Guidance Document: Resin Bonded Bridges (RBBs)

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Contents

Introduction

Adhesive bridgework utilises resin cement to allow restoration of missing teeth with a minimally invasive fixed prosthesis. They are conservative and can benefit from no tooth preparation so have become a routine treatment modality to manage patients with small edentulous spaces.
Adhesive dentistry, to both splint teeth or restore missing units has been in use for over 50 years (1), during that time techniques have evolved substantially including the material used, surface treatment of the retainer and components of resin cements.

A recent systematic review (2) demonstrated a high 5-year survival for adhesive bridges of 91%, and 82% 10-year survival. The most frequent complication seen was debond, which occurred in 15% of the restorations over the 5-year observation period. An earlier evaluation of 771 adhesive bridges provided to a UK cohort (3) found that the majority of failures occurred within the first four years, with a strict criteria of time to failure being the first debond, so the restoration life in service may ultimately have been longer; survival was estimated at 80.4% at 10 years.

This document outlines the key considerations when providing RBBs as well as the practical steps and discusses management of failing bridges. It is however important to always follow the guidelines of your specific manufacturer.

Material choices

Resin bonded bridges have been constructed out of a range of materials, including:

- Fibre reinforced resin composite
- Metal ceramic
- All ceramic
    - Glass infiltrated alumina
    - Lithium disilicate
    - Zirconia

Fibre reinforced composite can be used both directly and indirectly, but is seldom used due to lower strength, unstable aesthetics and fracture of composite (1). Its use is realistically limited to direct immediate/natural pontic bridges.

Lithium disilicate restorations have excellent aesthetics but are limited to anterior bridgework due to the reduced strength compared to Zirconia, there are problems with increased chipping of ceramic.

Debond and fracture are more common problems with restorations constructed with glass infiltrated alumina than metal ceramic, there are few circumstances when they could be used in preference to metal ceramic or other ceramics (4).

Most resin bonded bridges are constructed from metal ceramic (non-previous alloy) or zirconia. There is decades worth of research evidencing good survival of metal ceramic restorations, however there are times that the presence of a metal framework could be considered a disadvantage (will be discussed later), so zirconia can be a good alternative. Zirconia has good aesthetics, high strength, and although some clinicians are still concerned about the ability to bond zirconia there is a wealth of evidence indicating that this is a predictable procedure (5, 6) They have limitations, requiring sufficient space for larger connector dimensions, and with manufacturers only indicating zirconia ceramic for anterior adhesive bridges.
Each material will have a different requirement with regards to minimum retainer thickness and the dimensions of the connector, it is recommended to follow the guidelines of the chosen manufacturer closely.

Case selection

Success in the provision of adhesive bridgework is dependent on many factors, beginning at the stage of case selection, specifically in relation to the suitability of adhesive bridgework, and selection of the abutment tooth.

Prosthetic space
The key indication for adhesive bridgework is an edentulous span of short length (ideally a single missing tooth) with an adjacent unrestored or minimally restored abutment tooth. A larger space than this may be restored using two adjacent cantilever RBBs, but with each pontic no bigger than a single unit (premolar size).

Although research shows reduced survival posteriorly (2), adhesive bridges are used successfully in our unit to restore posterior and anterior spaces.

Careful planning must be carried out with the use of study casts mounted on a semi adjustable articulator to allow a wax up of the proposed restoration, including both the pontic and retainer coverage. This is an important step to allow assessment of inter-arch factors of importance and the occlusal relationship, this is made even more critical when providing bridgework for edentulous spaces of less ideal proportions.

The wax up of the desired result can be used to inform the patient of the planned aesthetic outcome, and important step in the consent process. Multiple wax ups can be created to demonstrate options with regards to pontic size or position.

Abutment tooth selection

As with any fixed prothesis it is essential to ensure that the abutment tooth is caries free, and sound endodontically and periodontally, ideally with a vital pulp and no history of periodontal disease. Strategic abutment teeth are universally accepted to be maxillary central incisors, canines and first molars.

The restorative status of the abutment tooth is an important consideration for the suitability of adhesive bridgework. A heavily restored tooth should be avoided, as margins on tooth would be challenging to achieve and there is reduced enamel available for a successful bond. Survival of adhesive bridgework is reduced for restored abutment teeth (3), and the bond strength will be restricted by the weakest adherent, enamel being the strongest, with dental amalgam, dentine and glass polyalkenoate (glass ionomer) much weaker (7). The bond to resin composite can be considered adequate (7), and still have good survival if this is a new restoration (3). Practically, a tooth with a small restoration could still be considered a suitable abutment, provided this is changed to resin composite or an old composite restoration resurfaced, and all margins finished on enamel.

Tooth shape and position can compromise the suitability of adhesive bridgework. An acutely angulated or tilted abutment tooth may not allow sufficient connector height for the restoration, resulting in flexibility of the framework and ultimately bond failure. If there is minor tilting, or a more bulbous tooth shape, minimal proximal reduction, remaining in enamel, may correct this and increase the available surface area for the connector. Classically this can be a problem when replacing maxillary lateral incisors with an adhesive bridge when the only suitable abutment is a bulbous canine.

To prepare, or not to prepare

Most of the evidence relating to tooth preparation relates to metal ceramic RBBs. Ideally the abutment tooth remains unprepared, to keep the restoration as conservative as possible. The survival rate has been shown to reduce with even the most minimal of preparation, with a hazard ratio of 2.85 for failure when prepared (3). Minimal preparation may be required to improve the design of the restoration, this should be confined to enamel so as not to compromise the bond strength, any more extensive preparation has been shown to lead to reduced survival of the RBB (3).

Preparation could include:

- minimal proximal preparation to reduce a bulbosity on the abutment, increase the connector height of the framework, improve aesthetics by reducing black triangles or correct minor mis-angulation of the abutment tooth.
- location of the restoration at cementation can be challenging on anterior teeth with minimal palatal/lingual contour, some clinicians advocate preparation of a cingulum rest to minimise this problem as well as reduce potential shear stress within the cement under occlusal forces.

Preparation of the abutment tooth is advocated when using zirconia RBBs (see figure 1) (6) However, the author and colleagues have experience of placing zirconia RBBS without any preparation of the abutment, this is clearly advantageous being the least destructive approach. In the absence of evidence of long-term data confirming this we would recommend following the manufacturer's guidelines.

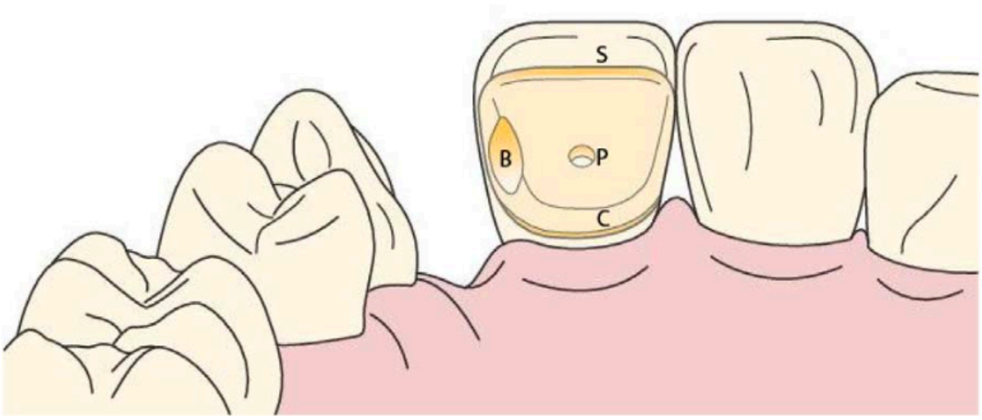

Fig. 1. Schematic drawing of the preparation design. C = light cervical chamfer, S = light incisal finishing shoulder, B = small proximal box, P = small pinhole; Fig. reprinted with permission from M. Kern, RBFDPs. Resin-Bonded Fixed Dental Prostheses - Minimally Invasive – Esthetic – Reliable, 1st ed., Quintessence, Berlin, 2017.

Figure 1 – preparation of abutment tooth for zirconia retainer wing (6)

Design principles

It is important that a clear prescription is provided to the dental laboratory technician detailing the design of the restoration.

The following factors should be considered when designing and constructing metal ceramic RBBs:

- **Cantilever with a single abutment tooth**
  Adhesive bridgework has been shown to be most successful when a cantilever design is employed (2, 8), with a hazard ratio of 2.23 for failure of fixed/fixed designs (3). Fixed-fixed designs carry the significant risk of debond of the minor retainer with the bridge remaining in situ, resulting in caries progression beneath the debonded retainer wing. One exception to this may be in the case of missing incisors post orthodontics, some clinicians advocate a fixed-fixed design when replacing two missing lateral incisors, with retainers linked and bonded to both central incisors in the "Bristol bridge" design (3), this can act as both orthodontic retention and prosthetic tooth replacement. This still carries a risk of caries progression should there be partial debond so careful monitoring is required.
- **The retainer design** needs to maximise enamel coverage to improve bond strength (figure 2). This should be a non-perforated (8) retainer wing providing full coverage of the abutment tooth surface; anteriorly 180 degrees wrap around palatal and upto the incisal edge; posteriorly coverage needs to include the lingual/palatal wall as well as wrap over the occlusal surface. Some clinicians incorporate a locating tag in the design of the anterior retainers, this allows accurate location of the retainer wing so by ensures a minimum thickness of resin cement (9). The locating tag is easily removed by sectioning at the fit appointment and smoothed using polishing discs (figure 3).
- Constructed in **non-precious metal alloy**, commonly cobalt chrome alloys, with a minimum retainer thickness of 0.7mm (10), to ensure sufficient rigidity and minimal flexure in the framework.
- **Minimum connector height** 2-3mm (11) to ensure adequate rigidity in the framework to reduce the risk of debond. If there is flexibility in the framework under loading this will create stress in the resin cement, and subsequent bond failure.
- To achieve successful adhesive bonding the **retainer surface must be prepared** according to material of the framework and manufacturers guidelines of the cement choice (see point 6 re considerations)
- **Pontic design** can vary dependent on the aesthetic demand of the case. Modified ridge lap or ovate pontics are most commonly used (12) to achieve a good aesthetic, balanced with cleansability. Pontic site preparation may be required to achieve an optimum outcome with ovate pontics, there is literature available describing this in detail (13).

- **The occlusion** should be organised so that there is light contact on the pontic in the intercuspal position to act as a holding contact, but the pontic should not be involved in guidance (14). Ideally there should be space between the abutment and the opposing tooth to allow the placement of the retainer wing and conform to the intercuspal position. This is often not the case and consideration must be given to either preparing the opposing tooth if minimal adjustment is required or cementing the restoration in supra-occlusion and allowing the occlusion to re-establish around it. There is evidence to support the effectiveness of relative axial tooth movement when placing a restoration in supra-occlusion on a single tooth (15), the use of this technique both anteriorly and posteriorly has been advocated (16). Time to re-establish occlusal contacts is evidenced as being between 15 days and 24 months (17).

Figure 2 – retainers on UR1 UL1 showing maximal coverage

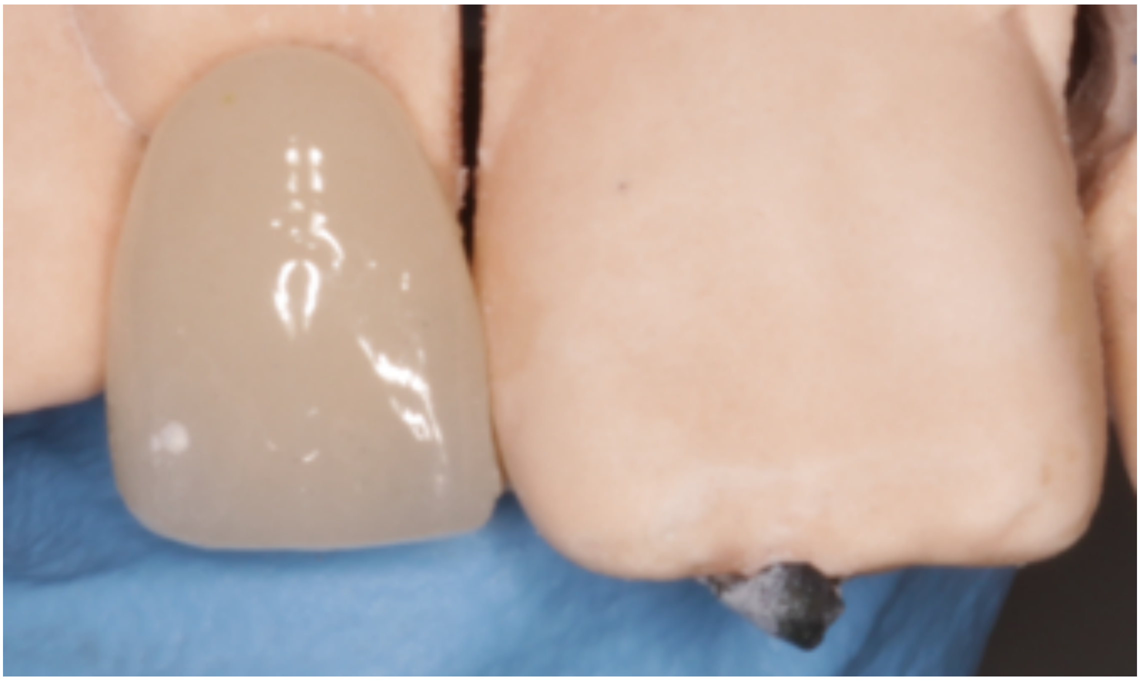

Figure 3 – locating tag on UL1 incisal edge to aid seating

Considerations during cementation

Please see the BSSPD guidance document on Bonding for more detail.

A successful bond relies on three key steps:

- Surface preparation of the retainer wing
- Use of an adhesive resin cement
- Meticulous protocol

The surface preparation required varies according to material. Metal (non-precious) retainers require sandblasting with 30-50 microns alumina particles; it is important this is carried out immediately prior to cementation to avoid excessive oxide layer formation over time as this can lead to cohesive failure within the oxide layer (9). Zirconia retainers should also be sandblasted with alumina in accordance with the APC concept (5).

Surface preparation should be carried out after try in, to give the opportunity to clean and prepare the retainer, ensuring there is no surface contamination present.

A primer containing 10-MDP must be used to achieve good bonding through adhesion of the phosphate group in the cement monomer with the oxide coating on the retainer wing (18). 10-MDP is either available for as a separate primer, or most commonly in the adhesive resin cement such as Panavia 21 (Kuraray Co Ltd, Osaka, Japan).

Every adhesive resin cement has clear instructions for use – these must be exactly followed to ensure success. The cement must be either chemical cure or dual-cure to ensure full depth of cure under the opaque retainer wing.

Cementation must be undertaken in an environment free from moisture, and on a clean dry tooth surface.

Clinical stages

Appointment 1

- Minor 'preparation' if required. Restorations should be changed to composite or resurfaced if existing composite restorations are present.
- Impression taking - full arch working impression (16) in a rigid tray in a material with sufficient surface detail (e.g PVS or polyether), and a good quality opposing impression
- Shade selection
- Jaw registration if required - When providing an occlusal registration this should be carried out using a rigid silicone-based registration paste(14), and appropriately trimmed by the clinician to ensure the models locate accurately.

Appointment 2

- Try in
- Cementation
- Initial clean up
- Impression if occlusal appliance/vaccuum formed retainer required

Appointment 3

- Final clean up
- Final checks of occlusion
- Fit of occlusal appliance if required

Subsequent appointments

If the restoration has been placed in supraocclusion, with an expectation for relative axial tooth movement, the follow up period should continue until occlusal contacts have been re-established, at this time careful examination of the occlusion will be required to ensure the pontic has not established any excursive contacts.

Resin bonded bridge failures

If adhesive bridgework is provided and maintained well, over 80% of these restorations have an expected survival of ten years; this is a high survival rate but demonstrates that some of these restorations will require management due to failure.

Failures are generally due to biological or technical complications, or aesthetic failures. Complications rarely result in long-term adverse effects, given that the restorations are conservative of tooth tissue.

Aesthetic failures

Aesthetic failures could relate to the pontic, retainer or abutment tooth. Such failures can and should be avoided with careful planning and temporary cementation of the adhesive bridge at fit to allow the patient to fully appraise the restoration.
Engaging the patient at the treatment planning appointment with a plaster cast and wax up of the planned pontic shape as well as the retainer position should give a good indication of the likely outcome.

The pontic shade can be difficult to select, particularly if the patient has a significant amount of characterisation. If there are concerns with regards to shade matching a bisque try in stage can be completed allowing further changes to more easily be made before the restoration is glazed.

A more common aesthetic concern is a 'greying' out of the abutment tooth due to the presence of the metal retainer. Djemal et al found one in ten patients were dissatisfied with the appearance of their adhesive bridge, this was mostly attributed to the retainer resulting in grey 'shine through' or loss of translucency of the abutment tooth (8). Try in of the restoration prior to cementation allows the patient to assess this, but it can be difficult to fully appreciate whilst in the surgery and no trial period is available at home.
The use of an opaque resin cement is usually sufficient to obscure the colour of the metal retainer (19). In cases where there is significant translucency of the incisal edge, as well as using opaque cement it may be appropriate to finish the retainer approximately 1mm from the incisal edge to ensure the translucency is maintained, but also ensuring this does not compromise surface area for bonding or strength of the framework. Although opaque cement will reduce the grey 'shine through' it may affect the shade of the abutment tooth, so when shade taking it is always best to mimic the retainer with use of a gloved finger or cotton wool on the palatal surface of the abutment tooth.

Technical complications

Technical complications are more prevalent, with debonding being the most reported, accounting for 92.6% of all failures in a systematic review (1).

Simple debond normally results in exposure of a cleansable enamel surface that is favourable for re-bonding.

If presented with a debonded adhesive bridge it is critical to understand the cause of this failure. Debond is most attributed to the following causes:

- Bond failure, due to several reasons, including moisture contamination during cementation, inadequate treatment of the retainer surface, or not following the cement manufacturer's instructions.
- Inadequate design of the prosthesis such as a lack of rigidity in the framework with insufficient retainer thickness or connector dimensions, resulting in flexure during function and stress at the cement/retainer interface.
- Errors in the occlusal scheme; a pontic subjected to unfavourable loads during static and dynamic occlusion can result in debond.

Clues as to the cause of debond can be sought by close examination of the abutment tooth and restoration. The presence of cement on the retainer wing indicates a bond failure at the cement/tooth interface through likely contamination. Cement on the abutment tooth may indicate an inadequate design, contamination on the retainer surface, or occlusal errors (figure 4).

Figure 4 – debonded retainer with cement remaining on wing

If the cause of debond is due to bond failures that can be easily rectified, then re-bond of the restoration is advisable. Should the failure be caused due to inadequacies in the restoration design, or major occlusal errors that cannot be modified then the restoration may require remake, or a different treatment modality attempted.

The next most prevalent technical complication is chipping of the veneering material, reported for 4.1% of RBBs over 5 years observation in a systematic review (2). Although minor chipping was seen frequently seen, it never occurred for zirconia restorations and had an annual chipping rate of 0.29 for metal ceramic bridges. The aetiology of ceramic chipping is likely due to poor design of the restoration and resultant unsupported porcelain, or occlusal errors.

Minor chipping that does not have an aesthetic consequence can simply be smoothed to ensure patient comfort. More extensive chipping may need further treatment to manage acceptably. Ceramic repair can be attempted intraorally, this can be carried out several ways but either requires a strong hydrofluoric acid etch to expose silica within the ceramic (such as in the Ultradent Porcelain repair kit), or tribochemical coating using a chairside system such as Cojet (3M), to allow application of a silane agent and composite bonding. Either method must be carried out under rubber dam to achieve moisture control and protect the patient from harmful by-products. Porcelain repair can be unpredictable, particularly if the cause of initial fracture is not addressed. If repair is unsuccessful, or technical faults in the restoration design are identified then replacement restoration would be the most appropriate management strategy.

Biological complications

Biological complications such as caries at the restoration margin, or progression of periodontal disease are rare, with cumulative 5-year complication rates of 1.7% and 0.8% respectively (2).

Caries is unlikely to occur under a restoration with a single retainer, any leakage would result in debond before caries could progress extensively. However, for fixed-fixed adhesive bridges, debond is frequently associated with one retainer wing meaning the bridge does not become dislodged. This ‘silent’ debond risks progression of caries beneath the single debonded retainer (14). If a fixed-fixed design is advocated, such as double abutted central incisors to both replace missing laterals and act as orthodontic retention then careful surveillance for any debond is essential.

Managing failure

As detailed above, a number of these failures are wholly preventable with appropriate planning and treatment execution.

Removal may be required of a partially debonded fixed-fixed design, a restoration with an aesthetic failure or following technical complication such as chipping. On the unlikely occasion that an adhesive bridge must be replaced due to failure, one of the challenges can be the method of restoration removal.

Removal techniques vary depending on the location of the bridge. Anterior adhesive bridges can be removed following being subjected to a quick, firm, shearing force. This is best achieved by hitting a straight enamel chisel placed at the retainer margin, to direct the force along the cement lute (14). A little preparation with a bur in high-speed handpiece is often needed to create a point of application for the chisel (9). Alternatively, the retainer wing can be partially sectioned down to the lute interface, then a flat plastic instrument used in the groove, a twist of the instrument can cause flexure and break the cement bond. With either technique it is key to prevent inhalation or ingestion of the restoration by tying dental floss around the connector which can be held by the assistant when applying the force, and protection of the airway using gauze in the mouth.
Posterior adhesive bridges are likely to have more wrap around and engage cusps and fissures, these are best removed by being cut off with a diamond bur in a high-speed handpiece (9).

Once the restoration is removed an interim prosthesis can be fitted while remake of the restoration is arranged.

Summary

With appropriate case selection, adhesive bridgework executed to a high standard is a predictable method of replacing missing teeth. This treatment is minimally invasive, and the procedure often well tolerated.

Complications can arise, although as discussed most are wholly preventable. Failure, if it occurs, is most commonly debond. This is less catastrophic than failure of conventional tooth or implant-based rehabilitations, and results in an easily retrievable situation.

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