The Use of All-Ceramic Resin-Bonded Bridges in the Anterior Aesthetic Zone

Abstract: For several years, all-ceramic resin-bonded bridges (RBBs) have been considered an aesthetic treatment option for the replacement of missing teeth in the anterior region. With continued developments in technology, various different ceramic materials have been used to fabricate all-ceramic RBBs including zirconia, glass-reinforced, alumina-based ceramics, and lithium disilicate glass ceramics. The aim of this article is to provide an overview of all-ceramic RBBs, the advantages and disadvantages associated with these prostheses, as well as to demonstrate their application in replacing missing anterior teeth.

CPD/Clinical Relevance: To present the current literature and clinical application of all-ceramic resin-bonded bridges for replacing missing anterior teeth.

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Resin-bonded/resin-retained bridges (RBBs/RRBs) are a well-recognized minimally invasive fixed prosthetic tooth replacement option. They have been in use since the 1970s, being briefly described by Rochette for their use in periodontal splinting before Howe and Denehy described in detail the use of perforated cast retainers for replacing missing teeth as a temporary restoration. However, these initial restorations demonstrated poor longevity.

In the intervening 40 years, with advancements in adhesive cements, improved understanding of retention methods, design of the prosthesis and developments in the materials used for RBB construction, it is now regarded as a predictable long-term tooth replacement option. There are a number of treatment options available when replacing missing teeth. These include resin-bonded bridgework, conventional fixed bridgework, conventional dentures and implant-retained prostheses.

RBBs have been shown to have a reasonable survival rate with systematic reviews estimating the five-year survival rate for RBBs at 87.7%, conventional bridges at just over 90% (dependent on the design) and 94.5% reported for implant-retained single crowns. Despite this slightly lower survival rate, RBBs are a simple, minimally invasive tooth replacement option for replacing a short span or single tooth and can be used as both an interim or definitive tooth replacement option. RBBs are also less invasive with reduced biological consequence in comparison to other tooth replacement options, such as conventional bridgework. They have reduced costs, and have been shown to have high patient satisfaction.

One of the main disadvantages of metal-winged RBBs is the greying effect of the metal wing showing through the abutment teeth, also known as ‘shine through’ (Figures 1 and 2). They also have the rare disadvantage of a higher corrosion rate, and an allergenic potential to the non-precious alloys used.

Increasingly, patients are becoming more demanding and have higher expectations for their oral health. They also want attractive aesthetic dentistry. These increased aesthetic demands of patients and a reluctance for intra-oral metal have led to the development of metal-free restorative alternatives; this includes the all-ceramic RBB, which is able to address this aesthetic issue.

All-ceramic RBBs were introduced in the early 1990s as a more aesthetic alternative to traditional metal-winged RBBs and have been subsequently...
optimized for the anterior aesthetic region. With continued development in resin and ceramic technology, it is now possible to replace missing anterior teeth with all-ceramic RBBs successfully.19-21

The aim of this article is to present the current literature and clinical application of all-ceramic resin-bonded bridges for replacing missing anterior teeth.

All-ceramic RBBs

Dental ceramics have come a long way from the low-strength ceramics bonded with poor adhesives to modern day high strength ceramics with improved adhesive technology, which are able to be used in a number of clinical situations. Two properties that are often quoted as weak points of ceramics are strength and fracture toughness,22 however, with advances in ceramic technology these are becoming less of an issue.

Planning and prescribing ceramic-based restorations can be confusing and deciding on the best ceramic material for each clinical scenario is a challenge. This issue was highlighted in a systematic review by Conrad et al.23 The review demonstrated that there is not a single universal ceramic material or system for all clinical situations, and that success is dependent upon the clinician to match the materials, manufacturing techniques, and cementation or bonding procedures with the individual clinical situation.23

Advances in high-strength ceramic systems have enabled the fabrication of robust and aesthetic cantilevered, all-ceramic RBBs.4 Evidence has shown that all-ceramic RBBs can be successful, and have relatively high success rates.19-21 Currently, however, they don't appear to be as successful as traditional metal framed RBBs, as shown in a review by Miettinen and Millar.17 This review stated that all-ceramic RBBs had an estimated annual failure rate of 11.7% whilst metal-framed RBBs had a failure rate of 4.6%.17

Table 1 shows the advantages and disadvantages of all-ceramic RBBs in comparison to traditional RBBs.

Ceramic types for all-ceramic RBBs

A variety of ceramic materials has been used to fabricate anterior all-ceramic RBBs, including feldspatic porcelain, zirconia, glass-infiltrated alumina and hot-pressed ceramics.19,21,25,26-38

Zirconia offers superior strength, fracture resistance and toughness,18 however, one of the problems with using zirconia is the inability to attain an adhesive bond. This is thought to be due to the lack of silica, and glass phase within the ceramic39-41 and its acid resistance, making it ineffective to traditional glass-etching treatments with hydrofluoric acid and bonding with subsequent silane application.42,43 There have been a number of studies that have examined ways to improve the bonding to zirconia, with the use of surface treatments44 and a variety of primers,45-47 which show some positive results in improving bond strength, but this will need to be verified with further studies. The use of zirconia in the provision of all-ceramic RBBs is documented within the literature.48 However, as the long-term success of RBBs is strongly dependent on the bond between the restoration and the tooth structure, zirconia isn’t seen as a predictiable material to use in the fabrication of RBBs. A randomized controlled trial by Sasse et al, examining single retainer all-ceramic zirconia RBBs using different bonding systems over a 55-month period, indicated that success was relatively high. However, the most
common complication was debonding.\textsuperscript{21} Additionally, a commonly reported issue with zirconia RBBs is fracturing of the veneering porcelain if a veneering technique is utilized.\textsuperscript{18}

Another study, by Sailer and Hämmerle, assessing 15 anterior cantilever all-ceramic zirconia RBBs with a follow-up of 8 years (mean follow-up of 53.3 months), reported 100\% success. There were, however, two RBBs that encountered early debonds which were successfully re-cemented with no other complications reported (Figures 3 and 4).\textsuperscript{49}

Glass-infiltrated alumina ceramic materials have improved physical properties with the addition of alumina, and as such the literature has reported their use in the construction of all-ceramic RBBs. An 8-year study by Galiatsatos and Bergou, examining anterior glass-infiltrated alumina all-ceramic RBBs, found reasonable success of 85.18\%. However, there were complications and failures which included debonding and fracture of the porcelain.\textsuperscript{20}

Another study by Kern, evaluating the long-term survival of two-retainer and single-retainer glass-infiltrated alumina all-ceramic RBBs, found that success was 92.3\% in the single-retainer group and 67.3\% in the two-retainer group over 5 years.\textsuperscript{19} This study also demonstrated that fracture of the porcelain was the most common complication occurring in 5 of the 37 RBBs and was predominately within the two-retainer group.\textsuperscript{19} This was also reflected in a study by Ries et al\textsuperscript{50} who investigated the effect of design of glass-infiltrated alumina all-ceramic RBBs on clinical survival rate and found that a two-retainer design RBB had a higher frequency of fracture. The authors proposed that clinical performance of RBBs made of a high-strength glass-ceramic is in large measure dependent on their design, with a recommendation of a cantilever design rather than a fixed-fixed design.\textsuperscript{50} A comparative study by Saker et al, comparing 20 anterior alumina glass infiltrated RBBs with 20 traditional metal ceramic RBBs over a 60-month period, found fewer complications with metal ceramic RBBs with no debonds than the all-ceramic group, which had three debonds and fracture of the porcelain in two cases.\textsuperscript{51}

Lithium disilicate glass ceramic is another material used within the literature for all-ceramic RBBs. It is composed of lithium disilicate crystals within a glass matrix Li$_2$Si$_2$O$_5$. It has high strength and good aesthetics,\textsuperscript{52} which is mainly due to its excellent translucent properties. In two observational studies looking at its use in all-ceramic RBBs, one study reported ‘high success’ over 3 years in 22 patients,\textsuperscript{53} and the other study of 35 patients reported 100\% success with high patient satisfaction.\textsuperscript{18} Another study by Sailer et al, examining 35 all-ceramic RBBs over a 6-year follow-up using either IPS E.max press or IPS Empress (Ivoclar Vivadent, Enderby UK) (leucite–reinforced glass ceramic) cemented...
with a variety of luting cements, showed 100% success rate. However, complications occurred such as chipping of the porcelain in 5.7% of cases and wear of the porcelain in 74.3% of cases.\(^{55}\)

Overall, when reviewing the effect of the type of ceramic on the outcomes of success for all-ceramic RBBs, there is currently a lack of evidence to support one ceramic material over another. There is therefore a need for long-term clinical studies with large patient numbers to assess this.

In this article the all-ceramic RBBs were formed of IPS e.max Press (Ivoclar Vivadent), a leucite-based, glass-ceramic. This ceramic is reported as having high compressive strength (400 MPa). It also has a variety of shades, translucency and opacity to produce good aesthetics.\(^{46}\) It is able to attain an adhesive bond and has higher bond strength to resin cement compared to other oxide ceramics\(^{57,58}\) (Figure 5).

**Complications**

It has been reported, in a review by Miettinen and Millar,\(^{17}\) that all-ceramic RBBs have a higher failure rate in comparison to metal-framed RBBs, with an estimated annual failure rate per year of 4.6% for metal-framed and 1.7% for all-ceramic resin-bonded bridges.

One of the most commonly reported reasons for all-ceramic RBBs failure is fracture of the framework.\(^{17,20}\) Miettinen and Millar\(^{17}\) reported that fracture of the framework accounted for 57% of all failures. This fracture of the framework commonly occurs at the connector,\(^{17,19}\) and in particular where there is inadequate thickness of the connector for the specific ceramic being used. Higher rates of fracture have been shown when lower strength ceramics are used, such as glass-infiltrated alumina,\(^{49}\) and appear to occur less with higher strength ceramics such as zirconia.\(^{21}\) Another common cause of failure of all-ceramic RBBs is debonding.\(^{17,20}\) This is more common in ceramics that cannot be bonded to, such as zirconia, and less common with ceramics that can be bonded to, such as lithium disilicate.\(^{17,23}\) Delamination of the ceramic veneer material\(^{44}\) (if this technique is used) can also occur as the veneering technique has been shown to reduce the strength of the structure.\(^{40}\) The exact estimates of how frequently these complications/failures occur and the ability to estimate the life span of all-ceramic RBBs is difficult to estimate owing to the lack of evidence currently available. However, current evidence would suggest that traditional metal RBBs currently perform better over time than all-ceramic RBBs.

**Clinical considerations**

The comprehensive treatment planning process, clinical procedure and bridge design is similar to that of metal-winged RBBs. For all-ceramic RBBs, careful assessment of the connector is also essential, as evidence has shown a high rate of fractures in this area.\(^{17}\) The recommendation is to have a larger/thicker connector where possible, but this will vary on the type of ceramic material being used and should be checked with the manufacturer’s guidelines (Figure 6).\(^{17}\) This increase in thickness, however, can lead to issues including an over-contoured restoration or heavier preparation of abutments.\(^{17}\) It will also lead to a wider connector and visually look like a longer contact point, which may not be aesthetic, and therefore a diagnostic wax-up to assess this may help in the treatment planning and case selection process.

One of the advantages of all-ceramic RBBs is their improved aesthetics. They can be useful in circumstances where teeth have increased translucency (Figure 7). Using a metal-winged RBB would result in either an aesthetic compromise of producing a ‘greying effect’ at the area of translucency (Figures 1 and 2) or, by removing the metal wing in the area of the translucency, would reduce the surface area for bonding and increase the likelihood of failure. There are techniques which can be used to minimize the greying effect, including the use of an opaque cement. However, this will lead to loss of translucency at the incisal edge and may not be aesthetically acceptable to the patient.

By using an all-ceramic RBB, maximal coverage of the wing can be achieved, increasing the surface area for bonding and subsequent likelihood of success. This is also true of abutment teeth in sub-optimal positions whereby the RBB metal retainers may be visible. Reasonable aesthetics can be achieved using all-ceramic RBBs without compromising the surface area of the wing for bonding (Figure 8).

Evidence also suggests that the design of the prosthesis affects the success, with a cantilever design being more successful than a two-winged/fixed-fixed design for all-ceramic RBBs. This is also true for metal-winged RBBs,\(^{19,21,50}\) due to a higher incidence of unilateral framework fracture of the porcelain leading to the pontic being bonded to a single retainer in a cantilevered fashion.\(^{35}\) Despite this failure, the majority of the RBBs studied, which had subsequent removal of the failed retainer and were transformed into a cantilevered RBB, were successfully retained. It was proposed that a cantilevered design approach minimized shear and torque stresses placed on all-ceramic RBB frameworks, which was attributed to the differential tooth movement of the abutments during function.\(^{54,61-65}\)

There are very few studies evaluating the use of all-ceramic RBBs to replace posterior teeth, and therefore this technique cannot be recommended for such use without further comprehensive studies to provide an evidence basis to support this.

The occlusion of the restoration being provided must also be considered like any other restoration. For all-ceramic RBBs the thickness of the retainer is going to be greater and therefore requires more care in selecting the correct cases for its use. An all-ceramic RBB would work favourably where there is sufficient interocclusal clearance and a favourable occlusion (such as replacement of an upper lateral in a Class III incisor relationship with a reverse overjet).

Where there is a lack of interocclusal space in which to place the restoration, the options are either to prepare the tooth to provide the space required or increase the occlusal vertical dimension (OVD) using the Dahl concept. However, preparation of the tooth to provide adequate space for a ceramic RBB may be aggressive in nature and will often lead to the preparation extending into dentine, which will compromise the bond strength and increase the likelihood of failure via debonding. The other alternative is to place the prosthesis high in the occlusion and allow the remaining dentition
to re-establish occlusal contact over time. However, this increase in OVD may be too excessive, due to the space required for adequate thickness of the retainer, and therefore may not be appropriate.

The cementation of the restoration is vital as it is a common cause of RBB failure of both all-ceramic and metal-winged RBBs. The cementation process allows high retention of the prosthesis, prevents microleakage and increases fracture resistance of the restoration. The cementation process for all-ceramic RBBs should always follow the manufacturer’s guidelines for the specific ceramic being used and the clinical situation for which it is being utilized. In the cases shown, the IPS e.max Press all-ceramic RBBs had the ceramic surface prepared with IPS Ceramic Etching Gel and silanized with Monobond Plus and cemented with Multilink® Automix. However, Variolink® can also be used (as per the manufacturer’s guidelines) (Figure 5, 6, 8, 9, 10). In the case using 3M™ ESPE™ Lava™ Zirconia all-ceramic bridge, the ceramic surface was prepared with 3M™ ESPE™ CoJet™ Sand and silanized with ESPE™ Sil and cemented using Rely X™ ARC (as per the manufacturers’ guidelines) (Figure 3 and 4).

**Conclusion**

All-ceramic RBBs provide an excellent minimally invasive option for replacing missing anterior teeth. Often, the use of all-ceramic RBBs is overlooked by clinicians because of lack of familiarity or comfort with providing such a treatment. The current evidence has demonstrated the potential for high success rates in the short term for anterior, cantilevered, all-ceramic RBBs using various high-strength ceramics. Unfortunately, good long-term data directly comparing the clinical survival and complications associated with
metal-ceramic RBBs in comparison to all-ceramic RBBs are lacking. There is also a lack of evidence to support which ceramic and bonding system provides the best outcome for all-ceramic RBBs and there is a need for further high quality research in these fields.

Overall, all-ceramic RBBs have the main advantage of having improved aesthetics. However, the research that is currently available would favour the use of metal RBBs and this needs to be discussed with the patient to attain informed patient consent before proceeding. All-ceramic RBBs have a limited application to single tooth replacement as a cantilever design with favourable occlusion and currently have been shown to be less successful than their metallic counterpart.

As with all aspects of dentistry, there is a requirement of the clinician to select cases appropriately, ensure adequate treatment planning and make sure that the execution of treatment is to a high standard. It is also necessary to ensure appropriate laboratory support is available to fabricate these prostheses and that the prostheses are maintained and reviewed routinely to give the best possible chance of success and longevity.

References
31. Turker S, Guvenli S, Arikan A. Replacement of two mandibular central incisors using a zirconium resin-bonded...


