Bonded Splints and Bridges

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Acid-Etched, Resin-Bonded Splints

Mobility of teeth has many causes, including traumatic injury to the face, advanced periodontal disease, habits such as thumb sucking and tongue thrusting, and malocclusion. In addition, teeth often need stabilization and retention after orthodontic treatment. In the past, clinical procedures for the stabilization of teeth either involved extensive loss of the tooth structure or were poor in appearance. A conservative and esthetic alternative has been made possible by using acid-etched, resin-bonded splints.

Certain criteria must be met when mobile teeth are splinted. Occlusal adjustment may be necessary initially. The splint should have a hygienic design so that the patient is able to maintain good oral hygiene. It also should allow further diagnostic procedures and treatment, if necessary. The acid-etched, resin-bonded splinting technique satisfies these criteria. Light-cured composites are recommended for splinting because they afford extended working time for placement and contouring.

Periodontally Involved Teeth

Loss of bone support allows movement of teeth, resulting in increased irritation to the supporting tissues and possible malpositioning of teeth. Stabilizing mobile teeth is a valuable treatment aid before, during, and after periodontal therapy. Splinting of teeth aids in occlusal adjustment and tissue healing, thus allowing better evaluation of the progression and prognosis of treatment.

A resin-bonded splint via the acid-etch technique is a conservative and effective method of protecting teeth from further injury by stabilizing them in a favorable occlusal relationship. If the periodontal problem is complicated by missing teeth, a bridge incorporating a splint design is indicated (see the section on conservative bridges).

Techniques for Splinting Anterior Teeth

In short-span segments subject to minimal occlusal forces, a relatively simple technique can be used for splinting periodontally involved teeth. Online Figure 21-1, A, illustrates a maxillary lateral incisor that remains mobile because of insufficient bone support even after occlusal adjustment and elimination of a periodontal pocket. Esthetic recontouring with composite augmentation can be accomplished along with the splinting procedure.

Anesthesia generally is not required for a splinting procedure when enamel covers the clinical crown. When root surfaces are exposed and extreme sensitivity exists, however, local anesthesia is necessary. Teeth are cleaned with a pumice slurry, and the shade of light-cured composite is selected. A cotton roll and retraction cords are used for isolation in this instance.

With a coarse, flame-shaped diamond instrument, enamel on both teeth at the proximal contact area is reduced to produce an interdental space approximately 0.5 mm wide. This amount of space enhances the strength of the splint by providing more bulk of composite material in the connector between teeth. Other enamel areas of the tooth or teeth that need more contour are prepared by roughening the surface with a coarse diamond instrument. Where no enamel is present, such as on the root surface, a dentin adhesive is used, according to the manufacturer's instructions. Additionally, a mechanical lock is prepared with a No. 14 round bur in the dentin at the gingivoaxial line angle of the preparation. After the prepared enamel surfaces are acid-etched, rinsed, and dried, a lightly frosted appearance should be observed (see Online Fig. 21-1, B).

The adhesive is applied, lightly blown with air, and polymerized. A hand instrument is used to place a small amount of composite material in the gingival area. Additional shaping with a No. 2 explorer reduces the amount of finishing necessary later. It is helpful to add and cure composite in small increments, building from the gingival aspect toward the incisal aspect. Finishing is accomplished with round and flame-shaped carbide burs, fine diamonds, and polishing disks and points. The retraction cord is removed, and the occlusion is evaluated to assess centric contacts and functional movements. Instructions on brushing and flossing are reviewed with the patient. The result at 4 years is shown in Online Figure 21-1, C.

Splinting also can be used when the mandibular incisors are mobile because of severe bone loss. The same general steps are followed as described earlier. If further reinforcement is deemed necessary, however, a plasma-coated woven polyethylene strip, such as Ribbond (Ribbond Inc., Seattle, WA) can...
splinting procedures, the rubber dam is removed, and the occlusion is evaluated with finishing burs to enhance esthetics. After finishing procedures, the rubber dam is removed, and the occlusion is evaluated. The final result is seen in Online Figure 21-2, I and J.

Stabilization of Teeth After Orthodontic Treatment

After orthodontic treatment, teeth may require stabilization with either fixed or removable appliances. The latter method allows continued minor movements for the final positioning of teeth. When this position is reached, it is better to stabilize teeth with a fixed retainer. Removable retainers tend to irritate soft tissue. Also, they may be damaged, lost, or not worn, which usually leads to undesired movement of teeth.

Online Figure 21-3, A, shows a patient with a removable orthodontic retainer. Optimal positioning of teeth has been achieved by orthodontic movement; however, stabilization of teeth is required, and the unattractive spaces caused by undersized maxillary teeth need to be closed (see Online Fig. 21-3, B). A carefully planned appointment is required to accomplish the following: (1) remove any fixed orthodontic appliance, (2) add composite to close the diastemas, and (3) stabilize teeth with a twisted stainless steel wire and composite.

Technique

After the orthodontic appliance is removed and routine procedures are followed for closing the diastemas (see Online Fig. 21-3, C), the occlusion is examined carefully to determine the best position for locating the twisted wire because it will be placed only on the lingual surfaces. A sufficient length of twisted stainless steel wire (i.e., 0.0175 inch [0.45 mm] in diameter) is adapted to the lingual surface of anterior teeth. A stone cast is helpful for adapting the wire. The wire must rest against the lingual surfaces passively without tension or interference with the occlusion. In the mouth, waxed dental tape is used to position the wire against teeth and hold it in place while the occlusal excursions are evaluated. The wire is attached only to the lingual fossa of each tooth. After the position of the wire has been determined, it is removed, and only the enamel in the fossae (not the marginal ridges or embrasures) is etched, rinsed, and dried.

Light-cured composite is best used for attaching the fixed wire splint. The wire is repositioned and held in place with dental tape, while a sparing amount of resin-bonding agent is applied and lightly blown with air. After polymerization of the adhesive, a small amount of composite material is placed to encompass the wire in each fossa and bond it to the enamel. The operator must be careful not to involve the proximal surfaces (see Online Fig. 21-3, D). After polymerization of composite, the occlusion is evaluated and adjusted, as needed, for proper centric contacts and functional movements.

This unique splint allows some physiologic movement of teeth, yet it holds them in the correct position. The splint should remain in place for at least 6 months to ensure stabilization. Longer retention may be necessary, depending on the individual situation and recommendations of the orthodontist.

Avulsed or Partially Avulsed Teeth

Facial injuries often involve the hard and soft tissues of the mouth. The damage may range from lacerations of soft tissue to fractures of teeth and alveolar bone. Partial or complete...
avulsion of teeth can occur. Maxillary central incisors are involved more often than are other teeth. A thorough clinical examination of soft tissue, lips, tongue, and cheeks should be made to locate lacerations and embedded tooth fragments and debris. Radiographic examination is necessary to diagnose deeply embedded fragments or root fractures.

Treatment of soft tissue lacerations should include lavage, conservative debridement, and suturing. Consultation with or referral to an oral surgeon may be necessary. A partially avulsed tooth is repositioned digitally and may or may not need splinting. Traumatically avulsed teeth that are reimplanted immediately or within 30 minutes have a good prognosis for being retained. After 30 minutes, the success rate declines rapidly. The avulsed tooth should be repositioned as soon as possible. In the interim, it should be placed in a moist environment such as saliva (i.e., held in the cheek or under the tongue), milk, saline, or wet towel. The replacement of avulsed teeth has immediate psychological value and maintains the natural space in the event that a fixed prosthesis is required later.
cause malpositioning of the loose teeth. The occlusion should be evaluated to ensure that the teeth are properly positioned.

The facial surfaces of the crowns are quickly cleaned with hydrogen peroxide, rinsed, and dried by blotting with a gauze or cotton roll or by lightly blowing with air. The dentist should avoid blowing air into areas of avulsion or deep wounds to prevent air emboli. If a crown is fractured, any deeply exposed

**Technique**

The maxillary right incisors that were completely avulsed in an accident (Online Fig. 21-4, A) are repositioned immediately. After the teeth are repositioned, radiographs reveal that no other complications exist. Isolation with cotton rolls or gauze is preferable to the use of a rubber dam, which could

Online Fig. 21-2, cont’d  

G, A fiber-reinforcing strip is pressed into the uncured composite on lingual with a gloved finger. H, The bonded strip is covered incrementally with flowable composite. I and J, Completed fiber-reinforced composite-bonded periodontal splint seen from facial and lingual views.

Online Fig. 21-3  

Conservative Bridges

In selected cases, conservative bridges can be made by acid-etching enamel and bonding a pontic to the adjacent natural teeth. These conservative bridges are classified according to the type of pontic: (1) natural tooth pontic, (2) denture tooth pontic, (3) porcelain-fused-to-metal pontic or all-metal pontic with metal retainers, and (4) all-porcelain pontic. Although the four types differ in the degree of permanency, they share a major advantage—conservation of the natural tooth structure. In addition, they can be viable alternatives to conventional fixed bridges in circumstances where age, expense, and clinical impracticality are considerations.

Because of the conservative preparation and bonded nature of all of these bridge types, retention is never as strong as in the case of a conventional bridge. As part of informed consent, patients should be told of the risk, although remote, of swallowing or aspirating bonded bridges that are dislodged. To reduce the risk of dislodgment, patients should be cautioned not to bite hard foods or objects with bonded bridge pontics.

The ideal site for a conservative bridge is where the edentulous space is no wider than one or two teeth. Other considerations include bite relation, oral hygiene, periodontal condition, and extent of caries, defects, and restorations in the abutment teeth. Conservative bridges are especially indicated for young patients because the teeth usually have large pulp chambers and short clinical crowns. Many older patients with gingival recession and mobile teeth are prime candidates because splinting can be incorporated with the bridge. More specific indications and clinical procedures for each of the four types of bridges are presented in the following sections.

Natural Tooth Pontic

The crowns of natural teeth (primarily incisors) often can be used as acid-etched, resin-bonded pontics. Considerations for this type of treatment include the following: (1) Periodontally involved teeth warrant extraction, (2) teeth have fractured roots, (3) teeth are unsuccessfully reimplanted after avulsion, and (4) root canal treatment has been unsuccessful. However lost, the immediate replacement of a natural anterior tooth has great psychological value for most patients, although the procedure may be temporary. Natural tooth pontics also can be placed as interim restorations until an extraction site heals if conditions require a conventional bridge or an implant.

Certain prerequisites must exist to ensure a successful result: (1) The extracted tooth and abutments must be in reasonably good condition, especially the pontic, because it may become brittle and more susceptible to fracture; (2) the abutment teeth should be fairly stable; and (3) the tooth to be replaced because a pontic must not participate in heavy centric or functional occlusion. Because of this third restriction, canines and posterior teeth are not usually good candidates for this procedure. If the adjacent teeth are mobile, it is frequently necessary to secure them by splinting with composite (see the section on acid-etched, resin-bonded splints).
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**Technique**

A maxillary right central incisor must be extracted for periodontal reasons (Online Fig. 21-5, A and B). Before the tooth is extracted, a small, round bur is used to place a shallow identifying mark on the facial surface to indicate the level of the gingival crest. After extraction, a 2 × 2 inch (5 × 5 cm) sponge is held in the space with pressure for hemorrhage control.

By using a separating disk or a diamond instrument, the extracted tooth is transversely cut a few millimeters apical to the identification mark. When pontic length is determined, shrinkage of the healing tissue underlying the pontic tip must be anticipated. The root end is discarded.

If the pulp canal and chamber have completely calcified, the next procedure is shaping and polishing the apical end of the natural tooth pontic as described in the following paragraphs. If the chamber is calcified as disclosed on the radiograph and the canal is nearly calcified, the canal is opened from the apical end by using a small round bur or diamond to the extent of the canal. The operator should be as conservative of the tooth structure as possible and yet provide access for subsequent injection of the composite material to fill the canal. A large chamber and canal are instrumented and debrided using conventional endodontic procedures with access from the apical end (see Online Fig. 21-5, C). Access is provided for subsequent injection of composite. Removal of the pulpal tissue in this manner prevents discoloration of the tooth caused by degeneration products. Traditional lingual access for instrumentation is avoided to prevent weakening the pontic. After these procedures, the canal (and chamber, if present) is filled and closed with self-cured or light-cured composite. Light-cured materials must be placed incrementally to ensure complete polymerization.

After composite has been polymerized, the apical end is contoured to produce a bullet-shaped ovate design (see Online Fig. 21-5, C). This design provides adaptation of the pontic tip to the residual ridge, and yet it allows the tissue side of the pontic tip to be cleaned with dental floss. It is also the most esthetic pontic tip design that can be used. While being contoured, the tip is occasionally evaluated by trying the pontic in the space. In the maxillary arch, passive contact between the pontic tip and the healed residual ridge is considered ideal for maximal phonetic and esthetic potential. In the mandibular arch (where esthetics is not generally a problem), the pontic tip is best shaped into the same bullet-shaped design but positioned as a hygienic pontic type that does not contact tissue (Online Fig. 21-6, A). The pontic tip is smoothed and polished using a proper sequence of abrasive disks or polishing points. A polished pontic tip not only is easier to clean but also retains less plaque.

Usually, a rubber dam is needed for isolation of the region to prevent seepage of blood and saliva. Isolation using cotton rolls and gingival retraction cords is acceptable if the
hemorrhage has been controlled. Any carious lesions or faulty proximal restorations on involved proximal surfaces of the pontic and the abutments are restored with light-cured composite (preferably the same material to be used subsequently for the bridge connectors) by using modified preparation designs. It is recommended that the resulting restored surfaces be under-contoured rather than over-contoured to facilitate positioning of the natural tooth pontic.

Next, the involved proximal surfaces on the abutment teeth and the pontic are roughened with a coarse, flame-shaped diamond instrument. Spaces of approximately 0.5 mm should exist between the pontic and the abutment teeth because stronger connectors are provided by the additional bulk of the composite material. Now, the operator should acid-etch, rinse, and dry all the prepared (i.e., roughened) surfaces (see Online Fig. 21-5, D).

Light-cured composite is preferred for bonding natural tooth pontics because the extended working time allows the operator to contour the connectors before polymerization. First, the adhesive is applied to the etched surfaces of the pontic and lightly blown with air to remove the excess. Then it is polymerized by application of light, and the pontic is set aside (ready for bonding in the mouth). Next, the adhesive is applied to the etched surfaces of the abutment teeth and cured. A small amount of composite material is placed on the proximal contact areas of the natural tooth pontic, and the pontic is inserted carefully in the proper position in the mouth. The composite is shaped around the contact areas with an explorer tip. After final verification that the pontic position is correct, composite is polymerized with light. Next, additional composite is applied in the proximal areas (more material is added on the lingual than on the facial surface), contoured, and cured. Adequate gingival embrasures must be provided to facilitate flossing and ensure gingival health. After sufficient material has been added and polymerized, the embrasure areas should be shaped and smoothed with carbide finishing burs or fine diamonds and polishing disks or points. The rubber dam is removed, and the occlusion is evaluated for centric contacts and functional movements. Heavy contacts on the pontic or the connector areas must be adjusted. The finished bridge immediately after bonding is illustrated in Online Figure 21-5, E. The patient should return in 4 to 6 weeks for evaluation of the relationship of the pontic tip to the tissue. Passive contact should exist between the pontic tip and the underlying tissue to prevent ulceration. If tissue ulceration is present, the pontic must be removed, recontoured, and rebonded. The finished bridge and healed residual ridge are shown in Online Figure 21-5, F.

As stated earlier, abutment teeth that are mobile often can be splinted with composite to afford stability to periodontally involved teeth. The abutments are isolated, roughened, and acid-etched (Online Fig. 21-7, A). Because esthetics is not as crucial, a hygienic pontic tip is recommended for mandibular incisors (see Online Fig. 21-6, A). The finished bridge splint is illustrated in Online Figure 21-7, B.

### Denture Tooth Pontic

An acrylic resin denture tooth can be used as a pontic for the replacement of missing maxillary or mandibular incisors by using the acid-etch, resin-bonding technique (Online Fig. 21-8, A through H). Although this type of bridge is sometimes used as an interim prosthesis and is called temporary bridge, it can be a viable alternative to a conventional bridge and may last for years in some circumstances. As with the natural tooth pontic, the major contraindications to this type of resin-bonded bridge are abutment teeth that have extensive caries, restorations, or mobility or a pontic area that is subjected to heavy occlusal forces. In the illustrated example, the permanent maxillary right lateral incisor is missing, and the adjacent teeth are in favorable condition and position (see Online Fig. 21-8, A). Further examination reveals an ideal situation for a conservative bridge that uses a denture tooth pontic.

### Technique

Although the entire procedure can be completed at chairside in one appointment, considerable time can be saved by an indirect technique. During the first appointment, the shade (see Online Fig. 21-8) and mold of the denture tooth are selected, and alginate impressions are made. In the laboratory, stone casts are poured, and the ridge area is relieved slightly and marked with a soft lead pencil. As the pontic is trial positioned, the pencil markings rub off onto its tip to facilitate contouring of this area (see Online Fig. 21-8, C). Countouring is best accomplished with acrylic burs and a Burlew wheel in a straight handpiece. The tissue side of the pontic should be contoured to a modified ridge lap configuration that is convex mesiodistally and slightly concave faciolingually (see Online Fig. 21-6, B). This type of design not only allows the pontic tip to adapt to the residual ridge, but it also allows for effective cleaning with dental floss. After it is contoured, the pontic tip should be smoothed and highly polished with pumice and an acrylic-polishing agent (see Online Fig. 21-8, D).

Because composite does not normally bond to acrylic resin, provisions must be made to facilitate a strong connection between the pontic and the adjacent teeth. One provision may be completed in the laboratory by preparing large Class III conventional preparations in the pontic that mechanically retain the composite material. The outline of the preparations...
must be large enough to provide adequate surface area of the composite restoration for bonding to the adjacent teeth (see Online Fig. 21-8, E through G). An appropriately sized round bur (No. 2 or No. 4) is used to cut each preparation to a depth of approximately 1.5 mm and extend the outline approximately 0.5 mm past the contact areas into the gingival, incisal, and facial embrasures. Even more extension should be made into the lingual embrasure to provide for bulk of composite material in the connector areas. The lingual extensions should not be connected because this unnecessary step would unduly weaken the pontic. Mechanical undercuts are placed at the incisal and gingival line angles with a No. 12 bur to lock the composite material (to be inserted later in the technique) mechanically in the acrylic resin pontic (see Online Fig. 21-8, G and H).

At the next appointment, the pontic is tried in place to confirm that the shade and contours are correct. Approximately 0.5 mm of space should exist between each proximal “contact” and the abutment tooth. The pontic is cleaned with acetone to remove dust and debris. Retention of the pontic by undercuts, as previously described, also can be augmented by a second provision—the conditioning of the proximal aspects of the pontic with two applications of ethyl acetate, a polymer softener. A thin layer is applied in the Class III preparations and on the cavo-surface areas and allowed to dry for 5 minutes. This process is repeated to ensure optimal bonding. The preparations are filled with the same light-cured composite material expected to be used for bonding the pontic in place. The composite should be applied and cured in the retentive areas before the remainder of the preparation is filled. This step ensures complete polymerization. After the entire preparation is filled, it should be polymerized again with the light source. It is better to leave the contact areas slightly under-contoured for the pontic to fit easily between the abutment teeth. The pontic is set aside in a safe place for some time.

Isolation of the abutment teeth should be accomplished with cotton rolls and retraction cords (rather than with a rubber dam) to relate the pontic better to the residual ridge area. Any caries or old restorations in the adjoining proximal areas of the abutment teeth should be removed at this time, and any indicated liners should be applied. The proximal surfaces of the abutment teeth are roughened with a coarse flame-shaped diamond instrument. This step is followed by acid-etching, rinsing, and drying. The adhesive is applied, lightly blown with air, and cured. Tooth preparations, if present, are restored with the same composite material.
Care is taken not to over-contour the restoration or restorations.

The pontic is evaluated by positioning it temporarily in the edentulous space. If adjustments are made, the surfaces should be cleaned with acetone. Next, a small amount of composite is wiped onto the contact areas (mesial and distal) of the pontic, and the pontic is placed into the proper position between the abutment teeth. An explorer tip is helpful in placing the material evenly around the contact area. Care must be taken to place the pontic so that it lightly touches the ridge, but does not cause tissue blanching. The composite material used to position the pontic is polymerized. It is helpful to add and cure the additional composite in small increments to obtain the correct contour and minimize finishing procedures. The facial, incisal, and gingival embrasures should be defined with a flame-shaped finishing bur or fine diamond and polished with appropriate disks or points. The lingual aspect of the bridge is contoured with a round finishing bur without defining lingual embrasures because this could weaken the connectors. The retraction cords are removed from the gingival crevice. Articulating paper is used to mark the occlusion, and any offensive contacts are removed. The final restoration is shown in Online Figure 21-8, I.

Porcelain-Fused-to-Metal Pontic or All-Metal Pontic with Metal Retainers

A stronger and more permanent type of acid-etched, resin-bonded bridge is possible by use of a cast metal framework. In anterior areas where esthetics is a consideration, the design of the bridge includes a porcelain-fused-to-metal (PFM) pontic with metal winged retainers extending mesially and distally for attachment to the proximal and lingual surfaces of the abutment teeth. In posterior areas where esthetics is not a critical factor, the bridge can have either a PFM or an all-metal pontic. The technique is more complicated and time-consuming than the previously described methods because it requires some initial tooth preparation, an impression, laboratory procedures, and a second appointment for etching and bonding. Compared with conventional bridges, resin-bonded bridges of this type offer five distinct advantages:

1. Anesthesia is usually not required.
2. The tooth structure is conserved (i.e., no dentin involvement).
3. Gingival tissues are not irritated because margins usually are not placed subgingivally.
4. An esthetically pleasing result can be obtained more easily.
5. The cost is lower because less chair time is required, and laboratory fees are lower as well.

Ideally, this type of conservative bridge is used for short spans in the anterior or posterior areas with sound abutment teeth in good alignment. The most favorable occlusal relationship exists where little or no centric contact and only light functional contact are present. However, teeth can be prepared and the bridge framework designed to withstand moderately heavy occlusal forces. Orthodontics may be required to improve tooth alignment. The bridge also can be extended to splint adjacent periodontally involved teeth. Surgical crown-lengthening procedures sometimes are indicated for teeth with short clinical crowns.

Although minimal, some preparation of the enamel of the abutment teeth is mandatory in the retainer area of the bridge to (1) provide a definite path of insertion or seating or both, (2) enhance retention and resistance forms, (3) allow for the thickness of the metal retainers, and (4) provide physiologic contour to the final restoration. The importance of the tooth preparation design cannot be overemphasized. The success of these types of bridges depends on the preparation design. The bridges must be independently retentive by design and cannot rely solely on resin bonding for retention. Preparation design for these types of bridges is similar to that for a cast three-quarter crown; however, it is restricted to enamel.

The preparation for each abutment varies, depending on the individual tooth position and anatomy. Approximately the same amount of surface area should be covered on each abutment tooth. In some situations, recontouring of the adjacent and opposing teeth may be indicated. The details of the preparations are described later.

Two primary types of resin-bonded bridges with metal retainers currently exist: (1) Rochette and (2) Maryland. Each type has advantages and disadvantages. The Rochette type uses small countersunk perforations in the retainer sections for retention and is best suited for anterior bridges (Online Fig. 21-9, A). Care must be exercised in placing the perforations to prevent weakening the framework. Perforations that are too large or too closely spaced invite failure of the metal retainer by fracture. The perforations should be approximately 1.5 to 2 mm apart and have a maximum diameter of 1.5 mm on the tooth side. Each hole is countersunk so that the widest diameter is toward the outside of the retainer. When the bridge is bonded with a resin cement, it is

Online Fig. 21-9  Acid-etched, resin-bonded metal bridges. A, Rochette type. B, Maryland type. C, Scanning electron micrograph of etched metal surface. (Courtesy of Dr. John Sturdevant.)
mechanically locked in place by microscopic undercuts in the etched enamel and the countersunk holes in the retainer (Online Fig. 21-10, A).

The advantages of this design include the following:

- It is easy to see the retentive perforations in the metal.
- If the bridge must be removed or replaced, the bonding medium can be cut away in the perforations to facilitate easy removal.
- No metal etching is required.

The disadvantages of this design include the following:

- The perforations, if improperly sized or spaced, could weaken the retainers.
- The exposed resin cement is subject to wear.
- It is not possible to place perforations in proximal or rest areas.

A second type of cast metal framework, commonly known as the Maryland bridge, is reported to have improved bonding strength (see Online Fig. 21-9, B). Instead of perforations, the tooth side of the metal framework is electrotytically or chemically etched, which produces microscopic undercuts (see Online Fig. 21-9, C). The bridge is attached with a self-cured, resin-bonding medium that locks into the microscopic undercuts of the etched retainer and the etched enamel (see Online Fig. 21-10, B). It can be used for anterior and posterior bridges. Although this design has been reported to be stronger, it is more technique sensitive because the retainers may not be properly etched or may be contaminated before cementation. Because the retentive features cannot be seen with the unaided eye, the etched metal surfaces must be examined under a microscope to verify proper etching (minimum magnification).

More recently, Maryland bridges have been fabricated with no electrolytic etching of the surface and chemically bonded to the tooth after a process called silicoating or with a 4-META or phosphate ester-containing, resin-bonding medium. Resin materials containing 4-META or other resin monomers are capable of strongly bonding to metal surfaces. Surface roughening with microetching (i.e., sandblasting) is commonly used in conjunction with these adhesive cements. These types of Maryland bridges are referred to as adhesion bridges and differ only in the means of retention. The design of adhesion bridges is the same for this alternative Maryland bridge design. Successes and failures have been observed with both bonded bridge designs. Because the procedures are technique sensitive, every step must be followed carefully.

**Maxillary Anterior Bridge**

In Online Figure 21-11, A, a maxillary lateral incisor is congenitally missing, and the teeth on either side are sound. The occlusion is favorable, and no periodontal problems are present (see Online Fig. 21-11, B). The patient has been wearing a removable partial denture that is undesirable. Radiographs and study casts are made to complete the diagnosis and to facilitate preparation design. The outline of the proposed preparation is penciled on the cast to cover as much enamel surface as possible for maximal bonding area but with the following two stipulations: (1) The lingual portions are extended neither subgingivally nor too far incisally; and (2) the proximal portions are not extended facially of the contact areas but enough to allow preparation of retention grooves (see Online Fig. 21-11, C and E).

Before tooth preparation, the dentist cleans the teeth, selects the shade of the pontic, and marks the occlusion with articulating paper to evaluate centric contacts and functional movements. If adjustment or recontouring of the abutment teeth is indicated, it should be accomplished at this time. When a base metal alloy rather than a high-gold alloy is used for the bridge framework, less tooth structure is removed because the metal retainers can be made thinner. Base metal alloys have superior tensile strength.

**PREPARATION**

Several depth cuts (0.3–0.5 mm) are made in the enamel with a small, round, coarse diamond instrument (1–1.5 mm in diameter). The depth cuts are joined with the same instrument or a round diamond instrument (see Online Fig. 21-11, D). A large surface area (i.e., outline form) is desirable to obtain maximum bonding and strength of the bridge. A shallow groove is cut in the enamel of each proximal portion of the preparations with a small, tapered, cylindrical diamond instrument to establish a path of draw in an incisal direction. This feature provides a definite path of insertion and positional stability for the prosthesis during try-in and bonding (see Online Fig. 21-11, E). In addition, the retention of the bridge is improved because a shear force is required to unseat the bridge. Online Figure 21-11, E, illustrates this groove on the working cut.

The dentist makes an elastomeric impression of the completed preparations and a bite registration. The patient continues to wear the partial denture as a temporary prosthesis. A small amount of self-curing acrylic resin is added to the
occlusion. Adjustments are made, and the bridge is returned to the laboratory for corrections (if needed), glazing, and polishing of the metal framework. Online Figure 21-11, F and G, shows the completed bridge from facial and lingual views. H, Teeth isolated with a gingival-retraction cord and cotton rolls. Preparations are etched and ready for bonding. I, Holding the bridge in place during polymerization. Bonded bridge: facial view (J) and lingual view in mirror (K).

mesial and distal portions of the removable partial denture tooth to maintain proximal relationships.

LABORATORY PHASE
The impression, bite registration, patient information, and instructions are sent to the dental laboratory. A perforated retention design (i.e., Rochette) is specified in this instance, although the other types could be used. The bridge is fabricated in the laboratory (porcelain contoured but unglazed, and perforations prepared in the retainers).

TRY-IN STAGE
During the initial try-in, the bridge is examined for proper shade, contour, tissue compatibility, marginal fit, and occlusion. The working cast shows the proximal groove prepared (a second groove is on mesial of canine) to establish path of insertion for prosthesis and provide positional stability and increase the retention form. E, The working cast shows the proximal groove prepared (a second groove is on mesial of canine) to establish path of insertion for prosthesis and provide positional stability and increase the retention form.

BONDING STEPS
The steps in bonding require an exacting coordination between the dentist and the assistant. All of the equipment and materials needed for isolation, etching, and bonding must be kept ready at the beginning of the appointment: prophylaxis angle handpiece; pumice slurry; self-curing resin cement kit with all accessories; plastic hand instrument; polyester strip; and cotton rolls. Alternatively, rubber dam isolation can be used;
it is particularly recommended for the placement of posterior bonded bridges.

The abutment teeth are cleaned with pumice slurry, rinsed, dried, and isolated with cotton rolls. If the cervical area of the retainer is subgingival, the dentist inserts a retraction cord in the gingival crevice to displace the tissue and prevent seepage. The bridge should be carefully tried in place to review the path of insertion and to verify the fit. On removal, the bridge is placed in a convenient location near where the resin-bonding medium will be mixed.

The dentist artfully applies the etching gel for 30 seconds to the prepared enamel and slightly past the margins. The acid must not be allowed to flow onto the unwetted proximal areas of the abutment or adjacent teeth. After rinsing, the teeth are dried of all visible moisture (see Online Fig. 21-11, I). If a lightly frosted surface is not present, the etching procedure is repeated. A clean, dry surface is absolutely essential. The slightest amount of saliva contaminates the etched enamel and necessitates an additional 10 seconds of etching, followed by rinsing and drying. A rubber dam is preferred for isolation; however, cotton rolls and gingival retraction cord provide adequate isolation in selected areas where salivary flow can be controlled.

The manufacturer’s instructions for the bonding procedure should be read and followed. Usually, equal parts of the resin cement (i.e., base and catalyst) are placed on one mixing pad, and equal parts of the adhesive (i.e., base and catalyst) are placed on another mixing pad. The operator mixes the adhesive with a small, foam sponge or brush and quickly paints a thin layer on the tooth side of the bridge and then onto the etched enamel. While the operator uses the air syringe to blow the excess adhesive off the bridge and then the enamel, the assistant mixes the resin cement and places a thin layer on the tooth side of the bridge retainers. The bridge is positioned on the abutment teeth and held in place with a polyester strip over the lingual surface. The retainers are seated and held firmly in place with the index fingers positioned on the strip over the lingual retainers, and the thumbs are held on the facial aspect of the abutment teeth to equalize the pressure (see Online Fig. 21-11, J). The amount of resin cement at the facial and gingival embrasures is quickly inspected. Sometimes, the assistant may need to add more cement or remove excess unpolymerized resin with an explorer or plastic instrument. Priority is given to the gingival embrasure because later correction is more difficult in this area.

**FINISHING PROCEDURE**

After the resin cement has hardened, the dentist removes the polyester strip and inspects the lingual area. If voids are present, more resin is mixed and added. Additions bond to the previously placed resin cement without additional surface treatment. The dentist removes excess resin along the lingual margins with a discoid–cleoid hand instrument, evaluates the occlusion, and makes any necessary adjustment. Contouring and polishing are accomplished in the usual manner with carbide finishing burs, fine diamonds, hand instruments, and disks. A completed Rochette-type bridge is shown in Online Figure 21-11, J and K, as viewed from the facial and lingual aspects. When the bridge is complete, the patient is instructed on how to use a floss threader and dental floss to clean under the pontic and around the abutment teeth. Another example of an anterior resin-bonded bridge replacing both maxillary central incisors is shown in Online Figure 21-12.

**Mandibular Anterior Splint-and-Bridge Combination**

An indication for a conservative bridge that incorporates a splint design of the PFM framework is illustrated in Online Figure 21-13. The patient’s mandibular central incisors were extracted because of advanced periodontal disease. The weak lateral incisors are stabilized by including the canines in a splint-and-bridge design. These teeth are caries-free and have no restorations. An ill-fitting removable, partial denture was uncomfortable and did not support the adjacent teeth (see Online Fig. 21-13, A and B).

The preparations for the splint-and-bridge combination consist of removing approximately 0.3 mm of enamel on the lingual aspect of the lateral incisors and canines (as outlined on the laboratory cast) and preparing proximal retention grooves (see Online Fig. 21-13, C). The perforated design of the winged retainers was the Rochette type for ease of replacement or repair (see Online Fig. 21-13, D and E). The splint bridge is bonded by the method previously described (see Online Fig. 21-13, F and G). The gingival aspect of the pontic is free of tissue contact and has sufficient space for cleaning. A similar splint also can be achieved with a Maryland bridge design.

**Mandibular Posterior Bridge with Metal-and-Porcelain Pontic**

In Online Figure 21-14, A, a missing mandibular first molar needs to be replaced to maintain proper occlusal contacts and to preserve the integrity of the arch. A clinical examination with radiographs confirms that the abutment teeth are in good alignment and are sound and that the occlusion is favorable. Conservative amalgam restorations have been inserted to correct the occlusal fissures on the abutment teeth. Impressions and a bite registration are made for study casts. An acid-etched, resin-bonded, cast metal bridge (Maryland type),
including a porcelain pontic with metal, occlusal, and centric stops, provides for optimal occlusal wear resistance and an acceptable esthetic result.

The dentist uses a surveyor to determine the most favorable path of draw and marks the outline of the retainer area with a pencil (see Online Fig. 21-14, B). The occlusal rest areas provide rigidity and resistance form to vertical forces, and the extensions on the facial and lingual surfaces provide a “wrap-around” design for added retention and resistance against lateral forces. In this example, the patient’s teeth have sufficient crown length to avoid subgingival margination.

**PREPARATION**

Prophylaxis, shade selection, and any needed occlusal adjustment are accomplished before the preparations are begun. As with the anterior teeth, some preparation is necessary to provide draw, to increase retention and resistance forms, and to provide bulk to the retainers for strength without overcontouring. Preparation is minimal and involves only enamel. Using the surveyed penciled cast as a reference, the dentist prepares the patient’s teeth with a coarse, tapered, rounded-end diamond instrument (see Online Fig. 21-14, C). The occlusal rests are prepared with a round diamond instrument. An elastomeric impression and a bite registration are made for laboratory use.

**LABORATORY PHASE**

The dentist includes a sketch of the bridge design with the laboratory instructions. The nonperforated, etched metal design (Maryland) is specified in this instance because the “wings” are very thin, and other areas of the bridge are inaccessible for placing perforations. It is helpful to the technician if the margins of the preparation are marked with an indelible pencil (see Online Fig. 21-14, D). Before any glazing of porcelain or polishing of framework or etching of metal, the bridge is returned to the dentist for the try-in stage (see Online Fig. 21-14, E).

**TRY-IN STAGE**

The dentist seats the bridge and evaluates for proper fit, occlusion, and color matching. After adjustments are made, the bridge is returned to the laboratory for corrections, final glazing, polishing of the metal framework, and etching or other metal treatment procedures. The etched metal must be examined under a microscope to ensure that proper etching of the metal has occurred.

**BONDING STEPS**

Care must be exercised in handling the bridge because the etched area can be contaminated easily. The bridge should not...
be tried in place (again) until teeth are isolated, and enamel has been etched (see Online Fig. 21-14, F). Rubber dam isolation is preferable when bonding mandibular resin-bonded bridges. Cotton roll isolation can be used with retraction cords if a rubber dam cannot be placed. Being careful not to touch or contaminate the etched metal, try-in of the bridge is done to verify fit and path of draw. Everything must be “ready to go” as the manufacturer’s instructions are followed for mixing and applying the bonding materials to teeth and the bridge. The preparations must be clean and dry to ensure proper bonding. When the bridge is in place, a polyester strip is placed over the pontic, and finger pressure is used to secure the bridge until polymerization is complete. After removal of the excess resin, the occlusion is evaluated. The occlusal and facial views are esthetic with only the centric contacts in metal (see Online Fig. 21-14, G and H). Another example of a posterior, resin-bonded, Maryland-type bridge is shown in Online Figure 21-15.

**Maxillary Bridge with Porcelain-Fused-to-Metal Pontic**

Online Figure 21-16, A, illustrates a space resulting from the extraction of a maxillary second premolar. As with the mandibular bridge, resistance to lateral forces must be provided by the design of the preparations and resulting prosthesis.
Because esthetics is more critical in the maxillary arch, however, the wrap-around design used in the mandibular arch cannot be employed to as great an extent, especially in the area adjacent to the facial aspect of the pontic. Proximal grooves are prepared (in enamel) in the same occlusogingival orientation as the path of draw to provide additional resistance form to lateral forces. The lingual extensions and occlusal rests are prepared as described for the mandibular bridge (see Online Fig. 21-16, B and C). For retention, perforations in the retainer (e.g., Rochette design) are used in addition to acid-etching the preparations. Perforations are placed in the accessible lingual extensions. This design aids in removing the bridge if replacement becomes necessary (see Online Fig. 21-16, D). The etched preparations, which are ready for bonding, are illustrated in Online Figure 21-16, E. The completed bonded bridge is shown in Online Figure 21-16, F.

**Mandibular Posterior Bridge with Metal Pontic**

Online Figure 21-17, A, illustrates a space between the mandibular premolars resulting from extraction of the permanent first molar at an early age and subsequent distal migration of the second premolar. Because esthetics was not a factor, an all-metal bridge (e.g., Maryland type) with a hygienically designed pontic was used. The steps are identical to the steps for the mandibular posterior bridge with a PFM pontic (as discussed earlier). The bridge is shown in Online Figure 21-17, B and C, after several years of service.

**All-Porcelain Pontic**

Improvements in dental porcelains along with the capacity to etch and bond strongly to porcelain surfaces have made all-porcelain pontics a viable alternative to pontics with metal winged retainers (e.g., Maryland and Rochette bridges). Although all-porcelain pontics are not as strong as pontics with metal retainers, far superior esthetic results can be achieved because no metal substructure or framework is present. All-porcelain pontics often can be used when tooth anatomy precludes or restricts the preparation and placement of a metal winged pontic. Long, pointed canines with proximal surfaces exhibiting little occlusogingival height often lack adequate areas for the placement of retention grooves. Anterior teeth that...
are notably thin faciolingually also are not good candidates for metal, resin-bonded bridge retainers and often are esthetic failures because of metal showing through the tooth. In both instances, custom-fabricated, etched porcelain pontics frequently can provide an esthetic, functional alternative.

All-porcelain pontics are particularly indicated in adolescents and young adults, in whom virgin, unrestored teeth are often encountered. Because teeth are not extensively prepared, this procedure is almost entirely reversible. This is a major benefit in young patients, where all-porcelain pontics can be placed as interim restorations until implants or a more permanent prosthesis can be placed at an older age. Because of their limited strength, all-porcelain pontics should be considered provisional in nature, similar to the natural tooth pontic and the acrylic denture tooth pontic.

Similar to the natural tooth and denture tooth pontics, certain prerequisites must be met to ensure a successful result. First, the abutment teeth must be in reasonably good condition with proximal enamel surfaces that are intact or contain very small composite restorations. Second, the abutment teeth should be stable with little mobility present. If the abutment teeth are mobile, it is frequently necessary to secure them as well by splinting with composite to adjacent teeth before placement of the bonded pontic (see the section on acid-etched, resin-bonded splints). Third, the pontic must not be placed in a position that would subject it to heavy centric or functional occlusal contacts. Because of these occlusion concerns, canines and posterior teeth are not usually good candidates for these types of resin-bonded bridges.

**TECHNIQUE**

Online Figure 21-18, A and B, illustrates a typical case of congenitally missing lateral incisors in which tooth contours contraindicated the use of resin-retained bridges with metal retainers. Central incisors are very translucent, and the mesial contours of canines are deficient (see Online Fig. 21-18, C and E). After assessing centric and functional occlusions, it was determined that all-porcelain pontics could be placed without subjecting them to heavy occlusal forces. At the first appointment, the involved abutments are cleaned with flour of pumice, and an accurate shade selection is made, noting any desired color gradients or characterizations.

No preparation of the teeth is recommended, unless the proximal surfaces of the abutment teeth adjacent to the edentulous space are markedly convex. In such cases, slight flattening of the proximal surfaces with a diamond instrument facilitates closer adaptation of the pontic to the abutment teeth, increasing strength of the connectors. Otherwise, no retentive features are recommended for the preparation in the abutment teeth; the connector areas are entirely made of composite.

Bridge connectors composed of porcelain are subject to eventual fatigue fracture, after which repair is made more difficult. Studies show that “veneer bridges” (i.e., all-porcelain pontics retained by adjacent etched porcelain veneers), in particular, are the weakest design of all and should be avoided. These types of bridges not only provide little bond strength to the pontic but also needlessly cover adjacent, healthy facial tooth surfaces. All-porcelain pontics (composite used for bonding to the abutment teeth) are similar to extracted natural tooth pontics in this regard. Those that have connector areas consisting of the design feature allow for easy repair and replacement of the composite connector should a fracture in this area be encountered.

If high-strength ceramics that are totally immune to crack propagation and cohesive fracture are developed, retentive features prepared in the adjacent abutment teeth may be desired. These features, prepared in enamel, would consist of proximal grooves or boxes, depending on the faciolingual dimension of the proximal surfaces. In the absence of such totally fracture-resistant ceramics, however, all-porcelain pontics are best placed with composite connectors for ease of repair and replacement.

An elastomeric impression is made, and a working cast is generated from it. A modified ridge lap pontic tip design as previously described (see Online Fig. 21-6, B) is recommended. An occlusal bite registration should be made and forwarded to the laboratory so that the occlusal relationship can be considered during fabrication of all-porcelain pontics. The proximal surfaces of the pontics are etched with hydrofluoric acid. The area etched must include all areas anticipated for bonding to the composite-bonding medium. The etched proximal surfaces should extend just beyond the lingual line angles so that additional composite can be placed in the lingual embrasure areas for additional connector strength.

At the subsequent appointment, teeth are isolated with cotton rolls. A 2 × 2 inch (5 × 5 cm) cotton gauze is placed across the back of the patient’s mouth to act as a protective shield should the pontic be inadvertently dropped. A rubber dam is not recommended for this procedure because it precludes accurate assessment of the adaptation of the pontic tip to the residual ridge.

Before the teeth dehydrate, the position of each pontic is tested in the edentulous space to assess the shade and relationship of the pontic tip to the residual ridge. The pontic tip should contact the residual ridge passively with no blanching of the underlying tissue evident. Spaces of approximately 0.3 to 0.5 mm should exist between the pontic and the abutment teeth because stronger connectors are provided by the additional bulk of composite material. Care must be taken not to allow contamination of the etched pontic from saliva to occur during the try-in phase. If saliva contamination occurs, the etched proximal surfaces of the pontic must be cleaned thoroughly with alcohol and dried. After try-in, all etched proximal surfaces of the porcelain pontics are primed with a suitable silane-coupling agent (see the manufacturer’s instructions for the specific technique). The pontics are now ready for bonding.

The involved proximal enamel surfaces of the abutment teeth are roughened with a coarse, flame-shaped diamond instrument. Thereafter, all of the prepared (i.e., roughened) enamel surfaces should be acid-etched, rinsed, and dried. Care must be taken to maintain clean, dry, uncontaminated etched surfaces until the pontic is positioned and bonded. The abutment teeth are now ready for bonding.

A light-cured composite is preferred for bonding all-porcelain pontics because the extended working time allows the operator to contour the connectors initially before polymerization. The dentist applies the adhesive to the etched surfaces of the porcelain pontic and the abutment teeth and lightly blows with air to remove the excess. A 20-second application of light from the light-curing unit is used to polymerize the bonding agent on each etched surface.
Online Fig. 21-18. All-porcelain pontics. A and B, Patient with congenitally missing lateral incisors. C and D, Right side before and after treatment. E and F, Left side before and after placement of all-porcelain pontic. G, Lingual view of completed bridges. H, Facial view of all-porcelain pontics.
A small amount of composite material is placed on the proximal contact areas of the natural tooth pontic, and the pontic is inserted carefully into the proper position in the edentulous space. A stent, or index, made from bite registration material or fast-setting plaster can be used to position the pontic, if desired. Positioning by hand is recommended, however, so that optimal gingival pressure can be maintained for best tissue adaptation. The dentist shapes the excess composite extruding from the connector areas around the contact areas with an explorer tip or small plugger end of a composite instrument. After final verification that the pontic position is correct, the composite is polymerized with light for a minimum of 40 to 60 seconds each from facial and lingual directions (for a total of 80–120 seconds).

Additional composite is applied in the proximal areas (more material is added on the lingual surface than on the facial surface), contoured, and polymerized. Adequate gingival embrasures must be maintained to facilitate flossing and ensure good gingival health. After sufficient material has been added and polymerized, the dentist shapes and smooths the embrasure areas with carbide finishing burs, fine diamonds, and polishing disks. Facial embrasures are defined for esthetics, but lingual embrasures are closed with composite to strengthen the connectors (see Online Fig. 21-18, D, F, and G).

The dentist evaluates the occlusion centric contacts and functional movements. Heavy contacts on the pontic or the connector areas must be adjusted. The finished bridges (immediately after bonding) are illustrated in Online Figure 21-18, D, F through H. As with all resin-bonded bridges, patients must be advised to avoid biting into hard foods or objects to reduce the risk for dislodgment. Also, as noted earlier, the patient must be advised, as part of informed consent, that although the chances are remote, the potential for dislodgment and the risk of swallowing or aspirating the pontic do exist. This possibility exists for all resin-bonded bridges, and patients must be warned of this hazard, even though the risk is minimal.

References