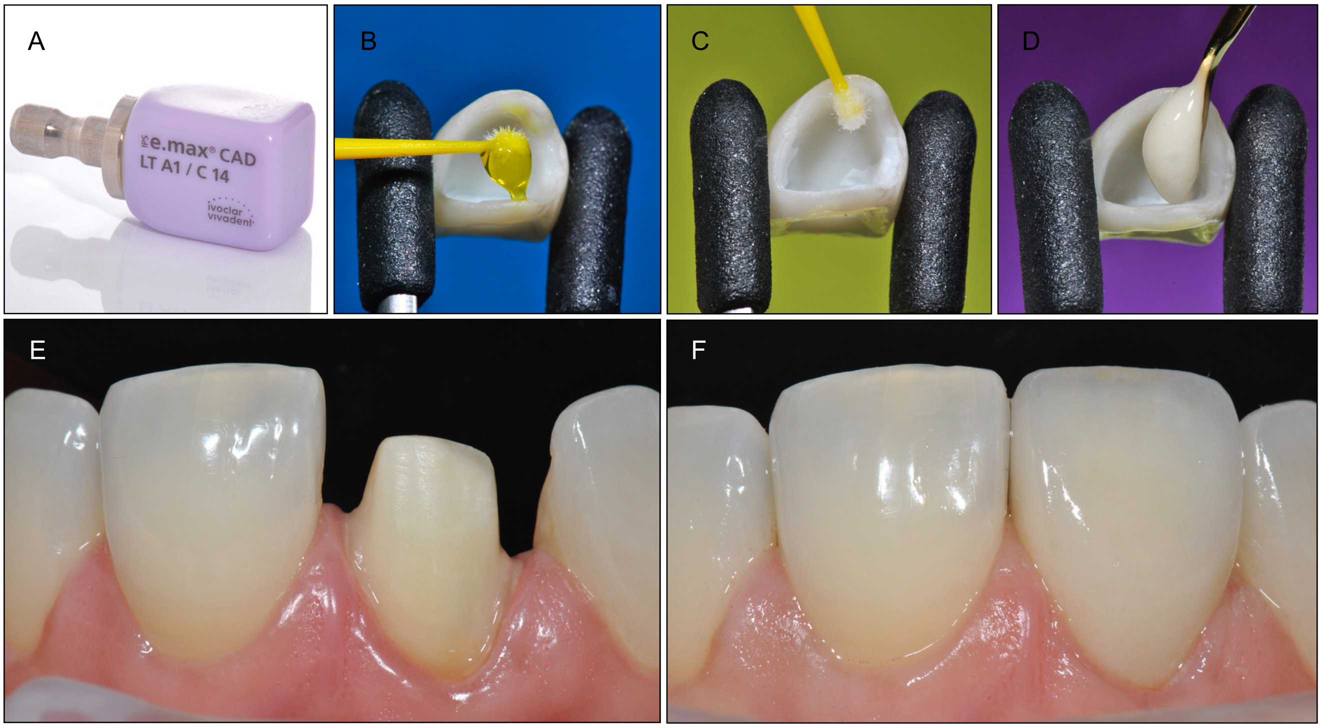
Figure 1. Recommended protocol for the adhesive cementation of glass-ceramics.



A. IPS e.max CAD block before CAD/CAM manufacturing of the metal-free restoration of a central incisor (1.1). **B.** Surface conditioning of the glass-ceramic using 9.5% hydrofluoric acid. **C.** Application of the silane-coupling agent. **D.** Application of the self-etching dual-cure resin cement. **E.** Tooth substrate prior to the cementation of the restoration. **F.** Medium translucency monolithic glass-ceramic crown. Translucent effects in the incisal edge were achieved using the cut-back technique.

ceramics. Among the latter, zirconium dioxide (ZrO_2) stabilized with yttrium oxide, also known as zirconia, has become the preferred alternative in rehabilitation treatments where resistance and aesthetics are paramount. Despite its extraordinary mechanical properties, the difficulties encountered in surface conditioning of zirconia poses an important clinical challenge and warrants the incorporation of alternative materials for its adequate cementation.[5] This is mainly due to its highly crystalline microstructure (99.9% of its composition) and the absence of an etchable vitreous phase.[2] The initial approach was therefore conventional cementation (*i.e.* using zinc phosphate or glass ionomer cements), basing only on macroretention to the dental stump. However, as the clinical indications for this material expanded to incorporate partial restorations and even replace titanium abutments in implant-supported prostheses, the need for adhesive cementation became increasingly evident. In order to achieve this goal, an alternative surface conditioning protocol using sandblasting with aluminium oxide particles was proposed. The principle of action is based on the generation of surface irregularities, thus increasing the total area available for microretention of the cement. Despite its wide use, this procedure has been controversial due to the potential damage caused by the impact of the particles on the surface of the material. Reports have been issued describing occurrence of microcracks as well as spontaneous transformation of the tetragonal-to-monoclinic phases.[6] An alternative approach is the tribochemical surface treatment using silica coated aluminium oxide particles (Cojet, 3M ESPE) with sandblasting devices at low pressure. In this procedure, known as silicatization, silica particles are deposited on the zirconia surface in order to allow chemical bonding to silane coupling agents.[7] Additionally, the use of various agents that enhance adhesion to oxides (in this case zirconium dioxide), such as functional phosphate and carboxylate monomers (present in Z Prime Plus, from Bisco), has been described. The use of other agents that enhance adhesion to various surfaces (Monobond Plus, from Ivoclar-Vivadent), as well as the application of adhesives containing the monomer MDP (10-Methacryloyloxydecyl dihydrogen phosphate), found in the Clearfil Ceramic Primer of Kuraray, have also shown an improved bonding ability.[8] The clinical success of the latter, together with the recent expiration of the commercial patent by Kuraray, has allowed its incorporation in various universal adhesive systems, including Scotchbond Universal, 3M ESPE; All-Bond Universal, Bisco; and One Coat 7 Universal from Coltene.

Recently, the emergence in the market of so-called "hybrid ceramics" and the expansion of indirect resins with nanoceramic fillers have extended the restorative spectrum of these materials, whose traditional indications were restricted to partial restorations. Although their main advantage is the ease of manufacturing and milling, being less susceptible to chipping during subtractive manufacturing procedures,[9] the high conversion rate of their polymer matrix reduces chemical bonding of the luting agent. Thus, novel surface conditioning protocols, different from those described for glass-based restorations, are required. In hybrid ceramics, where Enamic (VITA Zahnfabrik) is the main exponent, the interpenetration of a polymer matrix into a glassy network implies a combination of surface properties acquired from both, the glassy ceramic and the resin composite. Therefore, this material is susceptible to hydrofluoric acid etching, generating microretentive patterns similar to those observed in reinforced glasses and glass-ceramics.[2] The additional use of a silane coupling agent guarantees an adequate chemical bond to the vitreous matrix of the material.[10] On the other hand, indirect resin composites lacking of glassy phases (such as that present in Enamic), are resistant to hydrofluoric acid etching and non-sensitive to chemical bonding with silane coupling agents. This explains why manufacturer's of materials such as Lava Ultimate (3M ESPE), Cerasmart (GC) or Crios (Coltene) indicate cementation protocols based on sandblasting and silicatization to increase microretention and allow chemical bonding with silane coupling agents.

Aforementioned aspects lead us to emphasize the drawbacks of establishing a universal conditioning technique, given the wide range of products available and their diverse microstructures and compositions. Although cementation represents a critical and fundamental step for the success and longevity of our restorations, both clinicians and manufacturers commonly dismiss its importance. The marketing strategies used by the dental industry drive these new CAD/CAM materials under premises of aesthetic, and especially, mechanical improvements, aspects that sometimes seem to displace in importance their adhesive capacity.

The scientific evidence available on the adhesive behavior of different cements to new CAD/CAM materials is still scarce, and further studies are needed to determine the best conditioning and adhesive protocols in each case.

Therefore, clinicians must be aware and informed in order to take the best decisions during this key step of the restorative treatment. The knowledge and understanding of the composition and microstructure of new CAD/CAM materials becomes crucial for the selection of adequate cementation techniques that ensure a predictable result. The success achieved through outstanding aesthetics and the simplification of the workflow through digitization can be strongly jeopardized by an undesired event such as de-cementation.

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