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Crowns and other extra-coronal restorations: Resin-bonded metal restorations

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Resin-bonded metal restorations is the final part of the series. Cast metal restorations which rely on adhesion for attachment to teeth are attractive because of their potential to be much more conservative of tooth structure than conventional crowns which rely on preparation features providing macromechanical resistance and retention.

CROWNS AND EXTRA-CORONAL RESTORATIONS:

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The past 25 years have witnessed great strides in the development of adhesive dentistry. Many would say that our day-to-day practice has been influenced more fundamentally by these advances than by any other recent dental innovation.

One of the advances is the introduction of resin-bonded metal restorations (RBMR). Anteriorly, the RBMR resembles a retentive wing of a resin-bonded minimal preparation bridge. Posteriorly, the RBMR (sometimes termed a shim) resembles a conventional metal onlay but usually without box forms or other mechanical means of providing retention. Sometimes however, where pre-existing restorations have been replaced as part of the RBMR, the distinction between onlay and shim becomes blurred; the only differentiation being the means of cementation which has evolved from the technology developed for resin-bonded bridgework.

The need to remove tooth substance to achieve mechanical resistance and retention of worn teeth for conventional crowns would seem particularly counterproductive: RBMR can offer conservative solutions in this situation. A number of case reports and two surveys^{1,2} have appeared documenting and supporting the use of RBMR on the palatal aspects of worn maxillary anterior teeth (Fig. 1). The use of RBMR on the occlusal surfaces of posteriors has also been described (Fig. 2).^{2–4} However, there are no well-controlled clinical studies of the long-term success of RBMR in comparison with conventional restorations. Other uses have included production of rests for the support of partial dentures⁵ and restorations to alter the morphology of occlusal holding and guiding surfaces of canines.⁶

The ability to bond cast metal alloys to teeth

Fig. 1 Occlusal view of anterior palatal resin-bonded metal restorations

Fig. 2 Posterior resin-bonded metal restoration

was first demonstrated clinically by Rochette in 1973.⁷ His periodontal splint was made of cast gold and retained macromechanically by composite resin extruded through countersunk perforations in the metalwork. Tooth surfaces were etched with acid to provide micromechanical retention for composite resin cement. The major breakthrough was that other than etching no destructive tooth preparation was required.

As the adhesive minimal preparation bridge became commonplace, methods of modifying base metal alloys were developed to improve adhesion of the retainers to tooth substance via a resin-based cement. One technique was to incorporate irregularities into the fitting surface of the retainers during pattern formation, which were subsequently reproduced in metal; these took the form of voids left after the wash out of salt crystals, spheres or meshwork, but had the disadvantage that castings were bulky and the laboratory technique was exacting. Microscopic etch patterns in the fitting surface of bridge retainers greatly increase the surface area for contact with luting agents and can be produced by electrolytic corrosion in an acidic environment. Again this approach was technique sensitive but could produce reliable attachment between metals and resin.⁸ Base metal retainers can also be air abraded with alumina particles that as well as increasing the surface area may enhance the bond with some cements by chemical interactions.⁹

Lesser demands on rigidity with single unit restorations enabled the use of precious metal alloys (type III gold [ADA classification]) rather than the nickel based alloys used in adhesive bridgework. This gives advantages in casting accuracy, ease of adjustment and finishing, the potential for reduced wear of opposing teeth and perhaps of appearance. Several precious metal surface treatments have been documented. These include tin plating,⁹ heat treatment of high copper content gold alloys,¹⁰ air abrasion of the cast metal surface,^{2,10} and the Silicoater.¹¹ Air abraded base metal luted to etched enamel using two chemically active cements gave higher bond strengths *in-vitro* than precious metal alloy/surface treatment combinations.⁹ However, tin plating or heat treating air abraded precious metal alloys gave enhanced bond strengths *in-vitro* compared with this alloy air abraded alone.¹⁰ Clinically, air abraded nickel-chromium anterior RBMRs cemented with Panavia Ex gave a survival probability of 0.74 at 56 months,¹ and air-abraded gold RBMRs (anterior and posterior), also cemented with Panavia Ex, were associated with a survival probability of 89% at 60 months.² However it cannot be assumed that because a metal surface treatment works with one cement that it will necessarily be effective with others.

INDICATIONS

In the management of worn teeth

RBMR can protect worn and vulnerable tooth surfaces from the effects of further wear by forming a barrier against mechanical and chemical insults.

Any technique, which could delay entry into a restorative spiral necessitating ever enlarging restorations with endodontic implications, is to be welcomed. Although RBMR are susceptible to debonding, marginal recurrent caries and marginal lute wear, the fact that little if any tooth

preparation has been carried out prior to placement means that cumulative insults to the pulp are likely to be less than when conventional restorations have been placed (assuming that the bonding process to dentine is not damaging to the pulp!).

Central to the provision of RBMR are techniques to create occlusal space for the restoration; suffice it to say that non-preparation techniques, such as the Dahl approach,¹¹ involving controlled axial movement of teeth are attractive. In this approach teeth are built-up to cause their intrusion and the supra-eruption of others taken out of occlusion. This topic is summarised in Part 3 of this series. However, it is worth emphasising that the build-up must result in axial loading. Non-axial loading, resulting from a deflective contact or interference on the build-up, can cause problems such as pain and tooth mobility.

In occlusal management

RBMRs are made in the laboratory using the lost wax casting technique. In conjunction with the dental technician, the dentist has good control over form of occlusal surfaces of RBMRs, which can be used therefore to create occlusal stops and guiding surfaces with a high degree of precision. RBMRs are particularly helpful when such teeth are unrestored and where the alternative of conventional crowns would be unacceptably destructive.

A drawback of the technique is that the new guidance surfaces cannot be tested using provisional restorations as with conventional crowns. Guidance surfaces therefore need to be carefully formed with the use of a semi-adjustable articulator and the dentist must accept that some adjustment may be required after the RBMRs have been cemented.

Following molar endodontics

Many posterior teeth which have been root treated are at risk of fracture and will benefit from a protective cusp covering cast restoration.¹³ A RBMR with occlusal coverage can provide a conservative restoration for a tooth already compromised by the need for endodontic access.

TECHNIQUES

Choice of metal

If facilities do not exist to heat treat or tin plate gold after try-in, it may be more sensible to use air abraded nickel-chromium, accepting that its shade may look less harmonious in the oral environment than yellow gold.

Design and tooth preparation: anterior teeth

Very thin portions of unsupported buccal enamel remaining on some worn maxillary anterior teeth are highly vulnerable to damage on a stone master cast resulting in a casting which will not fit the tooth. Such enamel should be removed prior to making the impression and defects

waxed-up on the master cast before building up patterns for RBMR (Fig. 3). After cementation, composite resin can be packed against the RBMR to replace lost buccal enamel. The latter technique can also be used to restore pre-existing buccal tooth defects. No other tooth preparation is required for anterior palatal RBMR.

Fig. 3 Enamel defects waxed up on master cast prior to constructing restorations

To optimise adhesion, the maximum possible palatal tooth surface should be covered by the RBMR. Type III gold should probably be a minimum of approximately 0.5 mm thick though it may be reasonable to use nickel-chromium in thinner section because it is more rigid. It is necessary to incorporate features that aid accurate location during seating of the RBMR. A layer of metal overlying the whole of the incisal edge of anterior teeth facilitates accurate seating and following careful thinning can often be left in place without affecting appearance significantly (Fig. 4). In function, the latter feature should also reduce the likelihood that opposing tooth contacts will act directly on the cement layer to cause shear failure.

Fig. 4 Appearance of metal incisal coverage because of anterior palatal resin-bonded metal restorations

Design and tooth preparation – posterior teeth

The occlusal part of the restoration must be able to withstand functional forces and, in the absence of evidence to the contrary, dimensions for gold alloy RBMR should follow those recommended for conventional cusp covering crowns (see Part 6). As with anterior RBMRs it may be possible to reduce these dimensions when using nickel-chromium because it is more rigid. Occlusal preparation should only be performed where the treatment plan indicates that occlusal space for the restoration is required (see Part 3).

Table I Precautions for intra-oral air abrasion

Alumina particles are hazardous if inhaled, can scratch glass (eg spectacle lenses) and can leave patients feeling like they have a mouthful of sand. To avoid these problems:

1. Use rubber dam where possible.
2. Pack-off area around tooth with wrung out wet paper towels (alumina will stick to towel – not rebound).
3. Cover patient's whole face including spectacles, with wet paper towels. Fold to allow patient to breathe from beneath towel.
4. Dentist and nurse must wear masks and eye protection.
5. Use high volume aspiration.

Whereas conventional crowns are designed so that non-axial forces tend to put the cement layer in compression (non-adhesive cements are best able to resist compression), RBMR rely substantially on their adhesive luting agent to resist tensile and shearing forces. Axial preparation is useful in as much as it will facilitate accurate orientation on the tooth during bonding. Such a preparation would have an axial reduction of approximately 0.5 mm depth extending down the axial surfaces by one millimetre or so, terminating on a chamfer margin (Fig. 5). Axial preparation will also give the advantage of increasing the surface area for bonding to etched enamel. To what extent axial preparation will help resist peel and shear forces is currently unclear.

Fig. 5 Preparation form for posterior resin-bonded metal restoration

Managing existing restorations

RBMR rely primarily on adhesion to enamel for retention. Existing restorations which account for a large proportion of the surface area available for adhesion but also extend beyond the periphery of the RBMR are not ideally suited to restoration using this technique. The critical factor is to finish the margin of the restoration on enamel if at all possible.

Anterior teeth

Restorations deemed to be in need of replacement involving the labial surface of anterior teeth can be managed in several ways:

1. Replace prior to impressions. However by the time the RBMR is cemented the surface will be waterlogged and may only offer sub-optimal bonding to chemically active cements. Use of an intra-oral air abrasion device on the plastic restoration may be beneficial.
2. Remove prior to cementation of RBMR and pack fresh composite against either the trial

seated or cemented RBMR. Placement of composite against the cemented RBMR can make the job of shade matching easier than when replacement is carried out prior to impressions because opaques and appropriate shades of composite can be used over the metal.

Posterior teeth

Some caution is required in relation to existing restorations that will be completely covered by the RBMR, as they may not offer as great a bond to chemically active cements as etched enamel. Much will therefore depend on the area of enamel available for bonding. Strategies to manage existing restorations, which will be completely covered by the RBMR, would include:

1. Leaving the restoration undisturbed. In this case it may be best to assume that the old restoration offers no additional retention. An example for this approach would be a small sound restoration surrounded by a good periphery of enamel.
2. Air abrading the surface of existing restorations with the aim of providing micromechanical retention for the resin cement (Table 1).
3. Replacement of an existing amalgam restoration with GIC to facilitate bonding.
4. Removal of whole or part of the restoration with the aim of providing a retentive intra-coronal feature on the fit surface of the RBMR and exposing tooth structure for bonding. The resulting preparation will resemble that for a conventionally cemented onlay incorporating box forms, bevels and flares.¹⁴ However, removal of old restorations may be associated with unnecessary damage to the tooth and where necessary undercuts should be blocked out with glass ionomer cement.

Fig. 6 Appearance of heat-treated gold just after cementation

Fig. 7 Floss ligatures to facilitate isolation with rubber dam

Records

Impressions for the laboratory fabrication of RBMR should meet the same quality criteria as for conventional crowns (see Part 10 of this series). Anterior palatal wear often spares a rim of enamel in the proximity of the gingival crevice which should be captured by the impression as it may enhance adhesion significantly. It is helpful to use a gingival retraction technique to achieve this.

Fabrication can be carried out by investing and casting a pattern which has been lifted from the master cast or by forming the pattern for the restoration on refractory material which is itself incorporated within investment.

Bonding

Although occlusal adjustments are more easily polished if carried out before the RBMR is attached to the tooth, stabilising the restoration sufficiently to analyse occlusal contacts can be difficult. A small amount of paraffin jelly smeared onto the fitting surface of the RBMR can provide some retention but needs to be removed completely before bonding.

The fitting surface should ideally be air abraded and steam or ultrasonically cleaned before cementation. Gold alloy RBMR are heat treated at this stage. A brief cycle in a porcelain oven is required (400°C for 4 minutes in air). Despite the colour of the oxidised alloy, no further polishing should be carried out until after the restoration has been cemented as to attempt this risks contaminating the all-important oxide layer developed in the heat treatment (Fig. 6).

In the past there has been concern that the quality of bonding of the chemically active cements advocated for RBMR may be affected by the presence of eugenol.¹⁵ However another study¹⁶ indicates that eugenol containing temporary cements have no adverse effect on the shear bond strength of a dual-curing luting cement to enamel although there may be an effect if a composite core is used.

Several chemically active cements are available to bond RBMR: the same cement as would be chosen for adhesive bridgework. Manufacturers instructions for handling the chosen chemically active cement must be followed closely: it is the responsibility of the dentist to ensure that this is so. Rubber dam is mandatory. Floss ligatures can assist retraction of rubber at the gingival margins of maxillary anterior teeth (Fig. 7). Soft wax on the end of an instrument can be helpful to carry the RBMR to the tooth but great care must be taken not to smear wax onto the fitting surfaces.

After attaching a RBMR to the tooth, removal of excess cement, occlusal adjustments and polishing can be achieved with hand scalers and a sequence of rotary instruments (Table 2). Care must be taken not to overheat the restoration or the resin cement will be softened and the RBMR dislodged.

Table 2 Suggested sequence of instruments for removal of excess set cement at periphery of resin-bonded metal restorations

Hand scalers
Fine and very fine high speed diamond burs
Rubber points
Polishing cup and prophyl paste

PROBLEMS

Appearance

Maxillary anterior teeth, which have been thinned by wear on their palatal aspects, may transmit light easily. RBMR luted to the palatal aspects of these teeth may cause a grey colouration that can be unacceptable and is more likely if non-opaque cement is used. On the other hand, opaque cements may help disguise metal but can also cause a lightening in shade. At the initial assessment it is wise to assess possible shade change caused by a RBMR and its cement. White modelling clay applied to the palatal aspect of the thin tooth can mimic the effect of opaque cement. Tin foil burnished onto the palatal surfaces of teeth to be restored can indicate the effect of grey nickel chromium or dark oxidised gold in combination with non-opaque cement.

Showing metal is aesthetically acceptable to some patients but simply not for others! Yellow gold can look more harmonious in the oral environment than nickel-chromium. A useful technique is to use an air abradar to reduce the reflectance of the polished RBMR. In our experience the surface produced by air abrasion also picks up ink of occlusal marking tape more easily than metal left highly polished.¹⁷ A chairside air abradar for intra-oral use is a ideal for this purpose but needs to be used with care (Table 1). The advantages of RBMR should be fully explained to the patient: the informed patient may accept this compromise in appearance.

Temporisation of RBMR

In many cases temporary restorations are unnecessary but as with porcelain labial veneers retention can be a problem. These aspects are addressed in the ninth article in this series.

It is a significant disadvantage that RBMR cannot be reliably attached to teeth for a trial period using temporary cement. Glass ionomer cement (GIC) may afford easy retrieval (or unplanned loss) in some situations but in others acts as a final cement!

MAINTENANCE

Erosion can cause loss of tooth tissue at the periphery of a RBMR (Fig. 8). This problem may occur as a result of not identifying or not controlling the aetiology of the patient's presenting tooth wear. Repair with an adhesive filling material may however be straightforward, although concern has been raised about the ability of the repairing material to bond to the metal casting.

A RBMR whose lute has failed is more likely

Fig. 8 Recurrent erosion at the periphery of resin-bonded metal restorations *in situ*

Fig. 9 Partially de-bonded adhesive metal splint

to declare itself by debonding than a conventionally retained crown which may stay in place long enough for the consequences of leakage to take effect. Analysis of the cause of failure for a RBMR may indicate that an attempt should be made to re-attach it after appropriate cleansing and surface treatments. All traces of old cement should be removed from the RBMR, which should then be handled and treated as new. An air abrasion device, abrasive discs and ultrasonic scalers are useful in removing cement from the tooth surface. A round diamond bur can be used without water in a turbine or speed increasing handpiece. The powdery white surface of the instrumented cement can easily be distinguished from the glossy appearance of instrumented enamel. Occasionally etching tooth surface can help to establish whether or not cement remains: areas not appearing frosty are either dentine or residual cement. It is important to remove the resin-infiltrated layer in both enamel and dentine and hence facilitate bonding. Cement removal must be carried out carefully or changes in tooth shape or fit surface of the RBMR will result in an increase in lute thickness. Inevitably, repeated attempts at reattachment are increasingly likely to fail as the lute thickness rises.

RBMRs linked rigidly together to act as a post-orthodontic retainer or periodontal splint, carry the risk that one or more retainers may debond leaving the restoration as a whole attached without causing any initial symptoms. If this happens caries can progress unchecked beneath decemented elements with disastrous results (Fig. 9). Adhesive splints need careful follow-up: patients must be instructed to seek attention if they think a tooth has become debonded. It is often necessary to remove the whole restoration and attempt to re-bond it. A sharp tap to a straight chisel whose blade is positioned at the lute space is often sufficient to dislodge the cemented portions of an adhesive

splint. Occasionally it is possible to accept the compromise of removing a decemented retainer if this is at the end of the restoration. Linking RBMR should be avoided wherever possible.

CONCLUSIONS

RBMR rely for their attachment on chemically active cements. The choice is between precious metal and base metal alloys with various surface treatments to enhance adhesion with the cement. RBMR have the potential to be very conservative of tooth tissue but are technique sensitive. To date few clinical studies exist examining their success.

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