Submitted October 17, 2022;
accepted December 14, 2022.

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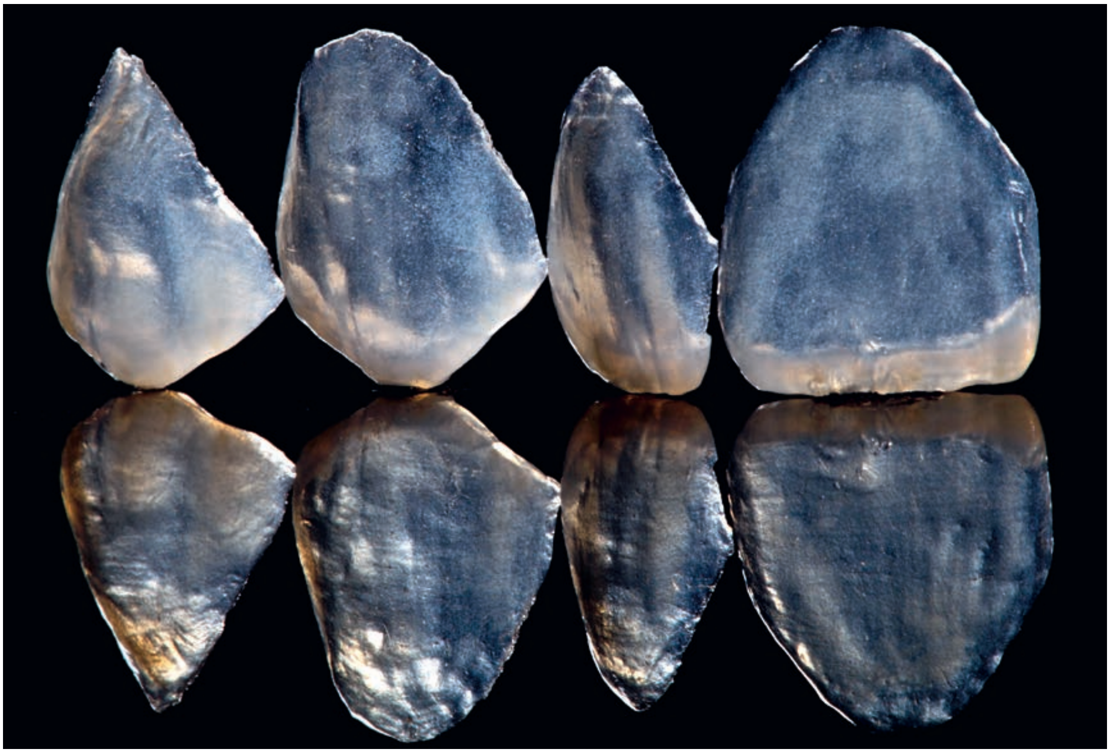
Ultrathin Feldspathic Ceramic Veneers: A Pilot SEM Evaluation of Etched Intaglio Surfaces

Ultrathin ceramic veneers are a viable therapeutic option to manage esthetic challenges in the anterior zone. Proper conditioning of the intaglio surface of porcelain veneers is essential to achieve an adequate bonding. In clinical practice, this is typically done with chemical etching using an acid-containing agent, such as hydrofluoric acid. While it is well established that the etching effect is dependent on etching time and the acid concentration, little is known about the impact of etching time and the veneer fabrication method. The purpose of this pilot study was to evaluate, using scanning electron microscopy (SEM), the effect that different etching-time protocols have on the intaglio surface characteristics of ultrathin ceramic veneers fabricated with either the platinum foil technique or the refractory die technique. Several replicas of an ultrathin feldspathic ceramic veneer for a maxillary central incisor were fabricated. Individual specimens were processed according to different intaglio surface-etching protocols: no etching, etching for 90 seconds, etching for 120 seconds, and etching for 150 seconds (9.6% hydrofluoric acid used for all etching groups). It was observed that the 120-second etching protocol resulted in a favorable microroughness surface pattern in the platinum foil group. This pattern was comparable to that obtained by etching for 90 seconds with hydrofluoric acid the intaglio surface of veneers fabricated with the refractory die technique. Increasing the etching time to 150 seconds did not result in a more favorable roughness pattern. *Int J Periodontics Restorative Dent 2024;44:59–69. doi: 10.11607/prd.6574*

Since its inception, cosmetic dentistry has unceasingly evolved through the adoption of new technologies and therapeutic strategies, with the purpose of achieving maximum patient satisfaction while respecting the existing biologic structures.[1] Ever since the introduction of ceramic veneers,[2] questions have been raised over the past several decades as to whether the clinical performance of these minimally invasive restorations is on par with full-contoured prosthetic designs, which typically require more aggressive tooth preparation. However, major advancements in the development and understanding of dental materials and adhesive protocols have progressively led to a wider acceptance by the dental profession of minimally invasive all-ceramic restorations to address prosthetic needs in the esthetic zone (Fig 1).

While it is well documented that long-term success of conventional ceramic veneers is generally high,[3–6] there is limited information on the outcomes of ultrathin ceramic veneers (range: 0.1 to 1 mm thick) delivered after minimal or no tooth preparation (Fig 2). Two fabrication methods

▲ **Fig 1** Clinical example of porcelain veneers in the esthetic zone for cosmetic purposes.



▲ **Fig 2** Ultrathin ceramic veneers.

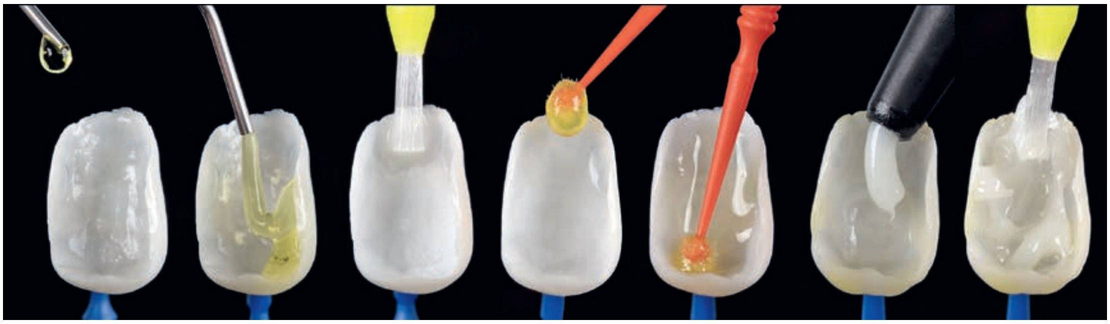
of ultrathin ceramic restorations have been described: the platinum foil technique and the refractory die technique.[7] The platinum foil technique leverages the inherent properties of platinum, which is a noble metal with an unmatched capacity to absorb and dissipate heat (Figs 3 and 4). This specific property allows for precise control of the ceramic baking, which is essential to achieving a pore-free thin veneer that retains top esthetic features (Fig 5). A recent clinical study investigating the outcomes of ultrathin veneers fabricated with the platinum foil technique found that, although patient satisfaction was extremely high, a moderate incidence of porcelain chipping (9.8%) occurred over a 3-year period.[8] This could be primarily attributed to functional habits and can therefore be largely prevented with careful patient selection and education.

▲ **Fig 3** Fabrication of ultrathin ceramic veneers with the platinum foil technique.

▶ **Fig 4** Removal of platinum foil after baking one ceramic veneer to restore a maxillary central incisor.

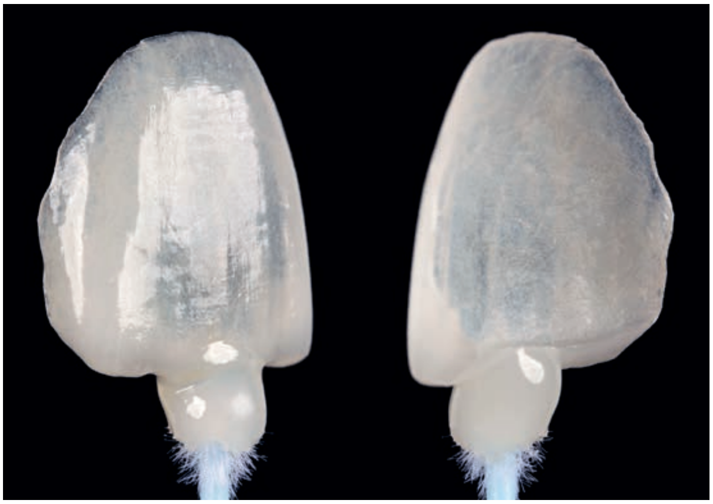
▲ **Fig 5** An ultrathin ceramic veneer made with the platinum foil technique.

▲ **Fig 6** Insertion of two ultrathin ceramic veneers.



▲ **Fig 7** Process of preparing a ceramic veneer for cementation. *(left to right)* Etching the intaglio surface with 10% hydrofluoric acid and applying the coupling agent (silane), the adhesive, and the composite resin cement.

Beyond the management of complications related to structural damage after function, one of the most challenging aspects of the clinical execution of restorative treatments involving ultrathin ceramic veneers is the insertion and proper adhesion of these extremely delicate dental prostheses (Fig 6). Long-term success of these restorations primarily depends on the strength and durability of the luting agent's bond to both the tooth and porcelain. Suboptimal bonding often leads to fractures, marginal discoloration, and secondary caries. Effective retention of ultrathin ceramic veneers and other all-ceramic restorations can be satisfactorily achieved with adhesive bonding, a process that requires conditioning of the intaglio surface of the veneer. Mechanical procedures, such as airborne-particle abrasion with alumina (sandblasting) and grinding with a mounted stone, as well as chemical etching with an acid-containing agent (usually hydrofluoric acid in concentrations between 5% and 10%), have been described. Due to the fragile nature of ultrathin ceramic veneers, acid etching is done chairside (Fig 7). Etching the intaglio surface with acid selectively dissolves the silica (SiO_2) in the glassy matrix, resulting in increased microroughness and surface area, which favors micromechanical retention of the luting composite resin by enhancing bond strengths. With the purpose of optimizing the adhesion to ceramic after acid



▶ **Fig 8** Frontal and internal view of one of the study samples fabricated with the platinum foil technique.

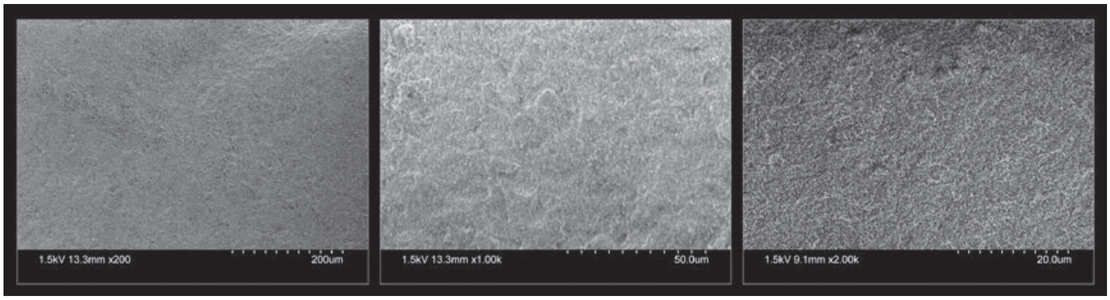
▶ **Fig 9** Close-up view of the intaglio surface of one of the study samples fabricated with the platinum foil technique.

etching, a coupling agent in the form of a silane is typically used. The combined physical retention offered by the microporosities created by the acid and the enhanced chemical bond obtained using silane provides a high-strength retention of ceramic restorations.[9,10]

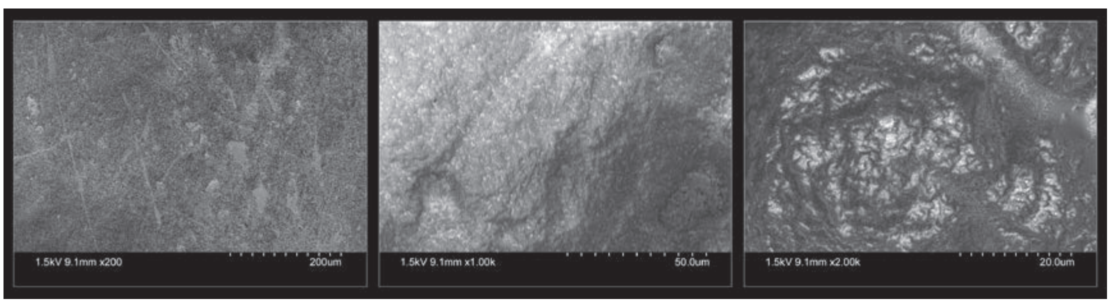
Various intaglio etching protocols for all-ceramic restorations have been described in the literature. It has been shown that the application of hydrofluoric acid to the surface of ceramic materials increased the surface roughness and bond strength when compared to unetched specimens. This effect is dependent on etching time and acid concentration.[11] However, little is known regarding the topographic features that result from the application of an etching agent on ultrathin veneers as a function of time and the fabrication method. Thus, the purpose of this pilot in vitro study was to evaluate, using a scanning electron microscope (SEM), the effect that different etching protocols have on the intaglio surface characteristics of ultrathin ceramic veneers fabricated with either the platinum foil technique or the refractory die technique.

Materials and Methods

Several replicas of an ultrathin feldspathic ceramic veneer for a maxillary central incisor were fabricated using the same model and ceramic material (d.SIGN, Ivoclar Vivadent) according to laboratory protocols previously described for the refractory die technique using an alveolar model[12] and the platinum foil technique[13] (Figs 8 and 9). Replicas were split into two groups based on manufacturing technique (platinum foil vs refractory die), with four samples per group.



▲ **Fig 10** SEM images of the intaglio surface of an untreated ceramic veneer made with the refractory die technique, in increasing magnifications from left to right.



▲ **Fig 11** SEM images of the intaglio surface of an untreated ceramic veneer made with the platinum foil technique, in increasing magnifications from left to right.

Specimens were treated according to different intaglio-surface etching protocols (one specimen per etching time per group): no etching, etching for 90 seconds, etching for 120 seconds, and etching for 150 seconds. For all etching, 9.6% hydrofluoric acid (Porcelain Etch Gel, Pulpdent) was used. After acid etching, the specimens were rinsed with water, dried, and attached to aluminum stubs using carbon paint. Subsequently, the specimens were sputter-coated and analyzed using a Hitachi S-4800 field-emission SEM at various magnifications. Standardized representative images were captured.

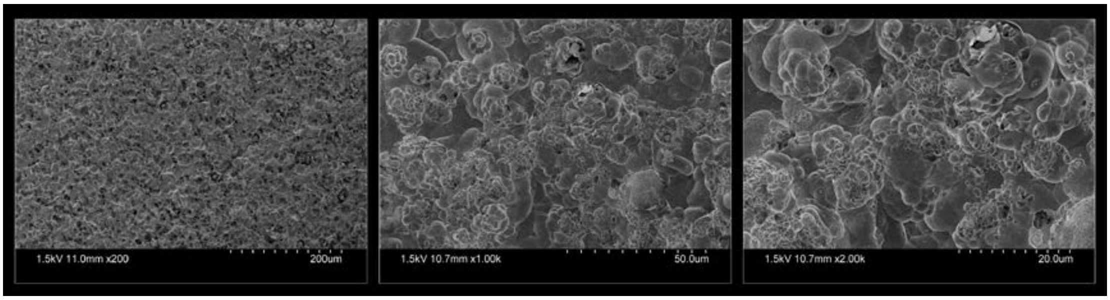
Results

No Etching

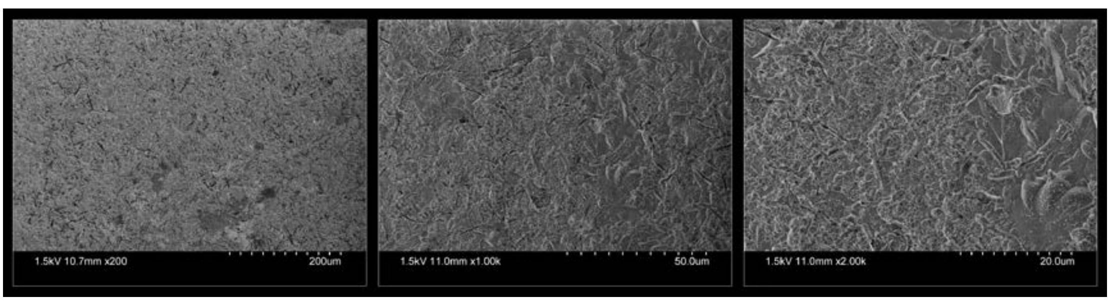
Ultrastructural assessment revealed a clear difference in the intaglio surface characteristics between both groups. The veneer fabricated with the platinum foil technique had a highly polished, mirror-like finish, free of pores and microgrooves compared to the veneer made with the refractory die technique, which exhibited a rough surface even in the absence of acid etching (Figs 10 and 11). These differential patterns between both types of ultrathin ceramic veneers are suggestive of a diverging response to acid etching.

Etching for 90 Seconds

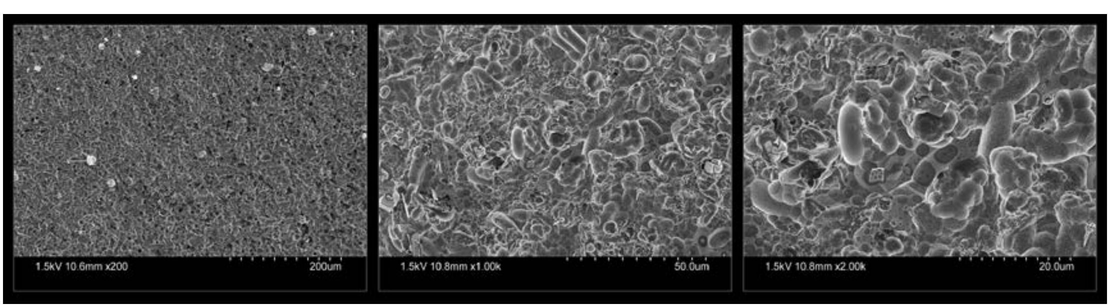
This etching time has been proposed as the standard for acid etching of the intaglio surface of ceramic restorations.[14] SEM evaluation revealed substantial topographic changes compared to the untreated samples. These included pore and groove formations, as well as exposure of the leucite crystals and glass matrix. However, pore size and distribution differed between groups, and they seemed larger, deeper, and more abundant and homogeneous in the veneer fabricated with the refractory die technique (Figs 12 and 13). This finding holds clinical significance, as the reduced microporosity and roughness resulting from 90 seconds of etching the veneer made with the platinum foil technique may reduce the bond strength of these restorations.



▲ **Fig 12** SEM images of the intaglio surface of a ceramic veneer made with the refractory die technique after 90 seconds of etching with 9.6% hydrofluoric acid, in increasing magnifications from left to right.



▲ **Fig 13** SEM images of the intaglio surface of a ceramic veneer made with the platinum foil technique after 90 seconds of etching with 9.6% hydrofluoric acid, in increasing magnifications from left to right.



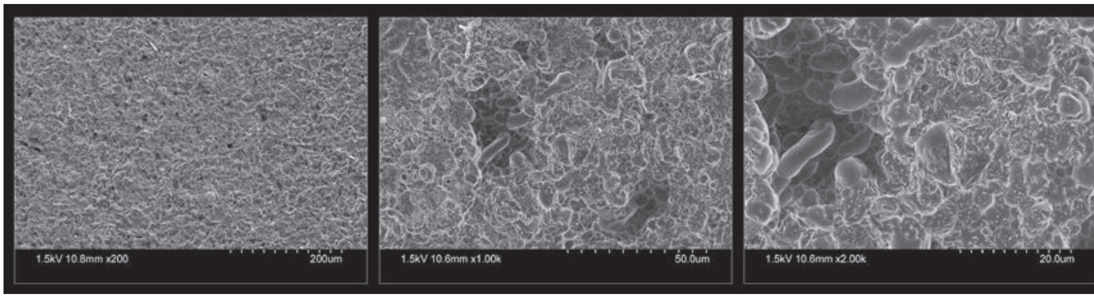
▲ **Fig 14** SEM images of the intaglio surface of a ceramic veneer made with the refractory die technique after 120 seconds of etching with 9.6% hydrofluoric acid, in increasing magnifications from left to right.

Etching for 120 Seconds

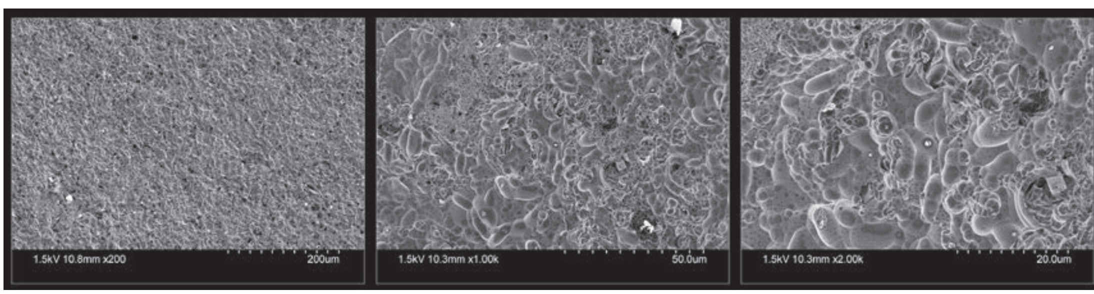
An additional 30 seconds of etching time resulted in a slight increment in the rugosity of the intaglio surface in the refractory die veneer (Fig 14). On the other hand, the longer etching time on the platinum foil veneer resulted in a noticeable increase in larger pores and grooves and a more evident exposure of leucite crystals compared to 90 seconds of acid exposure (Fig 15). Notably, this surface pattern resembled that observed in the refractory die sample after 90 seconds of acid etching.

Etching for 150 Seconds

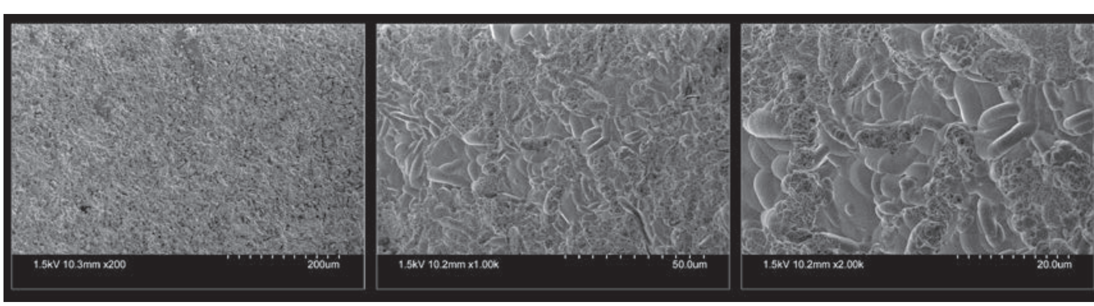
The intaglio surface of the sample fabricated with the refractory die technique presented a very similar ultrastructural aspect to that observed after 120 seconds of acid etching (Fig 16). Interestingly, compared to the pattern obtained after 120 seconds of etching, an apparent attenuation in surface roughness was observed in the platinum foil group, characterized by a reduction in the number and size of pores and grooves (Fig 17).



▲ **Fig 15** SEM images of the intaglio surface of a ceramic veneer made with the platinum foil technique after 120 seconds of etching with 9.6% hydrofluoric acid, in increasing magnifications from left to right.



▲ **Fig 16** SEM images of the intaglio surface of a ceramic veneer made with the refractory die technique after 150 seconds of etching with 9.6% hydrofluoric acid, in increasing magnifications from left to right.



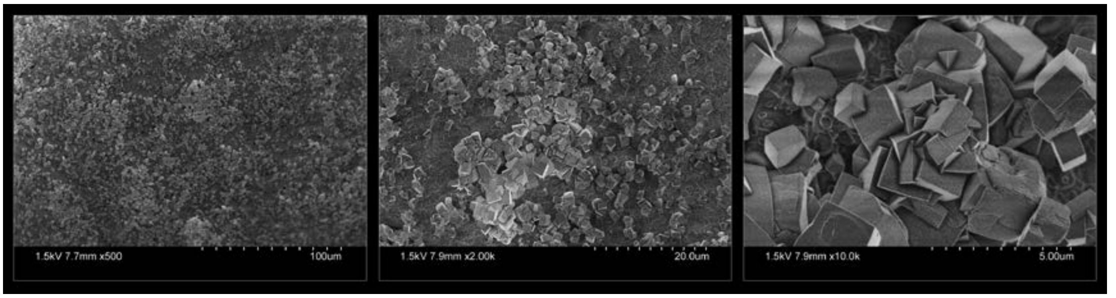
▲ **Fig 17** SEM images of the intaglio surface of a ceramic veneer made with the platinum foil technique after 150 seconds of etching with 9.6% hydrofluoric acid, in increasing magnifications from left to right.

Crystal Formations

Scattered deposits that seemed to be mineral crystal formations were observed in both groups at all acid-etching times (Fig 18). The presence of residues on the surface of ceramic veneers following hydrofluoric acid etching has been reported in the literature.[15] To eliminate this crystalline debris, which may interfere with the adhesive process, it has been recommended to apply 37.5% phosphoric acid for 30 to 60 seconds and subsequently rinse the specimen, although submerging the veneer in an ultrasonic bath with alcohol for several minutes (3 to 5 minutes) appears to be a more efficient method.[15–17]

Discussion

The use of minimal-thickness ceramic veneers has progressively gained popularity in recent years in the field of advanced cosmetic dentistry. Conservative, or even the absence of, tooth preparation



▲ **Fig 18** Example of crystalline debris found in one of the study samples after acid etching for 90 seconds, in increasing magnifications from left to right.

protocols are a consolidated alternative due to advancements in biomaterial science. However, scarce information is available regarding the optimization of bonding protocols and clinical performance of ultrathin feldspathic ceramic veneers fabricated with the refractory die or the platinum foil technique. These types of restorations, although minimal in thickness and invasiveness, are not a simplified treatment option but rather a highly sophisticated and technique-sensitive therapeutic approach, both from a laboratory and clinical perspective. Thus, prior to treatment planning with these restorations, it is crucial to carry out a meticulous process of case selection by carefully evaluating candidate patients from both anatomical and functional perspectives. Additionally, the laboratory technician should follow strict fabrication protocols to ensure that the final product meets all quality standards. Once the veneer is ready for insertion, it is also fundamental to adequately prepare the biologic substrate (the tooth surface) and the restorative interface (intaglio of the restoration) to maximize the chances of achieving proper bonding and long-term therapeutic success. There are two essential steps for intaglio preparation: *(1)* increase the surface area by creating microporosities on the porcelain surface via acid etching, which enhances the potential for mechanical retention of the resin cement; and *(2)* apply a coupling agent (silane) to increase the wettability of the hydroxylated ceramic surface and allow for a proper chemical interaction with the resin cement.[18]

This investigation used SEM to visually analyze and describe the topographic changes that occur after extraoral preparation of the intaglio surface of ultrathin ceramic veneers as a function of the laboratory fabrication technique (refractory die vs platinum foil) and total acid etching time. It was observed that etching the intaglio surface of ultrathin feldspathic ceramic veneers fabricated with the platinum foil technique with 9.6% hydrofluoric acid for 120 seconds resulted in an apparently favorable microroughness surface pattern that was very similar to that obtained by applying 9.6% hydrofluoric acid for 90 seconds on the intaglio of veneers made with the refractory die technique. Increasing the etching time to 150 seconds did not render a more favorable outcome. On the contrary, it appeared as if the intaglio surface lost roughness compared to the pattern observed after 120 seconds of acid etching.

These findings may have some important practical applications. When working with ultrathin veneers, obtaining a homogenous and sufficient microroughness is important to achieve an adequate and balanced bond strength over the whole intaglio surface to avoid mechanical failure. It seems that 90 seconds of acid etching may be insufficient to achieve that goal in veneers fabricated with the platinum foil technique, likely because of the greater material density and compactness compared to veneers made with the refractory die protocol. Sandblasting the intaglio surface of ultrathin veneers substantially increases the risk of causing structural damage to the restoration (eg, cracks and fractures) and should be avoided. Therefore, based on the present observations, a plausible option to optimize the microroughness is to increase the etching time by an additional 30 seconds, for a total of 120 seconds.

However, the present findings also highlight the importance of not exceeding the acid etching time. Excessive etching may adversely affect porcelain by creating an exacerbated increase in pore size and particle exposure, which may contribute to crack propagation. Hydrofluoric acid in concentrations of 20% to 40% has been used routinely in dental laboratories to remove residual platinum foil within porcelain crowns. The effect of this practice was examined in a classic study that revealed a 21% decrease in strength for aluminous porcelain jacket crowns after the use of 30% hydrofluoric acid, and a 24% decrease in strength for aluminous porcelain test bars after using hydrofluoric acid at a concentration of 20%.[19] As discussed elsewhere,[20] although acid etching may increase the strength of glass materials (such as ceramics) by removing the surface microdefects, it may also weaken the substrate through hydrolysis. This further emphasizes the importance of not exceeding the optimal etching time.

The primary limitation of this pilot study is the sample size, as one specimen was analyzed for each etching time per fabrication group. Future studies with a larger sample size should be conducted to verify the findings from this investigation.

Conclusions

While the present findings should be interpreted with caution because of the limited sample size, based on the observations derived from the microscopic analysis, it seems that etching the intaglio surface of ultrathin feldspathic ceramic veneers made with the platinum foil technique with 9.6% hydrofluoric acid for 120 seconds results in a favorable microroughness surface pattern. This is comparable to what is obtained by etching the intaglio of veneers fabricated with the refractory die technique by applying 9.6% hydrofluoric acid for 90 seconds. Additional etching time (up to 150 seconds) does not seem to result in a more favorable roughness pattern. Future research on this topic should be conducted to further explore the influence of etching time and fabrication technique on the microroughness of ultrathin ceramic veneers and to determine how these findings correlate with the clinical performance of this type of minimally invasive restoration.

Acknowledgments

The authors have no conflicts of interest to report pertaining to the conduction of this study.

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