Resin-bonded prostheses
Adrian U. J. Yap*/Alastair N. S. Stokes**

This article reviews the uses, advantages, and disadvantages of the different types of resin-bonded prostheses. Resin-bonded prostheses can be used for tooth replacement as well as for occlusal, cosmetic, and orthodontic/periodontic therapy. Proper case selection is essential to their success. Although long-term clinical studies are not available for some of these types of prosthesis, they are generally promising and have become important elements in the provision of dental health care. (Quintessence Int 1995;26:521-530.)

Introduction

With the evolution of adhesive techniques, the interest in and usage of resin-bonded prostheses has grown substantially. Application of resin-bonded prostheses is no longer confined to tooth replacement and periodontal splints; they are now used as cosmetic veneers, and occlusal and orthodontic appliances are among the many recent innovative applications of the resin-bonding technique.

Resin-metal bond

Rochette1 pioneered the use of the acid-etching system to bond perforated gold frameworks to loose teeth. At about the same time, case reports described the bonding of natural teeth2 and resin pontics3,4 to make small resin-bonded prostheses. The Rochette bridge, first described by Howe and Denehy,5 combined the principle of bonding a perforated metal plate to etched natural teeth with the provision of one or more integrated pontics. They used a chemically cured dimethacrylate resin composite to bond a perforated nonprecious metal framework to acid-etched enamel. Retention of the framework was, however, limited to areas around the perforations; this retentive area, which was small compared to the resin-enamel interface, favored failure at the resin-metal region. In an attempt to eliminate the disadvantages of the perforated framework, several indirect techniques have been developed to increase the retentive area. These techniques, aimed at improving the resin-to-metal bond, can be divided into mechanical and chemical methods (Table 1). Such techniques have been adapted for use with single restorations, splints, and bite planes.

Table 1 Techniques used to enhance the resin-to-metal bond

<table>
<thead>
<tr>
<th>Mechanical</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micromechanical</td>
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<td>Macromechanical</td>
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<td>Tin plating16</td>
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</tbody>
</table>

Resin-porcelain bond

Porcelain veneers, inlays, and onlays, like resin-bonded metal prostheses, require specific treatment of
Table 2  Luting techniques for resin-bonded prostheses

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Treatment</th>
<th>Gold</th>
<th>Base metal alloys</th>
<th>Resin</th>
<th>Porcelain</th>
</tr>
</thead>
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<td>✓</td>
<td>✓</td>
<td>X</td>
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<td></td>
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<td>✓</td>
<td>✓</td>
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<tr>
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<td>Etching</td>
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</tr>
<tr>
<td></td>
<td>Steam cleaning</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td></td>
<td>Priming (silane treatment)</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Preparation of adherent</td>
<td>Isolation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td></td>
<td>Etching enamel and dentin'</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td></td>
<td>Washing and drying</td>
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<td>✓</td>
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</tr>
<tr>
<td></td>
<td>Applying unfilled resin</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Cementation</td>
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<tr>
<td></td>
<td>Chemically cured resin</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

✓ = yes; X = no.
* If total-etch system is followed.
+ Electrolytic/chemical etching.

Advantages of resin-bonded prostheses

One of the most important advantages of resin-bonded prostheses (fixed partial dentures, onlays, and veneers) is the minimal tooth preparation required. Standard crown preparations demand the removal of at least 1.5 to 2.0 mm of tooth tissue. In teeth with large pulp chambers or small dimensions (eg, mandibular incisors), this preparation may result in short- or long-term pulpal damage. Because of the minimal preparation required with resin-bonded prostheses, there is often no need for analgesia. Margins of such prostheses can often be kept supragingivally. This simplifies impression procedures and maintains an environment conducive to gingival health. Chairside time is therefore reduced. The various luting techniques for the different resin-bonded prostheses are indicated in Table 2.

Disadvantages of resin-bonded prostheses

The worst reported disadvantage of resin-bonded prostheses is that their failure rate is higher than that of conventional prostheses. It is not certain whether this reported difference is absolute or whether it represents (at least in part) the willingness of practitioners to provide resin-bonded prosthesis in circumstances in which they would not provide a conventionally cemented prosthesis. The reported survival rates of resin-bonded prostheses, however, vary widely; rates range from 74% to 95%. More long-term studies with larger sample sizes are required before comparisons between their longevity and that of conventional prostheses can be drawn.

Occlusal interferences are often introduced with resin-bonded fixed partial dentures, especially when the maxillary anterior teeth are involved, because it is often not possible to reduce the abutment teeth
sufficiently to allow for the thickness of the metal and yet preserve enamel for bonding. Occlusal adjustments usually can be done only after cementation of the prosthesis. However, the tensile bond strength of these bonded prostheses can be adversely affected by the heat or vibration produced during finishing and polishing. Unlike standard crown-and-bridge prostheses, no trial periods for esthetic, functional, or periodontal reasons are possible with resin-bonded prostheses. These problems may be overcome with the use of retentive framework designs that can be provisionally cemented to allow trial periods and occlusal adjustment.

Appearance can be a problem with resin-bonded prostheses because discrepancies in tooth size, position, color, or pontic space are not as easily compensated as with standard crowns and fixed partial dentures. There is also the possibility of graying of the abutment teeth, especially in the anterior region, when palatal metal frameworks of resin-bonded prostheses approach the incisal edge. Porcelain veneers, as currently fabricated, appear to suffer relatively few debonds. Their immediate difficulties lie in achieving correct shape and color within a very limited bulk; long-term, the quality of the resin bonding agents stands as an unknown factor.

Resin-bonded prostheses can be used for tooth replacement, cosmetic therapy, occlusal therapy, and orthodontic/periodontic therapy.

**Tooth replacement**

It must not be misconstrued that resin-bonded prostheses are a cheaper, faster, and simpler route to tooth replacements than conventional fixed partial dentures. Failures do occur, and, if the design is complex, tooth destruction can be as severe and subsequent treatment as costly as that caused by the loss of cementation of conventional units (Figs 1a and 1b). Creugers and Van'T Hof conducted an analysis of about 60 clinical studies on resin-bonded prostheses and concluded that the overall survival rates were 89% ± 1% at 1 year; 84% ± 1% at 2 years; 80% ± 1% at 3 years; and 74% ± 2% at 4 years. Creugers et al reported survival rates of 75% for anterior prostheses and 44% for posterior prostheses, in a 7.5-year follow-up of 203 resin-bonded prostheses. Maxillary anterior resin-bonded prostheses were more susceptible to failure than were mandibular resin-bonded prostheses. Electrolytically etched prostheses were found to be more retentive than perforated ones; the survival rates were 78% and 63%, respectively. Dunne and Millar reported that perforated retainers had a higher debond rate than did other retainer designs. In this study, splints were found to have a higher debond rate than simple fixed partial dentures, as did restorations placed in patients in the age group 11 to 20 years, restorations involving more than two abutment teeth, and restorations containing more than one tooth pontic. Williams et al however, found little difference between electrolytically etched and perforated retainers and reported a general debond rate of 31% over a period of 10 years.
Dislodged and rebonded resin-bonded prostheses have a lower retention rate than do original bonded prostheses. To reduce failures, case selection, prosthesis design, and laboratory and clinical techniques should be executed carefully. Resin-bonded prostheses should be avoided when enamel is inadequate for bonding; esthetic problems are associated with abutment teeth in terms of position, color, and alignment; parafunctional activities are present; undesirable occlusal relationships are present; or the patient indulges in contact sport. Resin-bonded prostheses should be designed to ensure a maximal area of bonding of retainers to enamel. Framework designs should also mechanically engage each abutment and have a distinct path of insertion to limit the stresses placed on the luting agent and the bond. This is achieved by creating proximal resistance form (proximal wrap-around) and may be supplemented by the use of auxiliary retention. It is essential that the framework be rigid, particularly with increasing span and when it is not possible to control occlusal loads on the framework. All-porcelain resin-bonded prostheses have been introduced to improve esthetics, but long-term clinical studies of such prostheses are not available.

Decision making and occlusal planning are simplified by the use of diagnostic casts mounted on a semi-adjustable articulator. Trial preparations often help as well. The use of resin-bonded prostheses can be considered under the following situations.

No anterior guidance (open bite)

Flanges on abutments in such cases generally do not pose any problems. It is not essential that the flanges be extended to cover the incisal edges; thus, graying of these teeth is avoided. Occlusion should, however, be carefully examined to ensure that the flanges do not interfere with excursive movements. Phonetics should also be checked.

Shallow anterior guidance

If the path is less than a quarter of the clinical crown height, it is best not to alter the occlusal relationship. Rather, the margin of the flange should circumvent the contact areas, provided that this does not compromise the retention of the flange.

Moderate and large anterior guidance

If the path is greater than a quarter of the clinical crown height, space must be created to accommodate the flange either by removing enamel on the abutment teeth or trimming the opposing teeth. Point contacts should be achieved rather than broad contacts when the mandibular teeth are trimmed. It is preferable in such cases to extend the flange to the incisal edges although the appearance may be compromised. The problem of graying of the abutments can be reduced by cementation with an opaque luting agent. When flanges are not extended to the incisal edges, the cement will be loaded in shear during repositioning from a protruded mandibular position. It is important to ensure that the minimum permissible thickness (0.3 mm for base metal alloys) of the metal flange is achieved, to decrease the amount of adjustment required on the opposing teeth. In patients with large anterior guidance such as those with Class II, division 2, malocclusion, acid-etched prostheses are best avoided because the metal flanges usually cannot be accommodated without excessive adjustment of both metal and the opposing teeth.

For posterior resin-bonded prostheses, canine-guided occlusion is most favorable. For patients with group function, occlusal contacts in excursive movement should ideally be removed to decrease stresses on the cement lute.

Esthetic therapy

The concept of using porcelain veneers to mask unsightly teeth is not new. Pincus in 1928 first described the use of porcelain veneers, which were baked on platinum foil and cemented with denture adhesives, to alter an actor's teeth. Veneers can be fabricated through direct techniques with resin composites and indirect techniques with acrylic resin, resin composite, or porcelain. The veneers fabricated with indirect techniques are generally more accurate in fit and form. Direct techniques are, however, more practical when defects or discrepancies are localized, as with small diastemas or fractures and limited areas of discoloration. Acrylic resin and resin composite veneers offer smooth surfaces, good masking, and easy chairside finishing, but porcelain veneers (Figs 2a and 2b) are superior in appearance, color stability, resistance to abrasion, and longevity.

Essential to the bonding of porcelain to tooth is etching of the porcelain fitting surface, enhanced by silane coupling. Porcelain veneers seem to be providing better clinical results than initial impressions would have indicated. Calamia, who conducted a very thorough clinical trial, had an extremely low fracture rate of 0.4% over 2 to 3 years. He also found a slight deterioration of the marginal adaption and an
increase in marginal discoloration, neither of which was of any clinical significance. Marginal discoloration was frequently located at the proximal and gingival margins in dentin. Changes in marginal adaption were commonly in the incisal region and were caused by dissolution, or wash out, of the luting medium. Just as with resin-bonded prostheses, porcelain veneers are contraindicated in patients with active caries, periodontal disease, inadequate enamel for bonding, or parafunctional activities.

Preparation for veneers should be kept within enamel where possible to reduce microleakage and allow for assessment of margins. Wat et al., however, have shown that 80% to 100% of anterior teeth have exposed dentin cervically when prepared for veneers. Their study indicated that dentinal bonding agents may be ineffective in preventing marginal leakage at the cervical aspect of the veneers where exposed dentin is present. They found that the addition of a short bevel to the preparation prior to cementation improved marginal adaption and suggested that this occurred as a result of a better orientation of the enamel rods as well as an increase in the surface area of enamel for acid etching.

Several veneer designs have been proposed. These have been termed window, feather edge, and incisal coverage in relation to marginal position. Choice of design is dictated by the position and shape of the final restoration, the extent of discoloration of the tooth concerned, the anticipated tooth-loading pattern, and the existing occlusion. With regard to occlusal contacts, the aims are to minimize shear stresses in the luting agent while in function and to avoid intercuspal contacts on the porcelain-tooth junction. Although some authors have advocated placement of veneers without tooth preparations, Highton et al., have shown that, with normal incisal loading patterns, gingival and incisal tooth preparations reduce stresses within the veneer. An impact fracture study on intact and crowned teeth performed by Stokes and Hood., has indicated that porcelain veneers may actually stiffen teeth.

Several problems are associated with the use of porcelain veneers. To begin, the fit of such restorations needs to be improved. Gaps of 50 to 400 μm have been reported between veneers and tooth preparation. The different finishing techniques have their disadvantages as well. The use of a cotton pellet to remove excess resin tends to drag out the resin, resulting in a gap between the veneer and the preparation. The paintbrush and resin technique usually leaves excess resin over the outer surface of the veneer. The use of white stone or diamonds causes a loss of glaze and roughness of the porcelain. The color of the veneers in general is good, but it is influenced by the shade of the underlying resin composite, which may shift following cementation if dual-curing cements with a chemical catalyst are used. Although characterization can be done and instant investments that allow conventional glazing are marketed, glazing may be difficult because of the volume of investment material, which absorbs heat and precludes the porcelain from reaching a high enough temperature to fuse in the surface 100 μm. Luting agents used are either light cured or chemically cured. Linden et al., however, indicated that there is very little posture and that light curing alone is inadequate because of attenuation by the porcelain veneer itself. Some chemical curing is therefore desirable. The problem with dual-curing cements is...
their unknown long-term color stability, which may lead to disappointment after some years' use.

**Occlusal therapy**

The same principle of bonding a metal retainer to tooth substance that is used for resin-bonded prostheses may be applied to the provision of occlusal veneers to restore and protect worn teeth. In patients with extensive tooth wear, it is sometimes necessary to crown individual teeth or groups of anterior or posterior teeth to improve esthetics and function. Alteration of the vertical dimension of occlusion may be necessary to create space for restorations (Figs 3a and 3b) and enhance the patient's extraoral appearance. Adhesive onlays can be used to increase the vertical dimension of occlusion if esthetics is not compromised and if the tooth is not heavily restored. Margins of resin-bonded retainers placed on amalgam restorations have been shown to leak more than those placed on resin composite restorations or tooth. Minimal tooth preparations are required for this purpose, and thus conservation of the already-compromised tooth tissue is achieved (Figs 4a and 4b).

Traditionally such castings have been fabricated in nickel-chromium or cobalt-chromium alloys. Type IV gold alloys can also be used if they are heated to more than $650^\circ$C. This heating process results in the formation of an oxide layer that increases chemical adhesion to the resin cements. In prosthodontic terms, gold alloys remain popular, owing to their
stability under oral conditions, easy handling, and good adaptability.

Several other methods to achieve adhesion to gold alloy surfaces have been attempted. They include electro-oxidation, chemical oxidation, and electroetching. Wada\(^{37}\) concluded that a combination of sandblasting and tin electroplating is the best way to maximize resin adhesion to gold alloys. Tin plating produces a roughened surface; both micromechanical retention and chemical attraction through hydrogen bonding to the tin oxide that is formed appear to be responsible for the increased bond strength.\(^{48,49}\) It is essential to sandblast the bonding surface of the restoration before tin plating to clean it and to allow good wetting by the plating solution. There are no long-term data on the longevity of such prostheses.

McLundie\(^{50}\) has reported, the use of porcelain laminates for the restoration of localized palatal tooth surface loss after initial treatment with an anterior bite plane.

Orthodontic/periodontic therapy

Resin-bonded prostheses evolved from periodontal splints that were fabricated to increase the comfort of patients with disturbing tooth mobility. Practical problems with such splints include the immobilization of the teeth during impression procedures, the decreased access for oral hygiene maintenance, and the large differential mobility of teeth, which may lead to debonds. Such prostheses are no longer in vogue. Resin-bonded splints are, however, currently used for retention of tooth position after active orthodontic treatment. They are often preferred to the long-term provision of removable retainers, which depend on patient compliance. Resin-bonded splints are also more esthetic than removable retainers and are particularly useful in patients with cleft palate in whom both orthodontic and prosthodontic treatment is required (Figs 5a to 5c).

Orthodontic tooth movement can also be achieved with the use of Dahl’s appliance, which is basically a resin-bonded, cobalt-chromium anterior bite plate or splint covering the palatal surfaces of the six anterior teeth. Dahl and Krogstad\(^{51}\) used such prostheses as a temporary measure to treat 20 patients with pathologic attrition of maxillary and/or mandibular anterior teeth. They found that the continuous use of these splints under functional load caused intrusion of the front teeth and eruption of the other teeth in all patients. The mean intrusion was 1.05 mm and the mean eruption
was 1.47 mm after 6 to 14 months, which indicated that there is a potential for tooth eruption in human adults. More eruption than intrusion appeared to take place in the youngest age group. The use of such splints caused only transient discomfort for the wearers. Such resin-bonded appliances can be used to create space for restorations, increase the vertical dimension of occlusion, and reduce the need for elective endodontic and extensive prosthodontic therapy in the treatment of worn-down dentitions.

Other forms of resin-bonded prostheses

Ceramic inlays and onlays

Improved strength and the ability to bond to tooth structure through the use of adhesive resins make porcelain inlays and onlays an option for esthetic restoration of posterior teeth (Figs 6a and 6b). Such restorations must, however, be used with caution, because all ceramics, whether glazed or unglazed, will cause wear on the opposing natural dentition. Such prostheses are contraindicated in patients who clench, brux, have poor oral hygiene, or inadequate motivation and in situations in which adequate moisture isolation cannot be achieved. They are also contraindicated in preparations in which there are excessive undercuts and when proximal boxes have cavosurface margins primarily in dentin.

These ceramic restorations can be distinguished, according to their material composition and their fabrication, into three groups: castable materials (eg, Dicor, Dentsply International), materials fired on investment material (eg, Optec HSP, Jeneric/Penetron), and computer-aided, milled materials (eg, Cerec system, Siemens Dental). Compared with directly placed resin composites in posterior teeth, ceramic inlays have been shown to provide a better marginal seal at the cervical restoration-dentin interface. There is, however, a possibility of marginal quality deterioration at the enamel-resin composite and inlay-resin composite interfaces of ceramic inlay restorations after thermocycling. A clinical study by O’Neal et al showed that the width of the interfacial gap between the inlay restoration and tooth, which determines the vertical loss of wear of luting agents, varies among the different inlay systems. The vertical wear of luting agents tends to occur linearly in the first year and then generally levels off. They also concluded that microfilled luting agents or those containing submicron-sized fillers are considerably more resistant to wear than hybrid ones.

Jensen et al have demonstrated that resin-bonded ceramic inlays can restore the cuspal stiffness of prepared teeth to a level equal to that of unprepared teeth. Long-term clinical assessments of such restorations are not currently available.
Resin inlays and onlays

Resin-bonded resin composite inlays were introduced to avoid or reduce in situ polymerization shrinkage associated with direct placement of posterior resin composite restorations and to optimize restoration contour and adaptation. Such inlay systems may be classified according to the method of construction (direct or indirect), method of curing (post-cured, secondarily cured, or conventionally cured), and the type of resin composite (microfilled, fine, or coarse hybrid). Although it has been shown that the physical properties of some resin composite materials, such as hardness, in vitro wear, diametral tensile strength, and color stability, can be improved by supercuring of the material, overcuring of such materials will deplete the pendant groups available for chemical bonding with the resin luting cement.

Such resin-bonded inlays have been reported to provide a better marginal seal than directly placed resin composite restorations in both Class I and II situations. In a 1-year clinical study, Bessing and Lundqvist reported that 21 of 30 resin-bonded inlays had excellent ratings and eight of the remaining nine had acceptable ratings. Wendt and Leinfelder conducted a 3-year clinical trial of 60 inlays and observed no failures. They also stated that the marginal characteristics of the inlays are superior to those of directly placed restorations.

Conclusions

Resin bonding of prostheses has become an important technique in the provision of dental health care. Although the provision of such resin-bonded prostheses does not require any special training, and they are fairly easy to execute, cases must be selected with caution and patients must be warned of possible deterioration in the future. The need for life-long recalls and maintenance cannot be overemphasized, particularly for resin-bonded fixed partial dentures, because partial debonds can lead to extensive caries. The frequency of such debonds increases with the usage of multiple abutments. Designs should therefore be kept simple and practical. If used wisely, such resin-bonded prostheses can be a feasible component of the daily practice of dentistry.

References

Prosthodontics