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Etched casting acid etch composite bonded posterior bridges

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Abstract

The development of composite bonded cast posterior bridges is followed through its evolution from the perforated to the electrolytically etched casting for resin retention. The current state of the art in design and preparation for these retainers is reviewed stressing the path of insertion, proximal extensions, occlusal rests and gingival extent. Retainer fabrication and the alloy specific nature of the electrolytic etching process are discussed. The sequence and concerns in the acid etching of lingual tooth structure and subsequent bonding order for etched casting is described.

Acid etch composite bonded posterior bridges have only recently been employed clinically and have undergone a rapid evolution. These bridges utilize a cast framework which is composite bonded to the proximal and lingual enamel surfaces of the abutment teeth. The major areas of evolution are in the method of composite retention of the alloy framework (the resin to alloy interface) and in the criteria for abutment tooth enamel modification. These bridges represent an extremely conservative method of restoration as the abutment teeth undergo only modification to enamel contours, therefore making the technique reversible should the bridge be removed.

Historically, the use of these bridges depended upon several significant developments. Rochette[1] pioneered the use of a lingual perforated cast alloy framework with acid etch composite bonding for periodontal splinting of anterior teeth. Howe and Denehy[2] took a major step when they employed the perforated alloy framework for replacement of missing anterior teeth. Their cases were selected such that there was limited or no occlusal contact on the restoration. The excellent long term results observed in this study are discussed by Dr. Denehy in this issue.[3]

Based upon this work investigations were initiated at the University of Maryland Dental School using perforated retainers for replacing missing posterior teeth, and the restorations were placed in full occlusal function. Livaditis[4] recently reported on this latter application. A typical three-unit bridge retained by this mechanism is shown in Figures 1a, b.

In the course of these studies several factors became apparent. First, nonprecious or silverpalladium alloys had a distinct advantage over gold alloys due to their higher elastic modulus. They could be employed with a thinner cross-section thereby allowing better proximal embrasure form and reduced lingual contours. Second, conventional composite resins had too high a film thickness, which prevented complete seating of posterior retainers. With the cooperation of a manufacturer, this problem was solved by development of a low film thickness,

Figure 1a. (left) Preparation for a perforated casting acid etch composite bonded retainer to replace a second premolar.

Figure 1b. (right) Bonded retainer. This is typical of the lower limit in framework thickness over broad areas and measures 0.4-0.5 mm over much of the molar and premolar lingual arms.

(15-25 microns) composite resin.[a][4] Third, the resin is exposed at the perforations and can be expected to wear causing long-term loss of mechanical retention. Indeed, this becomes more important as the low film thickness composite resin is reported by the manufacturer to be 65% filler by weight; it can be expected to wear more rapidly. Finally, as reported by Eshleman,[5] the limiting factor in the bond of the alloy framework to acid etched enamel is the mechanical retention of the composite in the perforations. Thus, the composite to enamel bond exceeds the composite to perforated casting bond. In addition, trying to overcome this by increasing the number of perforations only weakens the framework and makes it more susceptible to fatigue fracture.

Fifteen three-unit posterior bridges placed using this retention mechanism have been functioning in normal occlusion for between two and four years. To date there have been no debonds, although wear of resin exposed at the perforations has been observed.

Tanaka et al.,[6] in the fall of 1979, published a method of mechanically retaining acrylic facings on a casting alloy by pitting corrosion of the alloy surface. This represented a possible new approach to bonding castings to enamel. However, early experimentation determined that pitting corrosion of nonprecious alloys for porcelain bonding was difficult and highly variable.

[a]Comspan — L. D. Caulk Company, Milford, DW.

Review of the literature established that Dunn and Reisbick[7] had previously used electrolytic techniques to etch a cobalt-chromium implant alloy and provide mechanical retention for ceramic coating. Following their example, a nickel-chromium alloy for porcelain bonding[b] was investigated and electrolytic etching conditions determined for this alloy.[8] The degree of surface relief possible with electrolytic etching for this alloy is evident in Figure 2.

The first bridges using an electrolytically etched

[b]Biobond C&B — Dentsply International, Inc., York, PA.

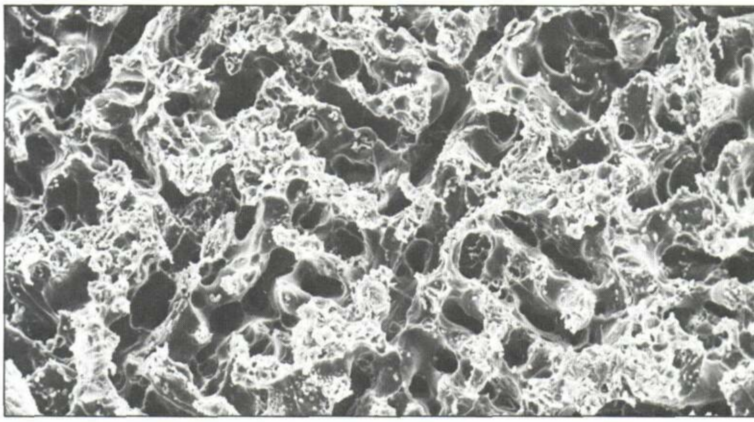
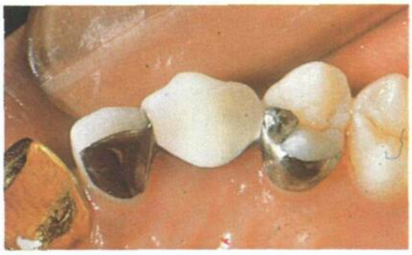


Figure 2. Scanning electron micrograph of the surface of a Ni-Cr alloy for porcelain bonding following electrolytic etching in 0.5 M nitric acid at a current density of 250 ma/cm^2 for 5 minutes followed by 10 minutes of ultrasonic cleaning in 18% hydrochloric acid. Original magnification 625x (full field 190 microns).



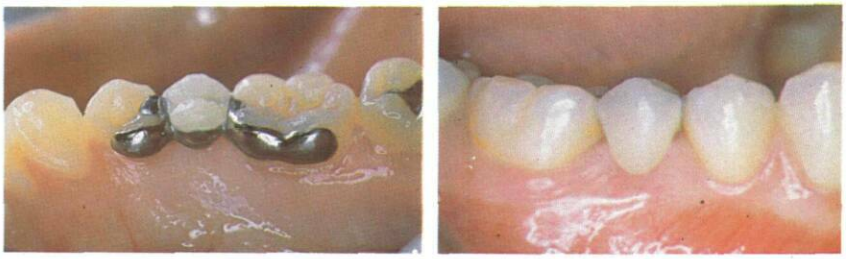


Figure 5. Etched alloy resin bonded retainer replacing a canine just subsequent to bonding and excess resin removal.

Figures 6a&b. (center and right) Etched alloy resin bonded retainer replacing a missing second premolar in a 15-year-old patient.

(Figures 5, 6a, & 6b — *see page 42)*

Figures 7a&b. Etched alloy resin bonded retainer replacing a missing first molar. Note the extent of the buccal wrap around of the framework on the distal of the second premolar. *(see page 42.)*

framework for micromechanical retention of the resin were placed in the late winter of 1980.

The resin to alloy tensile bond strength was determined to be greater than 20 MPa (2900 psi),[8] while the accepted resin to acid etched enamel bond is approximately 8-10 MPa (1160-1450 psi).[9] Consequently the weakest bond with this system is now the resin to etched enamel bond. Further, the bonding resin is applied to the bridge before the composite readily wets, thus penetrating into the nickel rich surface Ni-Cr-Mo-Al-Be alloy[c] that remains after etching (Figure 3).

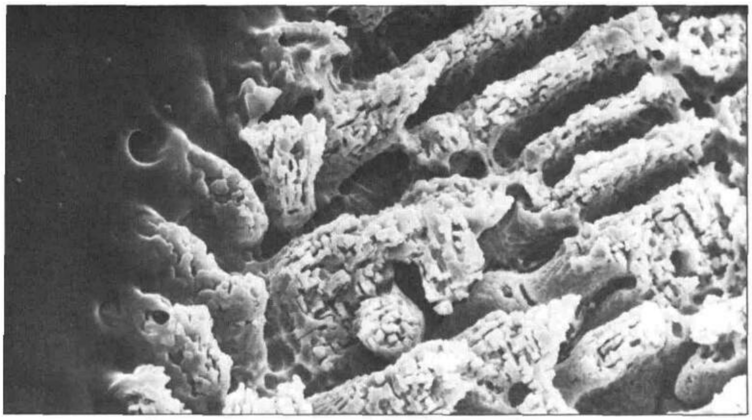


Figure 3. Scanning electron micrograph of an etched alloy surface placed vertically into freshly mixed bonding agent. Note the ready penetration of the resin into the surface and its climb up the surface. Specimen was solvent cleaned before viewing to remove oxygen-inhibited layer of resin covering entire surface. Specimen viewed horizontally in SEM. Original magnification 1800x (full field is 70 microns).

The general uses of etched casting resin bonded retainers has only recently been reported by Livaditis and Thompson,[10] while the short-term results of the longitudinal clinical study of etched casting resin bonded bridges was already in print.[11] Currently there are over 140 bridges 3-10 units in length being followed in this study; approximately 40% of these are posterior bridges. There have been three debonds of posterior bridges — all occurring before the two-week recall period (there was only one anterior debond and this was due to trauma). These restorations all failed at the resin to enamel interface and were thought to be the result of contamination of the etched enamel during the bonding process. The castings were re-etched following "burn-off" of the composite resin in a 500°C furnace. The restorations were then rebonded and have been functioning satisfactorily for a minimum of 5 months. The results of this continuing evaluation will be reported periodically.

[c]Rexillium III — Jeneric Industries, Wallingford, CT.

Design and Preparation

Based upon the earlier work of Livaditis[4] the elements of design that are essential for successful restorations have evolved; proper design dictates the modifications made to the enamel of the abutment teeth. An idealized diagram of a 3-unit posterior bridge and the modifications of the abutment teeth is shown in Figure 4. The following design elements should be included in any posterior bridge.

1. A *distinct path of insertion* must be created in an occlusogingival direction. This is accomplished by parallel modification of proximal and lingual surfaces of the abutment teeth. The height of contour is lowered to within one millimeter of the gingival margin where possible, provided that such modification will not penetrate the enamel. Thus in some proximal areas, due to the concavity created by the coronal narrowing in a gingival direction, the height of contour may only be lowered sufficient to provide occlusogingival depth for the connector — generally a minimum of 2 mm.

Modifications are made so that the maximum bonding area is to be utilized on a given abutment without compromising gingival health or esthetics. The bonding area can be increased by extending the framework toward the occlusal above the modified enamel, provided it does not interfere with the occlusion.

2. *Proximal resistance form* must be created. The alloy framework must extend buccally beyond the distobuccal and mesiobuccal line angles of the respective abutments. Thus the framework cannot be displaced from the buccal toward the lingual. This is another key element in creating a distinct path of insertion. If esthetics are compromised by the buccal extent of the alloy, then judicious modification of the buccal enamel allows the proximobuccal line angle to be moved lingually. The alloy only needs to extend just buccal to this line angle to establish the

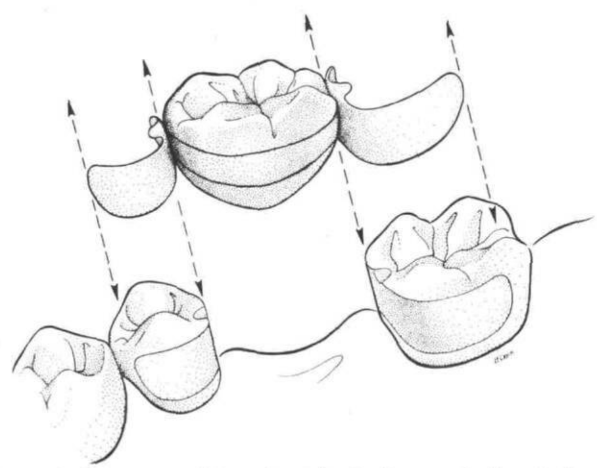


Figure 4. Diagram of 3-unit etched alloy resin bonded retainer illustrating the path of insertion.

resistance form and is easily hidden with proper contour of the buccal porcelain.

This proximal enamel modification is distinctly different from that used for a removable partial denture where guiding planes are the norm. Bonded bridges require the modified enamel to retain the approximate original buccal to lingual curve of the proximal surface when viewed from the occlusal.

3. *Some form of occlusal rest is required on each abutment of a posterior resin bonded bridge.* The rest should be small but well defined and *not* a broad spoon shape similar to classic removable partial denture occlusal rests. Usually a number 5 or 6 round bur is employed and the rest created is 1-1.5 mm in the buccolingual direction, 1-1.5 mm in the mesiodistal direction and 1 mm deep. The location of the rest is not critical and can be placed anywhere along the marginal ridge to remove it from an area of occlusal contact. When a distinct Cusp of Carabelli is present, this can be modified to function as a rest as was done in the perforated retainer shown in Figure 1. Note however, that the alloy framework is carried up to, and just over, the height of contour of the marginal ridge and thus functions as a broad additional occlusal rest.

Enamel is removed gingivally only to the extent that a knife-edge supragingival margin results. Thus the gingival contour of the restoration should duplicate the enamel removed during preparation. These fine margins are aided by the 0.3 mm minimum thickness commonly employed for the lingual portion of the retainer. There is no attempt made to create a chamfer margin at the gingival; this only removes enamel unnecessarily.

Retainer Fabrication

Upon completion of the preparation, an impression can be made using any accurate elastic material. Hydrocolloid, polysulfide, condensation silicones, polyether, and polyvinylsiloxane impression materials have all been used successfully provided good technique is observed.

Two methods are commonly used to fabricate the framework, either a pattern fabricated on a die, or a pattern waxed on a refractory model. Generally for 3-unit bridges use of die is advocated but more extensive cases are more easily handled on a refractory model.

When using a die, the pattern is usually built up using an acrylic resin[d] for strength due to the thin cross-section of the lingual arms of these retainers. Pontic sections and fine margins can be waxed.

The high resin to alloy bond strengths possible with electrolytic etching coupled with the high elastic modulus of the nonprecious alloys allows the retainers to be fabricated with a minimum thickness of 0.3 mm over broad surfaces, such as the lingual of maxillary molars. Thicknesses of 0.6 mm are the minimum recommended as the framework rounds a line angle toward the proximal where it thickens into the connector. These rather thin frameworks have functioned very well to date. It seems that the enamel supports the retainer due to the micromechanical bonding. Alloy flexing is apparently minimized or limited to the amount of deformation occurring in the tooth during function. Determination of the fatigue life of these alloys or of the bond can only be determined as the clinical studies progress.

When the lingual surface to be bonded is not broad, the retainer is then thickened toward the occlusal to approximately 0.5-0.6 mm while thinning to a knife edge at the gingival. This extra occlusal bulk helps stiffen the framework and reduce bond stress.

The pattern is invested, cast in nonprecious alloy and porcelain applied. The restoration is "tried in," the occlusion adjusted, then it is stained, glazed, and polished. The last procedure before the restoration is to be bonded is to return it to the laboratory for etching of the retainers (etching can be done in the dental office with the proper equipment and handling of the strong acids employed).

Electrolytic Etching

The details of the electrolytic etching of several nonprecious alloys has been described elsewhere.[8,10] The procedure can be outlined as follows: the polished bridge is mounted on an electrode (the electrode to the lingual of the retainers), electrical continuity is assured by use of a conductive paint at the contact point, and all areas not to be etched (and the electrode) are then masked with sticky wax. The electrode and bridge are mounted opposite a stainless steel electrode and immersed in an appropriate acid. The bridge is made anodic and current passed at a given density for a prescribed time. The etching acid, its concentration, the current density, and etching time must be carefully determined for a given alloy in order to get maximum resin to alloy bond strengths. Use of the wrong acid can result in electropolishing rather than etching. The conditions for etching a commonly used Ni-Cr-Mo-Al-Be[e] alloy are: 10% sulfuric acid at a current density of 300 milliamperes per square centimeter of surface to be etched for a period of 3 minutes.

The etched surface will be occluded with a black debris layer following etching and must be cleaned in 18% hydrochloric acid in an ultrasonic bath for 15 minutes. The etched surface will then have a matt grey appearance and care should be exercised to

[d]Duralay — Reliance Dental Manufacturing Company, Worth, IL.

[e]Rexillium III — Jeneric Industries, Wallingford, CT.

avoid contamination of the surface. The presence of an etch can only conveniently be determined by visual observation with the aid of a stereomicroscope at 60-80x. The etch should be confirmed before the bridge is removed from the electrode.

Bonding Procedures

Successful bonding of the etched retainers requires scrupulous attention to detail as the resin to enamel bond is the weak link in the system.

Upon seating the patient, the bridge is solvent rinsed with acetone or chloroform, the abutment teeth are isolated (rubber dam highly recommended) and thoroughly cleaned with flour of pumice — with particular attention to the lingual and proximal surfaces — and then rinsed. The usual 37-40% phosphoric acid is used for etching, but a 90 second etch is recommended due to general distribution of Type 3-5 etching patterns in the middle and cervical thirds of most teeth.[12] These patterns seem, in initial observations, to be more prevalent on the lingual surfaces of teeth.[13]

Following thorough rinsing and drying a bonding resin (unfilled resin) is applied to the etched abutments and then to the etched surfaces of the bridge. (It is generally recommended that the curing reaction of the bonding resin be slowed by varying the catalyst to base ratio trying for 90 second or longer setting time.) The low film thickness composite is then immediately applied to the bridge and the bridge seated before the bonding agent sets. The bridge is then held under pressure until the composite sets (approximately 5-7 minutes).

The bonding agent applied to the bridge before the composite has been found to increase the resin to alloy bond strength as indicated in Table I. In addition, without the bonding agent it is difficult to coat the etched alloy surface with the composite.

The excess composite and bonding resin must be thoroughly removed before dismissing the patient. A bridge replacing a missing canine is shown in Figure 5 just after completion of the bonding procedure. Note the lack of bulk on the lingual arm of the posterior retainer. Proper contouring of the restorations allows easy removal of the excess composite.

An early clinical case in which a second premolar was replaced in a 15-year-old patient is shown in Figure 6. Note the tendency in this case to overcontour the lingual arm of the retainer, particularly toward the gingival. First molar replacements are a common use for the etched casting resin bonded retainer such as that seen in Figure 7. Here the extreme buccal extension of the proximal "wrap around" on the second premolar can be appreciated; overcontouring of the lingual arm typical of the early cases is evident. This can be contrasted with the lingual contour of the retainer on the first premolar in Figure 5.

Table 1. Tensile bond strength[8] of composite resin columns to etched alloy surfaces following 2000 thermal cycles between 5° and 60°.

Condition		Bond (MPa)
Composite+ Only	(n=13)	16.1±4.8
Bonding Agent* and Composite+	(n=14)	21.2±3.2

Difference significant at p=.05.
+Comspan — L. D. Caulk Company, Milford, DW.
* Self Cure Bonding Agent — L. D. Caulk Company, Milford, DW.

Conclusions

The etched casting acid etch composite bonded posterior bridge is enjoying outstanding success at this early stage of its clinical evaluation. Based upon the 2-4 year results of the perforated composite bonded retainers, the projected performance of the etched casting variety is most favorable. The elimination of the exposed composite, and the high composite to etched casting bond strength appears to address the major limitations of the perforated retainers. In addition, with proper design the abutment can be effectively used to reduce the stresses on the micromechanical bonding of the composite to tooth structure. The technique must still be considered experimental and its efficacy can only be determined with long-term clinical evaluation.

In order to avoid confusion and standardize terminology it is recommended that these restorations be properly termed "etched casting resin bonded posterior bridges," and more generally, "etched casting resin bonded retainers."

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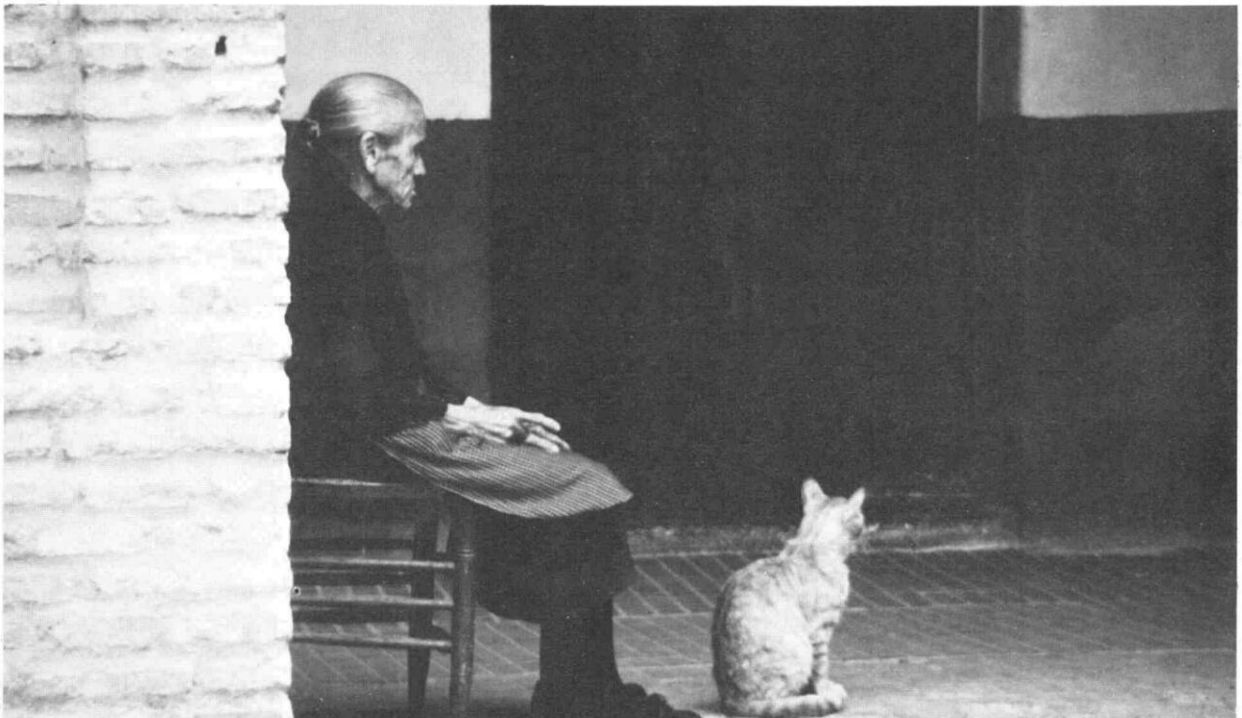

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