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Clinical Technique/Case Report

Two-Year Follow-Up of Self-Etching Ceramic Primer as Surface Treatment for Feldspathic Veneers: A Clinical Case Review

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Clinical Relevance

In this clinical case study, the single-step etching ceramic primer has been shown to be a suitable material for proper bonding between resin cement and feldspathic glass ceramics.

SUMMARY

The two-step approach of applying hydrofluoric acid followed by silane is deemed the gold-standard surface treatment protocol before bonding to glass ceramics. Given hydrofluoric acid is a toxic conditioning agent and with the intention to simplify this step, the dental company Ivoclar Vivadent (Schaan, Lietchtenstein) released a self-etching ceramic primer, Monobond Etch & Prime in 2015, claiming that hydrofluoric acid and silane application would no longer be required prior to luting glass ceramics. Therefore, this clinical case report and retrospective analysis describes the replacement of unsatisfactory anterior veneers due to clinical failures for new feldspathic glass ceramic veneers, using the aforementioned self-etching ceramic primer. After two years, feldspathic glass ceramics presented satisfying clinical performance with absence of debonding, tooth sensitivity, recurrent carious lesions, or marginal infiltration.

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INTRODUCTION

Among the restorative materials and techniques indicated for esthetic restorations, glass-ceramic veneers are very appealing to patients and clinicians due to their outstanding esthetic properties, chemical stability, and possibility of minimally invasive preparations.[1-4] A laminate veneer is a thin ceramic restoration (0.3 to 1.0 mm)[5] indicated for esthetic intervention on the buccal and/or interproximal surfaces of teeth, for restoring lost dental tissues (ie, due to discoloration, misalignment, trauma, wear, or caries), transforming smile design by modifying the anatomy and/or shade of dentition or simply closing interproximal spaces (ie, diastemas).

A dental glass ceramic is an inorganic/nonmetallic compound consisting of one or more type of reinforcement crystals dispersed in an amorphous/vitreous phase. Dental glass-ceramics may be classified as feldspathic or reinforced by crystals (leucite or lithium disilicate).[6] The composition of feldspathic ceramic is approximately 70% glassy matrix and 30% refined feldspar crystals; leucite-reinforced ceramics have a composition of 70% glassy matrix and 30% refined leucite crystals; and lithium disilicate-reinforced glass ceramics contain 30% glassy matrix and 70% lithium disilicate crystals. These materials are available in the form of a powder for laboratory layering/stratification (followed by sintering), ingots for hot pressing, or presintered machinable blocks (CAD/CAM). Feldspathic and leucite glass ceramics are indicated for veneers, inlays, onlays, covering metallic/zirconia/alumina frameworks, and full crowns for anterior teeth. In addition to these indications, lithium disilicate-reinforced glass ceramics can be utilized for 3-unit bridges as far distal as the second premolar.

A major advantage of glass ceramics in dentistry is their ability to adhere to resin-based materials through micromechanical retention and chemical bonds. The surface of the ceramic must be treated prior to bonding procedures. The most accepted treatment in the literature is etching the surface of the glass ceramic with hydrofluoric acid (HF) followed by a coupling agent (silane).[6] This allows both micromechanical retention and chemical bonds between the ceramic and resin cements.[7-11] The hydrofluoric acid acts by selectively dissolving the silica (SiO_2) in the glassy matrix, increasing the surface roughness, surface area, surface energy, and, consequently, wettability.[12-17] The increased surface area allows the resin-based materials to be in intimate contact with the etched ceramic surface, thereby improving the bond strength between them. The silane coupling agent is a bifunctional molecule with a silanol group (chemically bonds to silica) and a methacrylate group (copolymerizes with methacrylate-based materials), which are responsible for creating a link between the silica-containing ceramic substrates and the resin-based materials.[6,12,18] Thus, both strategies work synergistically to yield adequate and long-lasting bond strength between glass ceramics and resin cements.

The surface treatment requires a certain number of steps and the use of hydrofluoric acid, a hazardous/toxic material.[19] In order to reduce the chair-side time and technique sensitivity and to eliminate the need for hydrofluoric acid, a single-step self-etching silane/ceramic primer product has been released (Monobond Etch & Prime; Ivoclar Vivadent, Schaan, Liechtenstein). This product simplifies the steps of etching and silanization into a single solution, reducing the health risk and chair-side time for both patient and clinician. Many *in vitro* studies have been published so far; however, to date, only a six-month clinical report using a self-etching ceramic primer has been published.[20]

Therefore, the purpose of this clinical case report is to: 1) outline the benefits of using the single-step self-etching ceramic primer technique to replace unsatisfactory glass ceramic veneers on maxillary incisors by feldspathic glass ceramics; 2) discuss the chemistry associated with this technique; and 3) outline *in vitro* studies published until this date.

CASE REPORT

A 31-year-old female patient presented to her clinical appointment with a chief complaint of unsatisfactory glass ceramic veneers on maxillary incisors (7, 8, 9, and 10), mainly regarding the color alteration on the buccal surfaces and anatomy/misalignment. The veneers had been functional five years prior to the appointment (Figure 1). The patient reported that the treatment was performed in order to close diastemas after orthodontic and orthognathic treatments. After clinical evaluation, two restorative treatment plans were proposed: direct/indirect resin composite veneers or replacement with new feldspathic veneers. The patient chose the latter option. During clinical examination, a gap was observed at the tooth-ceramic adhesive interface (lingual), which was associated with marginal leakage (Figure 2). Prior to clinical procedures, at-home dental bleaching was prescribed for the patient on the maxillary and mandibular arches (except for maxillary lateral and central incisors) using 15% carbamide peroxide gel (Opalescence PF, Ultradent Inc, South Jordan, UT, USA) in custom acetate trays (0.035 Soft-Tray Classic Sheets; Ultradent Inc) for 2 hours/day on 16 consecutive days.

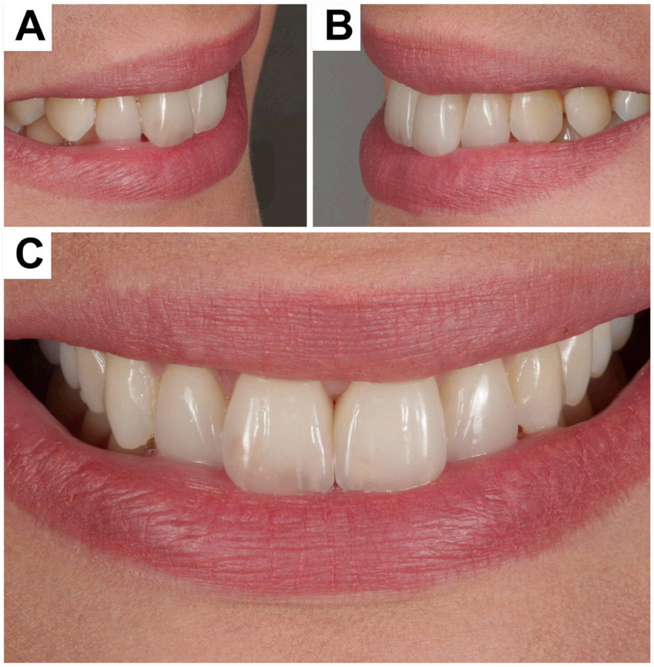

Figure 1. *Initial view (lateral views - A and B) demonstrating problems with anatomy and shade of ceramic veneers (C) in the upper central incisors.*

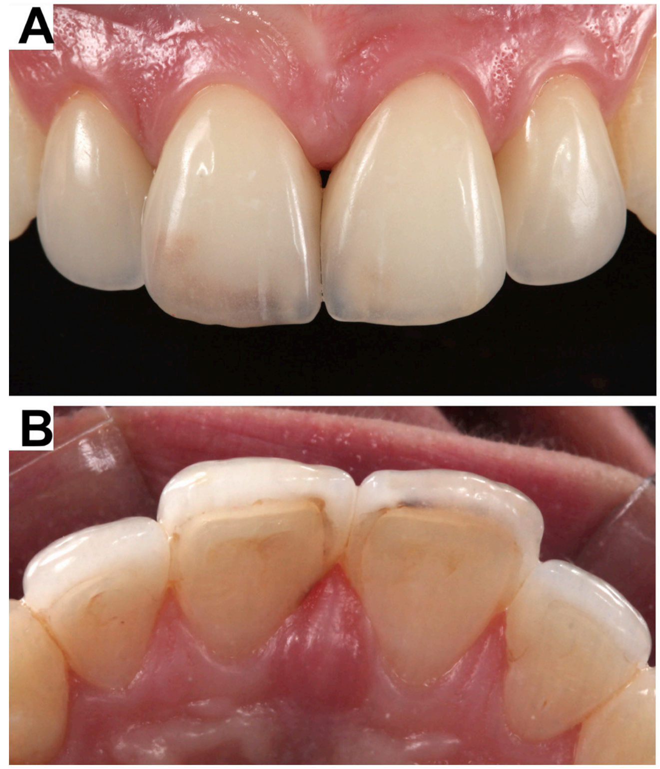

Figure 2. *Frontal view of upper central and lateral incisors; note the color alteration at the incisal third in both central incisors, mainly in the right central incisor (A). Palatal view showing marginal staining due to misplacement of ceramic veneers after adhesive procedures; both ceramic veneers in the lateral incisors were poorly adapted as well (B).*

Old ceramic veneers were removed using a spherical diamond bur (#1016, KG Sorensen, Barueri, SP, Brazil) by creating grooves at the buccal surface up to the bonding interface, which were later connected using a tapered diamond bur (#2135, KG Sorensen). In order to identify/differentiate the remaining glass-ceramic material from the tooth substrates, an exploratory probe was scratched on the buccal surface followed by proper removal using a fine tapered diamond bur (#2135F, KG Sorensen) (Figure 3). The bur was used in such a way as to provide an adequate path of draw and marginal adaptation. Later, aluminum oxide abrasive discs (Sof-lex, 3M ESPE, St. Paul, MN, USA) were used in order of descending abrasiveness to finish and polish the prepared teeth (polished substrates and rounded/nonretentive angles) (Figure 4).

A shade guide (Ivoclar Vivadent, Schaan, Liechtenstein) was positioned next to the prepared dental substrates for shade selection and better communication with the ceramic laboratory (the patient chose the final shade B1 for the new feldspathic veneers). A thin (#000, Ultrapack, Ultradent Inc) retraction cord was placed into the gingival sulcus (for vertical clearance) and an impression was taken using a high-viscosity polyvinylsiloxane (PVS) putty (Express XT, 3M ESPE). After the putty impression was taken, a thicker retraction cord (#00, Ultrapack, Ultradent Inc) was placed into the gingival sulcus (for horizontal clearance). The thicker retraction cord was removed after 5 minutes and a new impression was performed using the light-body PVS (Express XT, 3M ESPE) (Figure 5). An impression of the waxed-up diagnostic cast was performed and a bisacrylic material (Protemp, 3M ESPE) was used to create temporary restorations and mock-up, so the patient could evaluate the details of anatomy/contour/shade of the future ceramic veneers (Figure 6).

Feldspathic glass ceramic veneers were fabricated (Creation CC, Creation Willi Geller, Meiningen, Austria) by the laboratory (Figure 7) and positioned over the preparations for try-in assessments (shade, anatomy, and adaptation) (Figure 8). A single-step self-etching ceramic primer (Monobond Etch & Prime, Ivoclar Vivadent, Schaan, Liechtenstein) (MBEP) was actively applied to the intaglio surface of the feldspathic ceramic using a disposable microbrush (Brush, KG Sorensen) for 20 seconds and allowed to react for 40 seconds (Figure 9). Then, using the air syringe, air-water was sprayed for 30 seconds followed by air spraying until completely dry. A thin retraction cord (#000, Ultrapack, Ultradent Inc) was placed into the gingival sulcus and dental substrates were subjected to cleaning using pumice and water, and were air-water

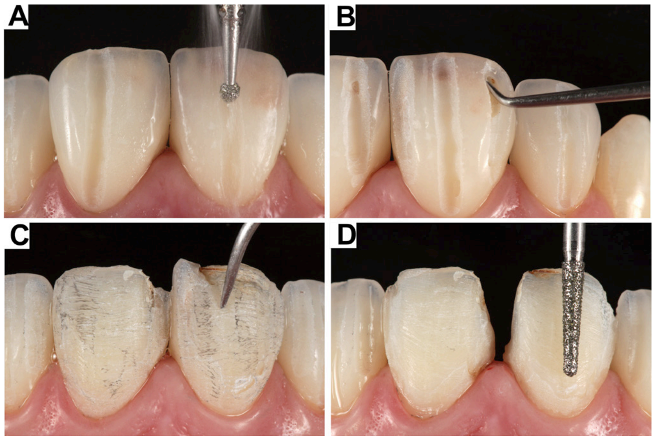

Figure 3. *Creation of guiding grooves using spherical diamond bur (A and B); scratching the explorer on the buccal surface in order to identify (according to the surface roughness) the remaining ceramic material (C); grooves were connected using a fine tapered diamond bur (D).*

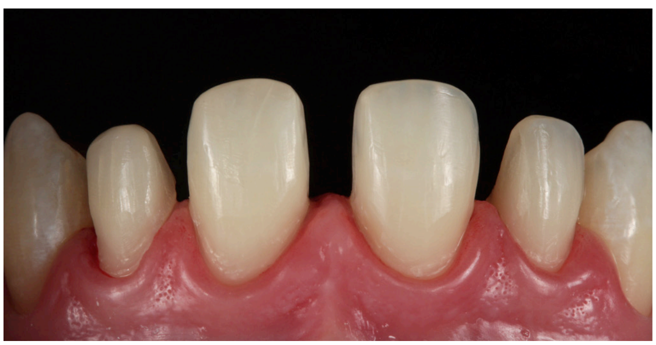

Figure 4. *Buccal view after removal of glass ceramic veneers.*

sprayed and later air-dried. Enamel (present in mid and incisal thirds) was etched with 37% phosphoric acid (Ácido Gel, Maquira Indústria de Produtos Odontológicos, Maringá, PR, Brazil) for 30 seconds, rinsed and air-dried. A primer from a self-etch two-step adhesive system (Clearfil SE, Kuraray Noritake Dental, Tokyo, Japan) was actively applied on the cervical third for 20 seconds and the solvent was evaporated using the air from syringe for 10 seconds. The bond/adhesive (hydrophobic solution) from the same adhesive system (Clearfill SE) was then applied over the entire preparation (Figure 10).

The same hydrophobic solution was applied to the treated feldspathic ceramic surface. Then, a light-curable resin cement (Variolink Esthetic LC, transparent color; Ivoclar Vivadent, Schaan, Liechtenstein) was placed in the same surface (Figure 11) and placed on the prepared teeth. The major excess of resin cement was removed using a brush, followed by light-activation using a specific light-curing tip (Point Cure, Valo Cordless, Ultradent Inc) for 10 seconds (Figure

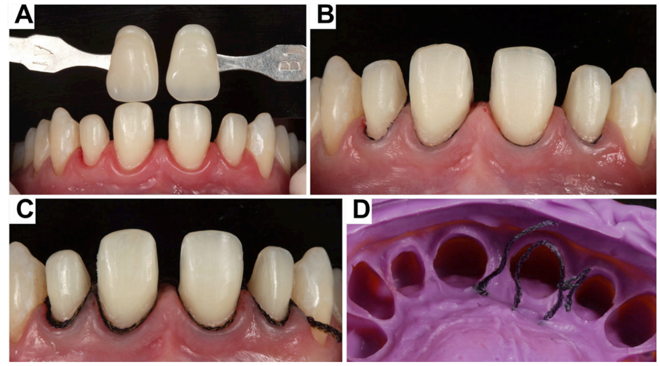

Figure 5. *Color assessment using a shade guide for communication with ceramic laboratory (A); placement of a thinner (B) and wider (C) retraction cord into gingival sulcus before impression procedure (D).*

Figure 6. *Buccal view of bisacrylic temporary restorations, based on diagnostic wax-up.*

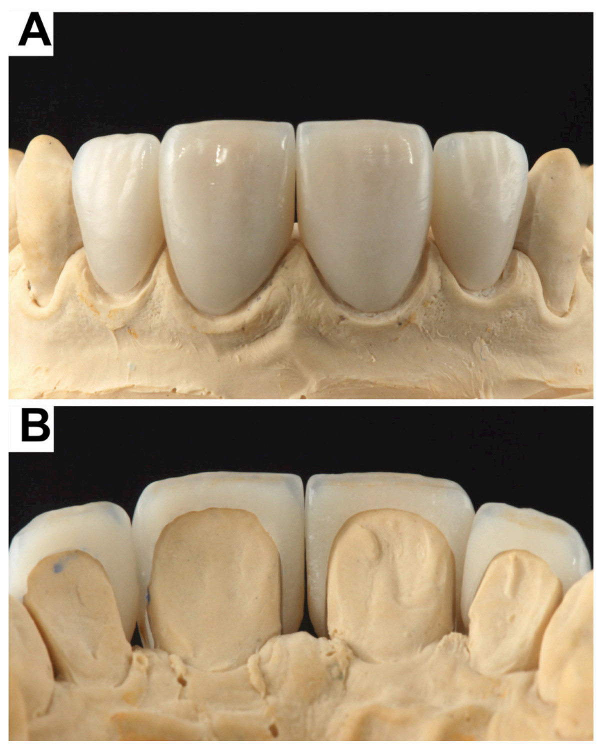

Figure 7. *Buccal (A) and lingual (B) views of the new feldspathic ceramic veneers.*

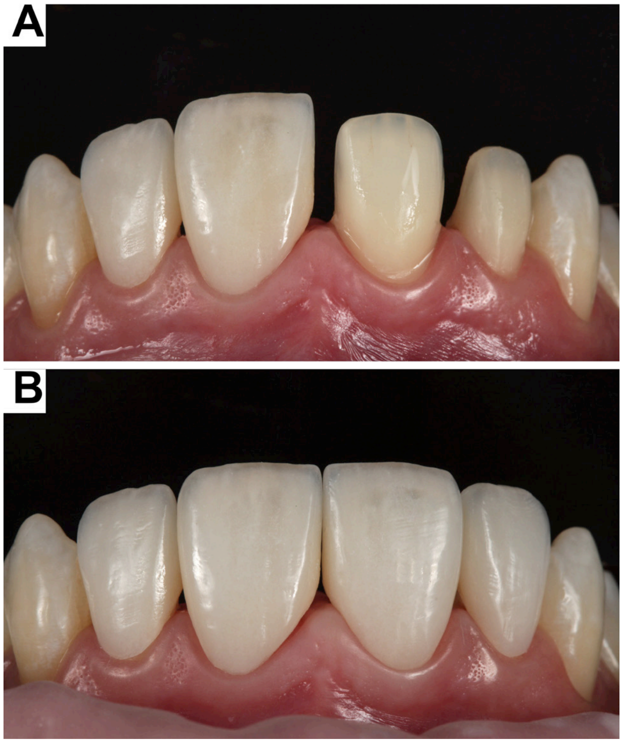

Figure 8. *Try-in of veneers in order to evaluate shade and marginal adaptation (A and B).*

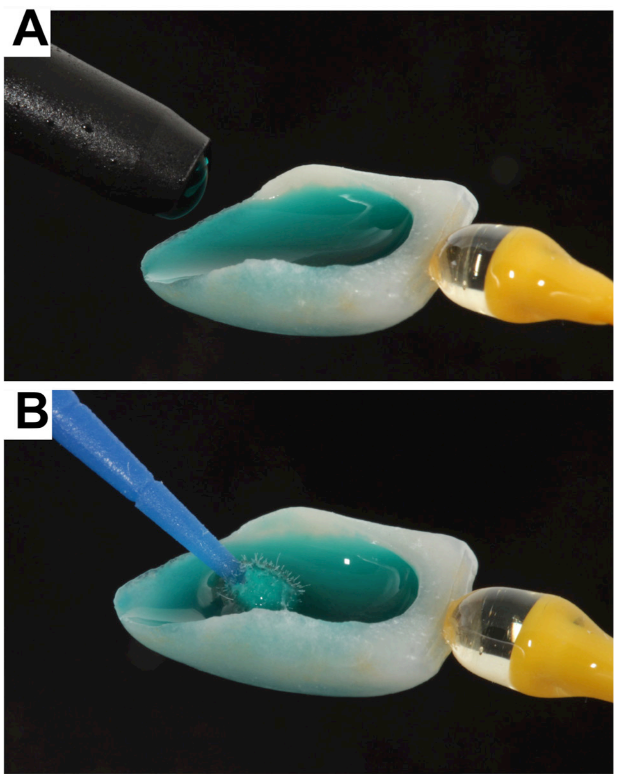

Figure 9. *Intaglio surface treatment using a self-etching ceramic primer (A). Active application for 20 seconds (B) and allowed to react for another 40 seconds.*

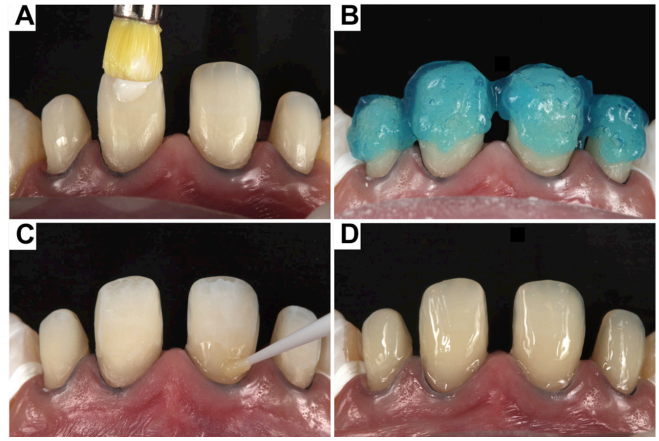

Figure 10. *Cleaning of preparations with pumice and water (A); 37% phosphoric acid etching at the mid and incisal thirds (B); application of a self-etching primer on the cervical third (C); and view after application of the hydrophobic adhesive material (D)*

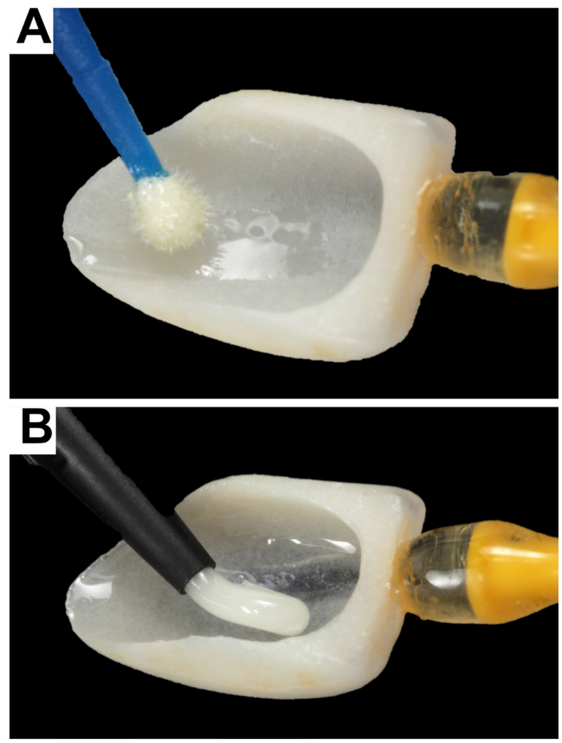

Figure 11. *Application of the hydrophobic adhesive in intaglio surface of ceramic (A); application of the light-curable resin cement (B).*

12) in order to stabilize the veneers and facilitate the complete removal of excess resin cement at the margins and proximal contacts. Then, light-activation of resin cement was performed at the buccal (cervical, mid, and incisal thirds, individually) and lingual surfaces for 1 minute using a polywave LED light-curing unit (Valo Cordless, Ultradent Inc) with an irradiance of 1,000 mW/cm^2 (Figure 13).

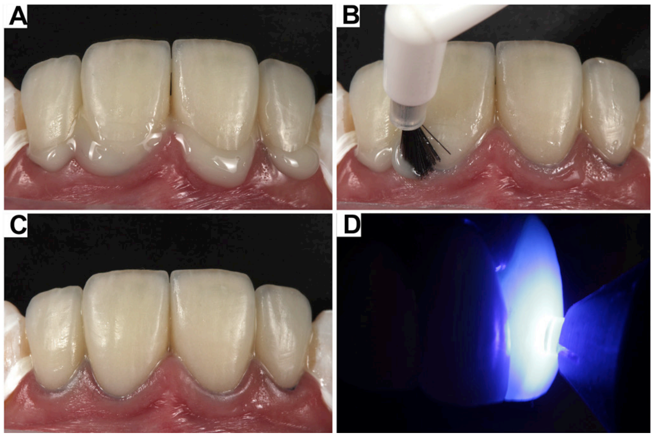

Figure 12. *Resin cement overflow after positioning the ceramic veneers on preparations (A) and excess removal using a brush (B). After removal of excessive resin cement (C), light-curing using a specific curing-tip in mid third of buccal surface (D).*

Retraction cords were removed and finishing and polishing procedures were performed at the interproximal areas using abrasive strips (Sof-lex strips; 3M ESPE). Abrasive rubber points (Politip Polisher, Ivoclar Vivadent) connected to a slow-speed handpiece were used at the cervical margins of the ceramic in order to produce a smooth surface (Figure 14). Figure 15 shows the immediate clinical results after bonding procedures. After two years, no signs of debonding, postoperative sensitivity, secondary caries, or marginal leakage/staining were identified (Figure 16).

DISCUSSION

The rationale behind MBEP is to combine the mechanisms of the HF etching step and silane application in a single solution. The reduction in clinical steps creates an easier, faster, and safer bonding procedure as HF would not be necessary. The intaglio surface treatment is a critical step for proper bonding between resin cements/glass ceramics, which is routinely performed incorrectly by clinicians. A survey regarding the use of glass ceramics[21] reported clinicians using high rates of erroneous bonding procedures/steps (62%) and lack of use of HF acid (14%-42%) and/or silane (71%-79%) prior to the resin cement. Therefore, it is reasonable to believe that the use of MBEP may decrease clinical errors/misconceptions during bonding procedures to glass ceramics, thereby contributing to its clinical longevity.

According to the manufacturer, MBEP is composed of an "alcoholic aqueous solution of ammonium polyfluoride, silane methacrylate, phosphoric acid, methacrylate and pigments." Ammonium polyfluoride is an acid salt that can be used to etch glass ceramics

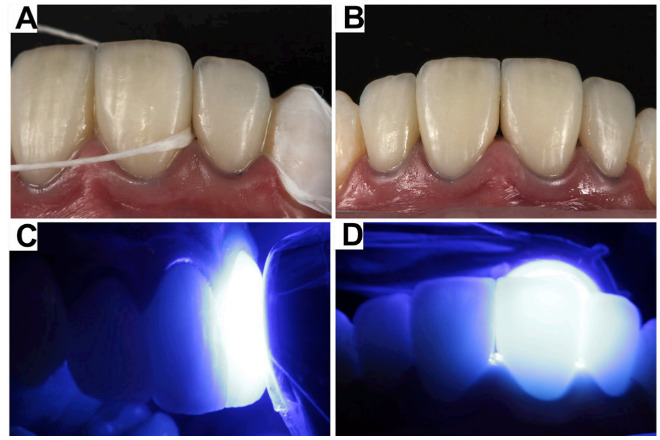

Figure 13. *Complete removal of resin cement excess from margins and interproximal areas (A and B). Final light-activation at buccal (C) and lingual (D) surfaces.*

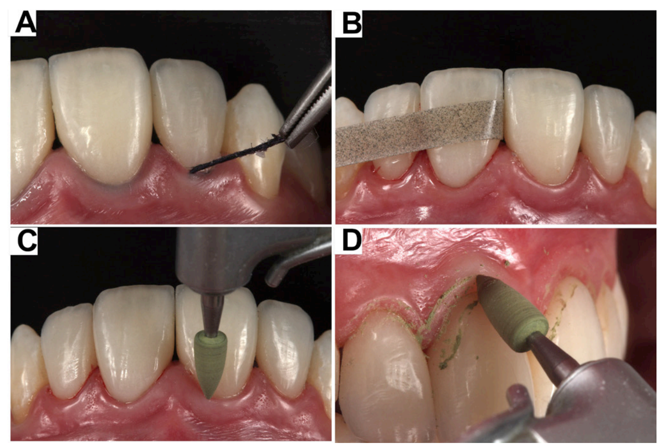

Figure 14. *Removal of retraction cords (A), finishing and polishing procedures at the interproximal using abrasive strips (B) and polishing glass ceramic/resin cement interface at the cervical third (C and D)*

and other silicates, leading to a rough surface and consequent micromechanical retention.[12] Due to its milder acidity, ammonium polyfluoride (which is ≤10% in MBEP) (Ivoclar Vivadent, Monobond Etch & Prime Safety Data Sheet, 2016) produces a shallower/less-pronounced etching pattern compared to HF on lithium disilicate, feldspathic, leucite, and polymer infiltrated glass ceramics.[12,15,16,22-28] El-Damanhoury and Gaintantzopoulou[12] reported a 60% reduction in surface roughness in feldspathic glass ceramic and an 80% reduction in a lithium disilicate reinforced glass ceramic when using MBEP compared to HF. Two *in vitro* studies reported statistically similar bond strength results when using MBEP compared to a silane-only coupling agent (17.2 MPa for the separated silane bottle and 14.7 MPa for MBEP;[12] 31.9 MPa for the separated silane bottle and 33.4 MPa for MBEP[29]), suggesting

Figure 15. *Immediate results after the cementation procedures (A and B).*

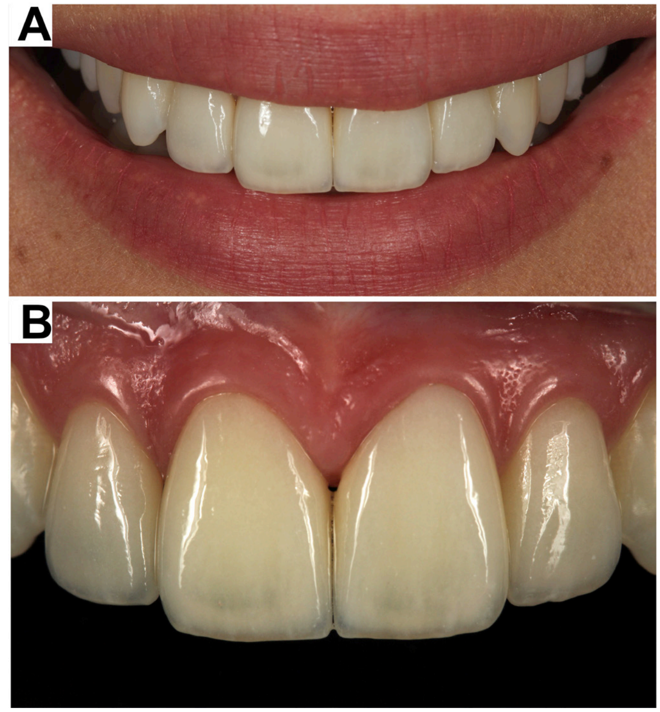

Figure 16. *After 2 years in use, there were no verified signs of debonding, post-op sensitivity, secondary caries, or marginal leakage/staining.*

that MBEP has a very low ability to promote surface alterations. In general, MBEP produced almost no surface alterations in leucite-reinforced glass ceramic (in terms of surface roughness or etching depth), yielding similar results to control groups, the surfaces of which were only polished with silicon carbide (SiC) #600 grit sandpaper.[15]

Feldspathic and lithium disilicate ceramics have considerably higher bond strength (30% to 100%) when using HF acid followed by a silane coupling agent compared to MBEP alone.[12,16,25] The increased roughness and surface area that HF acid yields promotes better micromechanical interlocking to resin cements, thereby explaining the higher bond strength values.[12] In an attempt to improve MBEP's surface conditioning ability (given it has a milder etching potential), Cardenas and others[28] reported that increasing MBEP scrubbing/reaction time resulted in a two-fold increase in bond strength to lithium disilicate glass ceramics. Although the active and prolonged application of MBEP resulted in progressive glass matrix dissolution, higher bond strength results were not reported for feldspathic glass ceramics. The microtopographical alterations promoted by MBEP, when applied to feldspathic ceramics as suggested by the manufacturer, were sufficient to yield similar bond strength to HF acid followed by silane.[28] On the other hand, *in vitro* studies reported similar or even up to 50% greater bond strength values for MBEP on lithium disilicate or feldspathic glass ceramics compared to HF + silane.[22-24,28-31] These controversial results indicate that increased roughness may not always be related to higher bond strength values.[26]

The silane contained in MBEP can form a water-resistant chemical bond between the glass ceramic and resin cement.[26] The hydrolysable inorganic functional groups of the silane molecules react with Si-OH on the ceramic surface through a condensation reaction and the organo-functional component (methacrylate group) chemically bonds/copolymerizes to the methacrylate-based groups of resin cements.[6,18] The silane system found in MBEP (trimethoxysilylpropyl methacrylate) leaves a thin chemically bonded layer, which remains after water rinsing and drying, forming a stable layer with reactive methacrylate functional groups.[12,16]

Both HF + silane and MBEP have limitations in their bond strength when exposed to aqueous enviroments. A high rate of adhesive failures have been reported when using HF + silane groups after one year in water storage.[16,26] A decrease of up to 30% in the bond strength for lithium disilicate and feldspathic glass ceramics treated with HF + silane has also been reported.[16,26] On the other hand, MBEP presented a prevalence of mixed and cohesive failures in resin cement and better stablized bonding for lithium disilicate and feldspathic glass ceramics after thermocycling and water storage.[16,26] These results can be explained through the following mechanisms:1) the incomplete evaporation of solvents and byproducts after silane application may have negatively influenced the bond strengths and failure modes; and 2) water rinsing and drying after MBEP application, as recommended by the manufacturer, may have removed the solvents and byproducts,[26] which could positively influence the bond stability over time. In addition, Cardenas and others[28] hypothesized that the MBEP bonding mechanism may be related to the interaction between the functional phosphoric monomers (10-MDP) and ceramic ions rather than the methacrylate silane to the glass ceramic, as silane molecules seem not to be stable in acidic solutions.[32,33]

Clinical studies reported the use of a hydrophobic bonding agent application on the intaglio glass ceramic surface after silane application.[34-36] Although the manufacturer does not recommend the adhesive application after MBEP, higher bond strength values to lithium disilicate and leucite-reinforced glass ceramics have been reported.[7] Furthermore, the increased interface homogeneity between glass ceramics and resin cement has been verified and may improve its clinical longevity.[7,37] Cardenas and others[38] reported that the presence of MDP (10-methacryloyloxydecyl dihydrogen phosphate) may contribute bond stability to lithium disilicate ceramics. This may be inferred to feldspathic ceramics as well; therefore, the two-step self-etch 10-MDP-containing adhesive system (Clearfill SE, Kuraray Noritake Dental) for treating the intaglio ceramic surface may be adopted.

Although many clinical aspects are involved in the success and longevity of glass ceramic restorations, special attention must be devoted to the bonding procedures since no retentive features are used for glass ceramic veneer preparations. Problems that occur during the first year are generally related to adhesive cementation failure. These occur most frequently in the first six months, after which the number of failures declines or stabilizes at a low rate.[39] The quality of the adhesive procedure relies mostly on proper tooth/glass ceramic surface treatments and how they interact.[40] Application of HF acid followed by a silane coupling agent remains the gold standard for intaglio surface treatment of glass ceramics before bonding procedures.[12] Although some controversial *in vitro* results were stated above and the exact mechanism of MBEP is not entirely clear, MBEP seems to be an effective material, given that glass ceramics presented satisfying clinical performance with the absence of debonding, dental sensitivity, recurrent caries lesions, or marginal infiltration. Randomized controlled clinical trials are needed to attest the effectiveness of MBEP.

CONCLUSIONS

As observed in this case study, MBEP appears to be successful two years following its application. Its benefits include the reduced number of clinical steps (and potential for human error) and the fact that its chemical composition (ammonium polyfluoride) is less toxic than hydrofluoric acid. Although MBEP presents a milder etching potential than HF, the silane coupling agent and/or phosphoric acid methacrylate (10-MDP) found in MBEP seems to play a major role in the quality and longevity of the adhesive interface between resin cements and glass ceramics.

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Conflicts of Interest

The authors have no financial interest in any of the companies or products mentioned in this article.

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