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An Update on Resin-Bonded Bridges

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Abstract - *Since the introduction of the 'Rochette' bridge in the 1970s the resin-bonded bridge has undergone a number of developments to become a commonly used technique for replacement of a missing tooth, especially in a minimally restored dentition. One of the major advantages of the resin-bonded bridge is that it requires less tooth preparation than conventional bridgework, with some authorities advising no preparation at all. Some reports have suggested poor long-term success rates, however, if used in appropriate clinical situations, this treatment modality can be extremely successful. The aim of this paper is to review the literature relating to resin-bonded bridges and suggest recommendations for clinical practice concerning the provision of resin-bonded bridges.*

KEY WORDS: Resin-bonded bridges, review, success-rate, design, cementation

INTRODUCTION

The resin-bonded bridge (RBB) was developed from an innovation by Rochette[1] in 1973, using metal wings to splint periodontally-involved mobile teeth. These were bonded by autopolymerising acrylic resin to acid-etched enamel, and contained perforations to provide macro-mechanical retention between the resin and metal structure. Following the success of this technique, the splint was modified into what became known as the 'Rochette' bridge, whereby a pontic was adhered to both adjacent teeth, using perforated wings on the palatal or lingual aspects (Fig 1).

One of the weaknesses of the Rochette design was that the wing perforations exposed the resin to wear, which ultimately could lead to loss of the bridge. Another theory suggests that as composite resin is not known for its excessive wear characteristics, a more significant factor may be the stress created around the rivets, leading to loss of material. This problem was overcome in the early 1980s when electrolytic etching of nickel-chrome alloys was developed[2,3]. This technique allowed the resin cement to bond micro-mechanically to the metal surface, and became known as the 'Maryland' bridge (Fig 2) as it was originally described by workers from that university. The first such bridges were posterior bridges.

Further developments in resin bonding agents led to the ability to achieve a chemical bond between the grit-blasted oxidised retainer surface and the resin cement, negating the need to etch the retainer surface[4]. Although the RBB is now a commonly used method of replacing missing teeth, there is still much debate over several aspects of their design and use. The aim of this paper is to review the literature and suggest guidelines on how and when RBBs should be provided.

Advantages

The major advantage of the RBB is that it requires minimal, or at best, no tooth preparation. It is therefore, by definition, a conservative method of replacing a missing tooth. Although there is currently debate as to the required amount of preparation, most authorities agree that if done, the preparation should be kept within enamel. Hence, the requirement for local anaesthesia during tooth preparation is often said to be negated. Recent research, however, has shown that even when it is the intention of the operator to keep the preparation minimal, some dentine is usually exposed[5]. This can obviously affect the need for local anaesthetic and reduce subsequent bond strengths.

If the preparation is kept minimal or no preparation is undertaken, then the RBB becomes a reversible treatment option, as no 'biological harm' is done. The margins of the RBB should be kept supragingival, with obvious advantages to the periodontal tissues, although research has differed when examining the effects of RBBs on periodontal health. One study[6] suggested no detrimental effect on periodontal health, whilst other studies[7,8] have suggested increases in plaque index, probing depth, gingival inflammation and loss of attachment. The clinical effect, however, is reported to be negligible after 10 years of service[7].

Another advantage of the RBB is that should a wing debond there is the option of simply cleaning the surface of the wing and tooth, and rebonding it. This is only possible if the wing has not distorted during debonding. However, if the bridge has more than one abutment, and only one abutment debonds, there is the potential for caries to develop (see later). This situation also complicates rebonding, with many clinicians preferring to remove the debonded abutment to leave a cantilever bridge remaining.

One could also argue that a RBB is a less expensive way of replacing a missing tooth when compared with a cobalt chromium partial denture, conventional fixed bridgework, or a dental implant. One reason for this is the reduced treatment time when compared to other forms of treatment, with one study suggesting an average of 80 minutes to complete a RBB[9] . This does not, however, take into account longevity and cost of future replacements. Patient satisfaction has been shown to be high[10,11], and does not seem to be influenced by the occurrence of failure[10]. With careful design and a skilled technician, a RBB can be a highly aesthetic restoration (Figs 3 & 4).

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Figure 1. *A Rochette bridge (courtesy of Dr Simon Northeast).*

Figure 2. *A Maryland bridge (courtesy of Dr Simon Northeast).*

Figure 3. *Single unit absent in a stabilised patient suffering from chronic periodontitis, displaying significant gingival recession and staining.*

Figure 4. *Resin-bonded bridge in situ: pontic 22, abutment 21.*

Figure 5. *Immediate placement of a RBB following implant placement to replace 12 (courtesy of Dr Simon Northeast).*

Disadvantages

The failure rate of RBBs is generally higher than conventional bridgework, particularly if the treatment is not planned thoroughly and all technical issues addressed appropriately. Aesthetic issues regarding 'greying out' of the abutment tooth can be a problem. This is exacerbated if the metal wing is taken too far incisally on the palatal or lingual aspect. This effect can be reduced by using opaque resin cement. Creation of a natural emergence angle for the pontic can be difficult in grossly resorbed ridges. Assessment of occlusal contacts pre-cementation is difficult. A method for trying-in the restoration to assess aesthetics has been suggested, involving temporary cementation with a dental lining material[12]. Temporisation prior to cementation is usually only possible using a removable partial denture.

Indications and contra-indications

A RBB is one of the options when replacing a single tooth space, along with a partial denture, conventional fixed bridgework and a single tooth implant. An evaluation of 496 RBBs showed that the main indications for treatment were congenital anodontia and loss of teeth due to dental caries and trauma[13]. Although the use of RBBs with more than one pontic has been reported, these have been shown to have a significantly-increased debond rate[14]. The use of RBBs placed immediately following tooth extraction has been reported to produce successful results nearly 3 years following placement[15]. Many clinicians now use RBBs to replace the missing tooth following implant placement, whilst waiting for osseointegration. This means the patient does not need to use a removable partial denture prior to placement of the definitive restoration (Fig 5).

Sufficient enamel is required on the lingual/palatal aspect of the abutment tooth/teeth to allow for acid-etch bonding. Therefore abutment teeth should ideally be sound or have minimal resin restorations. Large restorations and extensive dental caries are contra-indications for provision of RBBs. Clinical crown height should also be sufficient to provide enough surface area of enamel. If the crown height is insufficient, consideration can be given to crown lengthening. Occlusion and excursive contacts should be favourable or well-controlled. Oral parafunction, such as bruxism is generally considered to be a factor that may increase likelihood of failure.

As with all fixed bridgework, the abutment teeth should be sound from an endodontic and periodontal perspective. The need for a diastema between the abutment tooth and pontic is an obvious contra-indication. A grossly resorbed alveolar ridge in the area of the pontic is difficult to reconstruct with any fixed bridgework, although is not an absolute contra-indication (Figs 6 & 7). Allergy to any of the metals present in the metal framework (most commonly nickel) is a further contra-indication, although different alloys are available for the retainer.

Longevity

Many studies have assessed the longevity of the RBB. Recent studies have shown a general improvement in reliability and debonding rate, which is to be expected with the advancements in bonding technology and cementation materials. Studies from the late 1980s and early 1990s reported success rates of 73% at 18 months[13] ; 75% at five years[16] ; and 87.4% at just over three years[17]. A meta-analysis in 1991 combined results from previous research and reported a success rate of 74% at four years[18]. More recent studies from the late 1990s and early this decade have reported success rates of 93% after nearly four years[8] ; 94% after three years[19] ; and 94.3% after nearly three years[20]. Research evidence has been divided with regard to comparing the success rate of maxillary and mandibular RBBs. Studies have reported higher success rates in the maxillary arch[11] ; no difference between arches[20] ; and higher success rates in the mandibular arch[21] .

A number of studies have compared the success rates of anterior versus posterior RBBs. The majority of studies[20,21,22] have shown significantly greater retention rates of anterior RBBs compared to posterior RBBs, however, one study[23] actually reported higher retention rates in posterior RBBs. In posterior RBBs, survival rates for the maxillary arch are reported to be significantly greater than the mandibular arch[24-26]. Success rates have been reported to be high in RBBs provided by dental undergraduates[11], but a study in 1999 reported a high failure rate of RBBs provided in the NHS General Dental Services demonstrated by a high number of claims for re-bonding[27] .

DESIGN

Perforated vs non-perforated

The first bridges described by Rochette[1] were perforated, to allow the resin cement to enter the perforations and provide macromechanical retention through the formation of resin 'rivets'. This design, however, led to failure following erosion of the composite from the perforations, and indeed recent research[28] has shown that failure occurs due to deformation at these perforations. Following developments in micromechanical bonding and in resin cements, allowing chemical bonding to the metal wing, the perforated design fell into disuse. A number of studies[16,21,29,30,31] in the late 1980s and 1990s confirmed the superiority of the non-perforated design over the perforated one, although some of the studies[30,31,32] showed that the perforated bridges showed superior survival rates following rebonding. Given the range of excellent cements now available, the non-perforated wing is now, regarded as the most appropriate choice of design.

Number of abutments

The issue of what is the optimum number of abutments for a RBB has followed a similar pattern to that of the perforated wing issue, although there is still no definite consensus of opinion. The initial Rochette bridges were retained by two wings either side of the pontic (fixed-fixed). The main drawback of this approach, however, is

Figure 6. *Grossly resorbed alveolar ridge following childhood trauma. Implant treatment was initially attempted, but the alveolar bone graft failed, resulting in insufficient bone levels for successful implant placement. The patient was not keen to wear a removable partial denture, so a resin-bonded bridge was attempted, explaining to the patient the potential draw-backs associated with the resorbed ridge.*

Figure 7. *Resin-bonded bridge in situ, with pink porcelain to replicate the lost gingival tissue. The patient was extremely happy with the final result. Note the slight discrepancy in the occlusal plane. This was necessary to prevent excessive excursive forces on the pontics.*

that if only one of the retaining wings debond or partially debond, dental caries can quickly and 'silently' develop[33]. When it was shown that following debonding, the other abutment could successfully act as the only retainer, the concept of the cantilever resin-bonded bridge quickly grew in popularity. Indeed, a number of studies[17,34] have shown that cantilever designs perform as well, if not better than fixed-fixed designs, with high success rates[19] and are less liable to problems[17,23]. Research has also confirmed that 'double-abutting' RBBs is inappropriate due to increased likelihood of dental caries beneath one of the retainers[17]. The use of a RBB to restore spaces of more than one tooth width, as a defined issue has not been extensively researched, although most authorities would agree that this is only appropriate in a small number of carefully-selected cases.

The case for using a fixed-fixed design is perhaps stronger in certain clinical situations, especially where the amount of enamel for retention needs to be maximised. This might be the case where posterior teeth are to be replaced, or in the case of lower incisors, with a small surface area of enamel. A fixed-fixed RBB could also be employed to provide an element of periodontal splinting, in addition to the requirement for space restoration. Another clinical situation where a fixed-fixed design may be appropriate is following orthodontic treatment. In cases where post treatment stability may be of concern, such as canines which have been derotated, a fixed-fixed design can be employed to provide a form of post treatment splint. Given the current evidence advocating the use of cantilever designs, it is perhaps surprising that a recent study[35] showed that a significant number of dentists are still prescribing fixed-fixed designs and double abutments.

Surface area

As a RBB relies on micromechanical bonding as its primary form of retention, it follows that maximising the surface area of the retaining wing will increase the bond strength of the restoration, and has been shown to affect the success rate[14]. The concept of 180 degree 'wrap around' is now generally accepted as desirable in retainer design[22]. This approach must be tempered however, by the aesthetic requirement for the wing not to be visible, and to minimise the amount of 'greying out' of the abutment tooth. Careful consideration of design must be employed, especially in the incisal areas and in rotated abutments. The effect of 'greying out' can be reduced by the use of an appropriate cement[36]. If it is felt that there is insufficient surface area for bonding, then consideration can be given to crown lengthening by electrosurgery or conventional surgery (Figs 8 & 9). Even if sufficient enamel is present, a recent study[37] showed that following conventional etching procedures, over 69% of the lingual surface area of the teeth studied was unetched, with only 2% of the surface area ideally etched. This highlights the technique-sensitive nature of RBB placement. For the provision of posterior RBBs, many authorities recommend the use of occlusal rests, although in most situations this will necessitate preparation of the abutment tooth.

Preparation

As already mentioned, there is much debate as to the ideal amount of tooth preparation required, ranging from no preparation, to significant preparation resulting in a 'minimal' three-quarter crown preparation. As with most aspects of dentistry, it is reasonable to assume that specific aspects of design should be influenced by the individual clinical situation. The need for preparation will be influenced by factors such as the occlusion, the articulatory guidance, the clinical crown height and inclination of the abutment(s). Another factor that will affect the decision on preparation is the need for rigidity in the framework. It is generally accepted that a minimum thickness of 0.7mm is necessary for the required rigidity. Retainers less than 0.7mm have been shown to have reduced resistance to dislodgement in laboratory studies[38]. A number of studies[24,39,40] including a meta-analysis[41] have reported the preparation of abutment teeth to have a positive effect on the success-rate of RBBs. Two studies[42,43] have analysed the photoelastic stress in RBBs, and concluded that preparation of vertical grooves at the proximolingual line angles and a lingual chamfer margin should be included to reduce the stresses on the cement bond. The use of vertical grooves has also been shown to increase resistance to debonding forces in laboratory studies[44]. Further clinical studies[24,40] have recommended the use of vertical grooves as a method of increasing survival. Other preparation forms include a

Figure 8. *Absent upper laterals with gingival overgrowth over palatal aspects of upper canines, resulting in insufficient surface area for cementation of resin-bonded bridges. Note fixed retainers on central incisors to prevent relapse of median diastema, following orthodontic treatment.*

Figure 9. *Resin-bonded bridges in situ following electro-surgery to palatal aspects of upper canines to expose 2-3 mm extra surface area for bonding.*

central concavity in the abutment tooth and/or the use of a cingulum rest. Many clinicians utilise tooth preparation to aid location when fitting the restoration.

In posterior teeth, there is more of an argument for tooth preparation in order to provide 180 degree 'wrap around' and occlusal rests. In laboratory studies, the use of proximal grooves has been shown to significantly increase retention/resistance in maxillary second molars, but have less of an effect on mandibular second molars[45]. Some clinicians prefer the use of small occlusal rest seats, whilst some recommend more extensive occlusal coverage. It is important during preparation to try to avoid dentine exposure. Some authorities recommend that if inter-occlusal space is not adequate for the minimum 0.7mm thickness of retainer, then the restoration can be cemented 'high', with little or no tooth preparation. The occlusion should re-establish through intrusion of the involved anterior teeth and over-eruption of posterior teeth (the Dahl principle)[46,47]. If this is done then the bridge should be designed so that the occlusal forces are directed through the long axes of the teeth, to avoid unwanted tooth proclination.

Alternative designs/Recent developments

A number of alternative designs have been reported for RBBs over the years. These include 'hybrid' bridges[23], which involve Maryland cantilevers that slot into conventional units; two-part RBBs[48], suggested for use when abutment teeth have unequal root surface areas; and a RBB with a non-rigid connector[49] (which remained in place for seven years, as reported in a case report). The use of all-ceramic RBBs has been described[50], most recently the 'Carolina bridge', which relies on bonding of the ceramic pontic to interproximal enamel for retention, hence, negating the need for a retaining wing[51]. A number of studies[52-54] have described the placement of direct fibre-reinforced RBBs with promising results, giving clinicians a rapid, simple and cost-effective means of replacing anterior teeth in selected patients.

Laboratory considerations

The main laboratory considerations are the type of material from which the metal retainer is constructed, and the surface treatments that are applied to the fitting surface of the wings. The most commonly used alloy for the retainer is nickel-chromium, due to its rigidity[55]. Other non-precious alloys include cobalt-chromium, although this is not as rigid as nickel-chromium. In the case of allergies to non-precious metals (especially nickel) being a consideration, a precious metal alloy can be used, although these are significantly less rigid.

The surface treatments that can be used include sandblasting, etching and silicate-coating. Other, less commonly used surface treatments include oxide formation on high-copper content yellow gold[56] and tin plating of precious alloys[57]. It is important that the correct cement is used for the surface treatment that has been applied to each retainer surface. For example, following sandblasting, the adhesion relies on a chemical bond between the cement and metal oxide layer on the alloy's surface. The cement used must incorporate 4-META or phosphate groups, to provide the necessary chemical bonding. An example of an appropriate material, following sandblasting, for use as a cementing agent, is resin composite of low filler-particle content. A number of studies have examined the effect of surface treatment and type of cement used, and found no significant difference between etching, sandblasting, and silicate-coating and their respective cements[24,26,40]. Therefore, given the simplicity of the sandblasting method, it would seem reasonable to consider this the most appropriate surface treatment in the majority of cases, when used in conjunction with the appropriate resin cement.

Try-in

At the planning stage it may be useful to construct a 'mock-up' of the final restoration by asking the laboratory to create an acrylic stent from the wax-up. Using this stent and auto-polymerising temporary acrylic material, in an appropriate shade, the patient can be given an idea of how the final pontic will look with regards to size, contour etc (Figs 10-12). If there are any problems with the aesthetics, they can be addressed at this early stage, rather than following construction of the final restoration.

When trying-in the final RBB, the fit, stability and aesthetics should all be assessed. The retaining wing should be closely approximated to the abutment tooth with no marginal discrepancies. If preparation was conducted, then the restoration should locate along the path of insertion, accurately into all preparation features, such as grooves, rest seats and finishing lines. In an ideal situation and especially for posterior RBBs, there should be a definite 'sense' of physical retention and resistance form. Aesthetics can be assessed by simply holding the bridge in place and giving the patient a mirror with which to view the restoration. As with all porcelain restorations, it is important for the patient to view the restoration in a number of different lighting situations, in particular, natural light. Prior to cementation, there will be exaggerated grey 'shine-through' on the abutment tooth, which can be reduced or even eliminated by using an appropriate opaque cement. A method of trying-in the restoration using a dental lining material as temporary cement, has already been described[12]. If this technique is used it is important to re-sandblast the retainer to remove contaminants. The occlusion and articulation of the bridge are difficult to accurately evaluate at the try-in stage and, in truth, these aspects are often only properly viewed once the restoration is cemented. It can sometimes be helpful to suspend the bridge in place with floss in order to attempt to assess the occlusion and articulation.

Cementation

The RBB is a technique-sensitive restoration, and cementation is one of the main stages where errors can be made. Following selection of the appropriate resin cement, it is mandatory that the manufacturer's instructions are followed to ensure optimum bonding. With regards to isolation and moisture control, the gold standard is the use of rubber dam. There are various techniques for using a rubber dam in the cementation of a RBB, one of the most appropriate being the 'trough technique'. A study, however, has shown that method of isolation was not a significant factor in success rate of the bridges studied[14]. Etching of the enamel surface should be thorough to avoid the problem of under-etching, as already described[37]. The restoration

Figure 10. *Acrylic stent in place to construct bridge 'mock-up' to replace missing upper lateral incisors.*

Figure 11. *Acrylic pontics being held in place, allowing patient to assess size and contours. This process was deemed necessary in this case due to the minimal space available for the pontics. Following the mock-up the patient decided that she was happy to have the bridges constructed without the need for further orthodontics to create more space.*

Figure 12. *The final restorations in place.*

should be seated firmly and stabilised for long enough for the material to fully set. Excess cement should then be removed and if using auto-polymerising cements that are inhibited by the presence of oxygen, the necessary oxygen-excluding medium should be applied for an appropriate length of time. Following this, any remaining set cement at the margins can be removed with rotary instruments. If necessary, further 'fine' finishing may be required at the review stage.

After cementation the occlusion can be checked properly. If the RBB has been cemented 'high' (using the Dahl approach), the patient should be informed that the occlusion will temporarily feel 'altered', although should return to normal within a few weeks. Articulation should also be checked thoroughly. Excursive forces on the pontic of the RBB should be planned on an articulator and kept to a minimum.

Recementation

A significant advantage of the RBB is that if the restoration debonds, provided the restoration is recovered and not damaged in any way, it can be rebonded successfully. It is essential that the metal retainer is first thoroughly sandblasted to remove any debris and contaminants, and to prepare the surface for the resin cement. The abutment tooth surface should also have any traces of cement removed to maximise the surface area of enamel for bonding. It is important not to remove any enamel during this stage, as the restoration will not relocate properly.

It is important to try to ascertain the reason for debond. If this was due to aspects of design, occlusion or case selection, then these aspects should be addressed before considering rebonding. If no other reason can be found for the debond, it may be assumed that the reason was failure of the cement, and rebonding attempted. A number of studies[58-60] have reported decreased success rates for recemented RBBs, although longevity was still acceptable enough for rebonding to be attempted. If multiple debonds occur then other reasons for failure should be investigated more thoroughly.

CONCLUSION

In conclusion, the RBB has been around in various forms for a number of decades. It has proven to be an extremely valuable restoration, and should always be considered as a treatment option when single units are to be replaced with adjacent sound teeth. The advantage of minimal preparation leads many clinicians to think of the RBB as a non- or minimally invasive restoration. Although there is a great variety in the design of these restorations and they are generally considered as technique-sensitive, they have a proven high success rate in many clinical trails. New designs and improvements in technology, such as in resin cements, suggest there may be further developments in the near future.

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