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Optimization of the Bonding of Glass-Ceramics to Dental Structures: A Case Study

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Abstract

Glass-ceramic restoration of eroded teeth is becoming a routine therapeutic procedure. The glass-ceramic prosthesis is held in place by adhesive bonding, the strength of which is dependent on the materials and specific techniques employed. The clinical case study presented afforded the opportunity to optimize and fine tune the bonding procedure. Surface treatments of the different substrates (tooth and ceramic) have been developed so as to maximize the strength of the adhesive bond of ceramic to both underlying dentin and enamel. The success of the procedure is often evaluated by the time that the prosthesis remains in the oral cavity. This case demonstrates those three years after bonding, the restoration remains securely in place despite a severe accident resulting in a root fracture.

Keywords: Bonding; Ceramic; Erosion; Adhesion; Occlusion; Treatment planning

Introduction

In modern society there is a high and still increasing prevalence of dental erosion [1-3]. Reported prevalence is variable in the literature complicated by other forms of tooth wear, age, country's origin and evaluation standards. Erosive tooth wear is caused by sustained direct acid attack of enamel, the acid arising from an intrinsic source such as gastro esophageal reflux or vomiting or extrinsic sources [4-7]. The extrinsic causes of dental erosion can be grouped under the headings of environmental, diet, medications and lifestyle [8]. Glass-ceramic restoration of teeth to treat dental erosion is becoming a routine procedure in modern dentistry as it not only enables conventional treatment but also provides aesthetic improvements over metal-ceramic restoration [9,10]. Glass ceramic prostheses are securely bonded to underlying supporting tooth structures with adhesive cements. The strength of the bonding is paramount in determining the success of the completed restoration. There has been a plethora of research examining adhesive bonding in ceramic restorations and the factors that affect the strength of the bond [11-16]. Not only is the strength of the bond influenced by the materials employed but it is also dependent on the procedure. This case study provided an opportunity to investigate the bonding of ceramics to dental structures and to further optimize the procedure with respect to the surface treatment of both substrates (tooth and ceramic).

Pre-Prosthetic Examination and Diagnosis

A 31 year old male patient presented at the clinic due to 'absence of teeth in his smile' and expressed a wish for restoration. He had been an inpatient in a psychiatric hospital for 10 years. He did not complain of pain or masticatory deficiency. The hard tissue erosion was thought to be a result of the patient's medication. Anti- depressant and anti-psychotic medicines often have anti-cholinergic peripheral side effects and therefore can have an impact on salivary flow and composition [17,18]. Decreased salivary flow and alterations in the clearance and buffering capacity of saliva will result in a more acidic environment in the oral cavity. Demineralization of enamel occurs if the oral environment reaches a critical threshold of pH 5.5. In addition, due to the symptom of 'dry mouth' the patient is likely to have consumed more beverages potentially exposing the teeth to acid attack from a dietary source (Figure 1).

Clinical examination revealed a severely eroded dentition with the anterior maxillary teeth and the premolars most significantly affected. All teeth were vital and there was no other clinical symptomatology. The periodontum presented as a thick biotype with significant attached gingival (Figure 2).

The severity of dental erosion as classified by Vailati and Belser was deemed to be Class V which indicates extended dentin exposure on the palatal aspect, loss of the incisal length of the

Figure 1: The smile is contracted but shows dentition.

tooth (> 2mm) together with distinct reduction/loss of facial enamel [19] (Figures 3 and 4).

The buccal version of the mandibular incisors and the absence of egression of the maxillary anteriors are due to the interposition of the tongue. The Vertical Dimension of Occlusion (VDO) did not appear diminished and the molars adequately interlocked. The occlusal plane was correct without any deformities or abnormalities. The intermaxillary relation showed no severe mandibular protrusion and no lateral deviation in intercuspal relationships was established during the pre-prosthetic evaluation. The molars were in a Class I of Angle relation. There was no anterior guidance because of the erosion. Tooth number seven was missing and the lateral incisor had been replaced by a canine during orthodontic treatment 15 years previously. The centre of the maxillary incisors was laterally positioned.

Therapeutic Plan

The primary therapeutic objectives were the rehabilitation of function and aesthetics. The treatment aimed to respect the teeth together with the conservation of as much tissue as possible. The patient wanted to avoid surgery and lengthy orthodontic work and expressed a wish for the best possible treatment within a short timeframe.

Prosthetic strategy

A premolar to premolar restoration in the upper and lower maxilla was proposed. The diagnostic wax up revealed that the VDO had to be augmented in order to build correct proportions for the final teeth. (Figure 5) Final restoration was to be performed in a centric relation and there were to be no major changes in the occlusal plane.

Figure 2: Frontal view of pre-operative situation.

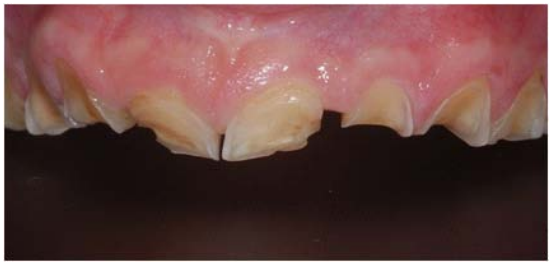


Figure 3: Class V ACE dental erosion.

Figure 4: Occlusal view of the maxilla.

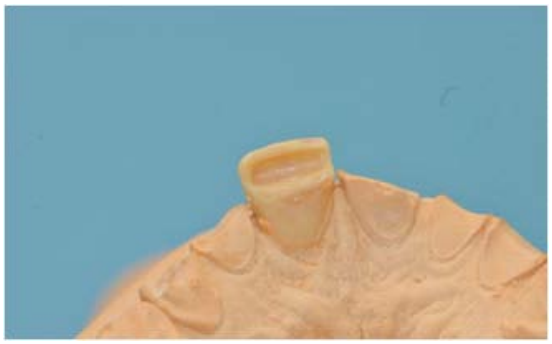


Figure 5: Wax up of the central incisive without VDO augmentation, normal anatomy cannot be built in that situation.

Figure 6: The full wax-up allows us to show, prepare and anticipate the results.

The restoration options available to treat and rectify this case of severe dental erosion are either to look for retention or to exploit the remaining tooth structures and use adhesive bonding. The former is the more conventional approach and involves endodontic treatments, insertion of posts for maxillar anteriors, and crowns on vital teeth in the posterior region. Materials can either be all-ceramic or metal-ceramic, although all-ceramic restorations are preferable to than metal-ceramic as they have superior aesthetics and are more biocompatible [9,10]. The occlusal concept is commonly a mutually protected occlusion with canine or group guidance.

The second option represents a more moderate treatment method, taking advantage of the large enamel band around the incisors and canines and aiming to conserve as much original

tissue and dental structure as possible. Although there was very little capacity for retention in this case, there was good adhesion potential. The materials of choice in this approach are glass ceramics for their bonding ability. Lithium disilicate ceramic offers a material that has the necessary characteristics of good mechanical strength combined with the capacity for natural light transmission [20]. These ceramics are produced with pressed ingots (Emax Press ® Ivoclar Vivadent) and depending on the restoration thickness they are either stratified (anterior region) or lightly coated on the posterior region. The occlusal concept in this scenario is generally a balanced occlusion in order to minimize lateral impacts on the anterior guidance [21].

After extensive consultation with the patient with full explanation of both options, the second approach was chosen, notably as it seemed preferable to conserve the tissue and remaining dental structures, and also for the fact that the first approach remained a viable option in the event of failure of the latter method.

Figure 7: Positioning of shells in a resin splint.

Figure 8: Shells relined with acrylic resin, luted with polycarboxylic acid without Eugenol.

Figure 9: Occlusal view of the maxilla with minimum teeth preparations.

The second approach is dependent on the adhesive process and the mechanism and strength of adhesion is very much influenced by the type of adhesive employed and the technical procedures and protocols followed. To this end, a review of the literature revealed that there are many protocols and procedures employed in glass ceramic bonding and that there was potential to optimize these procedures in order to achieve a strong adhesive bond (Figure 5).

Treatment plan and clinical stages

- A full wax up enabled the evaluation of the proposed treatment plan and VDO adjustment (Figure 6).
- The primary temporary prostheses were made from shells that were jointed because of the poor retention offered by the available tooth structures after preparations (Figure 7).
- The shells were relined with acrylic resin and luted with polycarboxylic acid without Eugenol (Durelon™) [22] (Figure 8).
- The patient and the practitioner were able to test the new occlusion and aesthetic for a few weeks, making necessary adjustments and occlusal equilibrations (Figure 9).
- The final restoration began with the molars so that the occlusal relation was stabilized by premolars and anteriors. The molars were rebuilt with table-tops, also called overlays, the most appropriate technique in order to raise the VDO with a consevative approach [23].
- Subsequently the anteriors and premolars were bonded. Final equilibration was performed following the technique of Fillastre [24].

The luting session of ceramic prostheses: The process of adhesion of dental prostheses must not only take into consideration the nature of the luting agent(s) and the material of the prostheses but also the techniques and procedures employed to obtain a strong and long-lasting bond. The literature indicates that there are different protocols followed in order to maximize the strength of the bonding [25]. Before sound adhesion can be obtained it is necessary to prepare and treat the surfaces to be adhered. This is applicable to any adhesion process and maybe more so in prosthetic dentistry where the permanence of the bonding is determinant of treatment success. The two surfaces involved are the ceramic prosthesis andremainingtooth.

Treatment of the tooth side: Isolation with a dental dam provided control of the dental surface while the temporary cement was removed with ultrasound followed by pumicing with a brush so that the tooth surface was adequately cleaned [26,27] (Figure 10).

Figure 10: The 8 table tops for the molars.

Figure 11: Removal of the temporary cement with ultra sound and pumice.

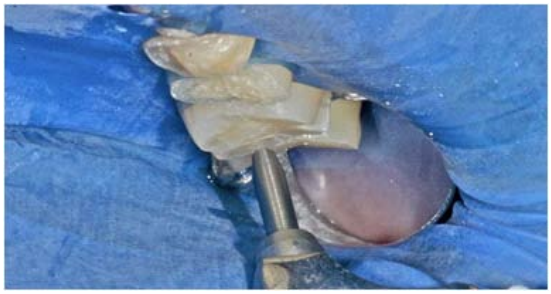


Figure 12: Sandblasting to optiminize bonding.

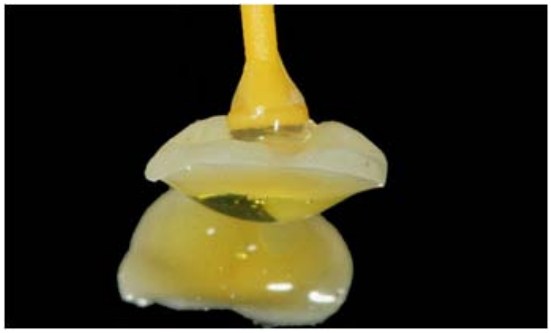


Figure 13: Etching of table tops.

Optimization of the treatment of the tooth surface involved sandblasting with alumina, 27 µm, 2-5 bars, 10 seconds, in order to develop the surface energy and enhance the mechanical retention of the adhesive [28] (Figure 11).

The etch and rinse system with a primer then bonding with 4th generation adhesive is still the gold standard in terms of retention and micro leakage, particularly on to enamel [29].

The standard protocol followed encompassed:

- Etching enamel for 30 seconds with phosphoric acid at 34% v/v.
- Etching dentin for 15 seconds maximum.
- Rinsing for 30 seconds.
- Light air blasting, no drying.
- Application of primer and gentle brushing.
- Light air blasting
- Application of bonding material, gentle brushing.
- Light air blasting to evaporate solvents.
- Light curing for 40 seconds.

Materials employed: Syntac™ and Variolink II™ from Ivoclar-Vivadent.

Treatment of the ceramic side: Surface treatment of the ceramic prior to bonding is a standard prerequisite. A fairly standard protocol was initially followed but there were opportunities where optimization steps were included. Box 1 summarizes the surface treatments for glass ceramic (Figures 12 and 13).

The procedure involved:

- Etching with hydrofluoric acid (5% concentration during 30 seconds using Porcelain-etch® Ultradent) again in order develop surface energy and to increase mechanical adhesion of the resin (Figures 14 and 15). Etching time is dependent on the concentration of acid used and on the nature of the glass ceramic as shown in Box 1.
- Rinsing for at least 30 seconds.
- Drying of the surface with air blasting.
- Application of silane : two thin layers on two orthogonal directions, brushing the surface and allowing to evaporate, in this case ceramic primer® (3 M) was used .

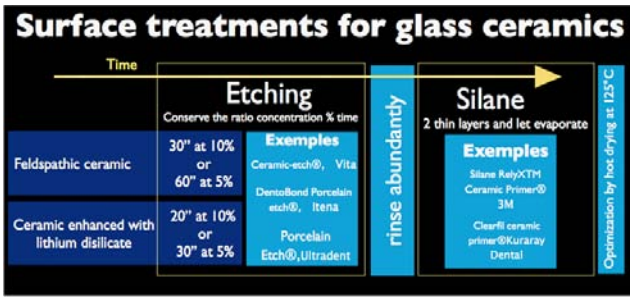
Optimization of the procedure comprised heating the silane to 125°C has this been shown to increase tensile strength of the bonding. This can be achieved with a hair dryer or better in a ceramic furnace [30,31], this is the chosen option for this case. The dual composite (Variolink II™) was injected and the excess removed with a brush (Box 1)

End of luting session: It is important to finish the luting session by treating the inhibited surface layer with oxygen. Two methods are available: either a glycerin gel is applied before the last curing, or a little excess of luting resin will be polished. The former method was used on this occasion as it seemed more practical with respect to the excess of resin before the light curing.

Primary occlusion corrections were made followed by polishing, final occlusion corrections and application of fluoride varnish on the margins to minimize sensitivity and to fill in microporosities. The patient was provided with a night mouth guard to minimize parafunction effects (Figures 16, 17 and 18).

Overall Reflection and Discussion

The procedures used in this case study demonstrate a commitment to conservative dentistry. The treatment modality described involved the preservation of as much sound tooth structure as possible within the framework of the existing hard tissues' loss and the patient's expectations for aesthetic. The overall permanence or longevity of the prostheses is highly dependent on the technical steps taken in the bonding session. However, while optimization of the procedures is key to strong adhesion, adequate consideration must be given to the concept of occlusion with the knowledge that there may be shrinkage of the adhesive layer [32]. Furthermore, for a restoration to be considered successful, a minimum of 5-years preservation in the oral cavity is necessary, so future evaluation of the same restoration will validate the applied optimization procedures.



Box 1: Showing etching times and silane treatment of glass-ceramic.

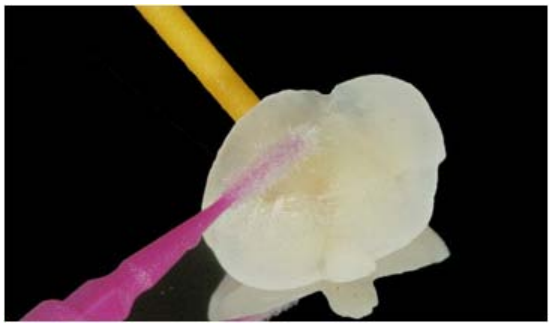


Figure 14: Silane brushed and dried.

Figure 15: Work in progress during the luting session.

Figure 16: Occlusal view of bonded table top before corrections.

Figure 17: Polishing the occlusal correction is mandatory.

Figure 18: Because of the very poor retention on the canines group fonction on excursions are realized, controlled and polished.

While the conservation of tissue was possible in this case and was consistent with the initial aims for the treatment, it also meant that options remain available if future treatment is required. In the event of failure of the bonding it will still be possible to either re-bond, re-do the ceramic employing different materials or utilizing alternative procedures, or to opt for the more conventional retention option (Figures 19 and 20).

Conclusion

The procedures employed allowed for maximum tissue conservation and was in agreement with the patient's expectations in this case. The success of the treatment is dependent among

Figure 19: Occlusal view of the maxilla at the end of the treatment. Function and esthetics are restored.

Figure 20: Frontal view of anterior arcade at four years recall.

other parameters-on the strength of the adhesion of the glass ceramic to the dental structures. The tensile strength of this bonding mechanism is influenced not only by the agents used but also by the surface treatment of the adhering surfaces and the techniques employed. Optimization steps have been adopted at both the surface treatment stages and at the luting stage in order to maximize bond strength. The permanence of the prostheses is the definitive measure of treatment success and the recall at four years gives satisfaction to the patient and the dental team.

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