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The Use of Zirconium, Single-Retainer, Resin-Bonded Bridges in Adolescents

Abstract: This paper presents a series of case reports which demonstrate the replacement of the causes of tooth loss which primarily affect children by the use of all-ceramic resin-bonded bridges.

Clinical Relevance: To keep practitioners informed of alternative techniques and materials which can be used to replace missing teeth in adolescents.

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Patients have missing teeth for a variety of reasons. Although the most common cause of tooth loss is extraction as a result of caries or periodontal disease,¹ children are frequently affected by developmental disorders affecting tooth formation, including cleft lip and palate, and are at an increased risk of trauma leading to tooth loss.

In such childhood cases, the type of prosthesis provided to replace these missing teeth requires careful consideration. The options for replacing missing teeth include:

- Partial dentures;
- Single tooth implants;
- Conventional fixed-fixed or cantilever bridges and resin-bonded (also termed resin-retained) bridges.

Implants, although often considered the treatment option of

choice for adults, have been shown to react similarly to an ankylosed tooth when placed before the growth of the alveolar process has ceased,² and hence have a poor prognosis and cannot be recommended in children. Alternative treatment should be considered in these young patients until alveolar bone growth is completed and the patient is able to give informed consent for this complicated and irreversible treatment. Any treatment offered, however, should not preclude the placement of implants in the future should the patient so wish. For this reason, the conventional fixed-fixed or cantilever bridge is not appropriate. The preparation is not only irreversible, but damaging to tooth structure and, due to the presence of larger pulp chambers in young patients, there is a high risk of damage to the pulp.³ This, therefore, leaves the remaining viable options to be a removable partial denture or a resin-bonded bridge. The resin-bonded bridge is therefore often favoured.

Bullying of children within school is a very common problem, with

up to 21% of children having reported being bullied.⁴ A recent study, looking at social judgements by children, confirmed that children are likely to make negative social judgements based on poor dental appearance. This enforces the need to provide an aesthetically acceptable option to replace missing teeth in this age group.⁵

Resin-bonded bridges

The metal ceramic resin-bonded bridge has been used by practitioners for many years to replace single missing teeth, especially those in the anterior region. The success rate of this prosthesis is high⁶ and preparation is more conservative of healthy tooth tissue than the conventional bridge designs.⁷

However, much of the data surrounding the use and prognosis of these prostheses are related to adults rather than children. With respect to the childhood cases, in particular, the metal ceramic resin-bonded bridge does have significant disadvantages.

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The unabraded incisal edges of the anterior teeth in children often appear blue, grey or violet, with increased translucency due to the absence of dentine in this area. Metal ceramic materials struggle to replicate this natural appearance and the metal wing can result in a grey shimmer through the abutment tooth. There is an allergenic potential of the non-precious alloy.⁸

Any alternative material must be able to exhibit similar advantageous properties to the metal ceramic. In order for the material used to be successful, it must be able to provide the patient with a biocompatible, aesthetically pleasing, strong, sustainable and economically viable resin-bonded bridge. This is possible with the use of the all-ceramic resin-bonded bridge, which shares many of the advantages of metal ceramic without the disadvantages.

All-ceramic materials

Dentists have always strived to achieve aesthetic tooth-coloured restorations. This has encouraged the development of dental porcelains. The first all-ceramic tooth restoration based on a feldspathic composition was fabricated in the 18th century. Further developments have attempted to improve the fracture resistance of ceramic materials by increasing the crystalline content. Currently, there are four different groups of all-ceramic systems available on the market:⁹

1. Conventional ceramics;
2. Glass ceramics;
3. Glass infiltrated aluminium oxide;
4. Polycrystalline high performance ceramic.

Groups 1 to 4 (4 being the strongest) show a progressive increase in the flexural strength (tolerance to mechanical stresses) and the fracture toughness (resistance to crack propagation) of the material.¹⁰ The material properties in these all-ceramic materials vary owing to the differences

in their chemical composition and structure. The conventional ceramics (feldspathic porcelains), despite their ability to deliver excellent aesthetic properties as a result of their amorphous nature, are not physically strong. In the glass and glass infiltrated ceramics, fracture toughness is improved by the infiltration of a variety of filler particles into the glass matrix in order to improve the fracture toughness by blocking the propagation of cracks through the amorphous matrix. They are, however, inferior to polycrystalline ceramics. The matrix for polycrystalline ceramics is alumina or zirconia. In these materials, both filler and matrix are crystalline and all of the atoms are therefore packed regularly, creating a material which is more resistant to crack propagation. These materials are shown to provide both necessary aesthetics and material properties required of a modern tooth restoration.¹¹ They are also more stable than glass in the long term, which has been shown to be prone to corrosion in saliva.¹²

Polycrystalline ceramics have only been available for clinical use for approximately 10 years. However, it has only been since the advent of CAD/CAM techniques in the 1970s that high strength polycrystalline ceramics have been constructed and are suitable for dental application.

The cases documented in this paper demonstrate the use of the all-ceramic 3M ESPE Lava adhesive bridge system in the replacement of tooth loss in young patients.

The framework material for the Lava restorations, used in the case studies detailed, is the polycrystalline ceramic zirconia.¹³ The mechanical properties of zirconia are very similar to those of metals, and yet its colour is similar to natural teeth.¹⁴ For this reason, stabilized zirconia was nicknamed 'ceramic steel' by its inventor, Ron Garvie.¹⁵ The combination of zirconia with 3% yttrium creates a dense tetragonal stabilized zirconia which

further improves the key properties and enables the material to demonstrate high fracture toughness and flexural strength. When a stress occurs in this material, crystalline modification of the tetragonal stabilized zirconia grains results in localized expansion arresting crack propagation.¹⁵ These properties allow the Lava system to withstand many times the load level occurring in the mouth and to remain strong in very thin sections, and hence are ideal for a durable, resin-bonded bridge.

Apart from the material properties, the manufacture and processing of the all-ceramic systems can also significantly affect the performance of the final restoration. Fractures are often caused by cracks which begin as flaws on the material surface. Alternative manufacturing processes involve the milling of fully sintered ceramic materials, which usually leads to a reduction in strength of the restoration owing to the formation of micro-defects on the milled surface. However, Lava uses pre-sintered zirconia blanks which are milled into the required restoration while the material still has a soft and chalk-like consistency (green stage); this is then sintered into its full strength and density. The final sintering causes shrinkage to occur. In order to compensate for this, the milling is carried out in an enlarged form. The homogeneous structure of the tetragonal stabilized zirconia ensures shrinkage is uniform and predictable which, along with the high accuracy CAD/CAM milling technology, enables excellent marginal fit values to be achieved.^{16,17,18,19}

When replacing a single anterior missing tooth, aesthetics are paramount and appear to have the greatest influence on the patient's perception of dental restoration success. The ideal ceramic material, therefore, will imitate the polychromatic appearance of natural teeth and include a variation in hue, chroma, value and translucency.²⁰ In children's teeth,

translucency may be a problem. While metal retainers for resin-retained bridges may cause grey/blue shine through, all-ceramic alternatives do not encounter these problems.

Clinical considerations all-ceramic bridges

Careful patient selection is paramount for all types of resin-bonded bridge. Ideally, the patient should have:²¹

- Good oral hygiene;
- Involved teeth should be in their final occlusion;
- No parafunction;
- No periodontal mobility of the abutment tooth;
- No heavy occlusal load on the abutment tooth;
- Unrestored or minimally restored abutment tooth.

In order for the optimal properties of the Lava restoration to be achieved in the above patients, the manufacturer recommends several design considerations. The minimum thickness of the Lava wing is 0.6 mm and hence there should be sufficient inter-occlusal space to accommodate this. The connecting surface area of the Lava resin-bonded bridge must be at least 6.25 mm.^{2,22} Hence, all-ceramic resin-bonded bridges are only suitable when the distance between the interproximal papillae and the incisal edge is approximately 4 mm. This point can prove restrictive, particularly if there is reduced clinical crown height due to erosion or attrition; fortunately, in children toothwear of this severity is rarely seen.

Bonding system

Finally, the bonding system used to adhere the prosthesis and abutment tooth must be considered. A strong, durable resin bond provides high retention,²³ prevents microleakage²⁴ and increases fracture resistance of the restoration.²⁵

Surface treatment and cement selection are crucial in obtaining a strong resin bond between zirconium and tooth



Figure 1. Case 1: Pre-operative labial view.



Figure 2. Case 1: Pre-operative occlusal view.



Figure 3. Case 1: Post-operative labial view with all-ceramic resin-bonded bridges replacing the missing upper lateral incisors.



Figure 4. Case 1: Post-operative smile view.

structure. Zirconium surface treatments have moved to the use of tribochemistry, the application of mechanical energy to create chemical bonds, which have been shown to improve bond strength significantly when compared to air particle abrasion.²⁶ The resin-bonded bridges described in this paper used the tribochemical 3M ESPE CoJet Silicate Ceramic Surface Treatment System. This involves a soft high purity aluminum oxide (30 µm) modified with silica (SiO₂), which sandblasts the surface causing abrasion and ceramization, leaving SiO₂ impregnated. The coated surface must then be silanated in order for a bond to be created between the resin and zirconia. The silanation process used for the described cases was carried out by 3M ESPE Sil.

Panavia was used to bond all the resin-bonded bridges to the tooth structure in the case studies described. According to Kern *et al*, only the phosphate-modified resin cement *Panavia 21* is able to provide a long-term durable resin bond to zirconium oxide ceramic.²⁷

Case 1: Hypodontia

Hypodontia is a condition where one or more teeth are developmentally absent. The teeth affected, with most relevance to this paper, are the maxillary lateral incisors, which are shown to be missing in 1.6–1.8% of the population.²⁸ The treatment of children suffering from hypodontia is often multidisciplinary, an orthodontic opinion being sought to determine whether closing, opening and/or maintenance

of the space is required. In patients where the space is opened, prosthetic replacement with an 'all-ceramic resin-bonded bridge' may be considered.

A healthy 14-year-old girl presented to our paediatric department with aesthetic complaints regarding her missing upper lateral incisors. The patient was a regular attendee at her general dental practitioner, and had received orthodontic treatment, which had been completed one year earlier.

Following clinical and radiographic assessment, a diagnosis of hypodontia relating to the two upper lateral incisors was determined, of which there is a family history (Figures 1 and 2). Oral hygiene was found to be excellent and all teeth present



Figure 5. Case 2: Pre-op labial view with partial acrylic denture *in situ* replacing the missing upper right lateral incisor.



Figure 6. Case 2: Pre-op labial view demonstrating the extent of alveolar bone deficiency.

were sound. There was sufficient space present for aesthetic replacement of the upper lateral incisors and she was wearing an orthodontic retainer with prosthetic replacement of the teeth, which was acting as a space maintainer. All potential abutment teeth had good bone support, sufficient enamel thickness and were vital.

Articulated study models were used to assist in the treatment planning, and following joint restorative and paediatric opinion, it was decided that Lava resin-bonded bridge replacement of the upper lateral incisors, cantilevered from the canines, would be the treatment option of choice. Impressions were taken in silicone putty. The bridge was then manufactured, and finally cemented, using *Panavia 21*, following the manufacturer's instructions (Figure 3).

The importance of regular dental reviews, good oral hygiene and the need to return for treatment if de-bonding occurred was stressed. The patient was happy with the result and natural appearance (Figure 4).

Twelve months later the bridges remain successful with no complications.

Case 2: Cleft lip and palate

The presence of dental abnormalities is commonly associated with cleft lip and/or palate patients. The prevalence of hypodontia in these patients has been shown to be around 47.5%,²⁹ with the upper lateral incisor being the most susceptible to injury in the area of cleft in both the deciduous and permanent dentitions.³⁰ Orthodontic

treatment is often required and may be used to move the canine into the space of the lateral incisor; with appropriate restorative treatment, aesthetics can be favourable. The alternative is to replace the missing tooth prosthetically. However, problems can occur where the cleft has led to reduced alveolar bone height. Replacement of this alveolar bone and gingival tissue is required in these cases in order to optimize aesthetics.

A healthy 16-year-old girl was referred by the cleft team regarding replacement of her missing upper lateral incisor. She had previously been treated for a right unilateral cleft and had undergone orthodontic treatment to align the arches and open space for the UR2. Treatment had been carried out to attempt replacement of this tooth with a conventional resin-bonded bridge, which had been unsuccessful and had subsequently fractured.

At presentation, the patient was wearing a partial denture to replace the tooth, which she was understandably keen to replace with a fixed alternative (Figures 5, 6). On examination, it was noted that there was significant bone loss in the region of the UR2 associated with the cleft and hypoplasia of the UR1. It was decided that, firstly, composite build-up of the UR1 was required, followed by all-ceramic resin-bonded bridge replacement of the UR2, along with the use of pink porcelain to replace the deficient cervical margin. The UR3 was prepared and silicone putty impressions taken. The bridge was then manufactured (Figure 7).

Panavia 21 was used following



Figure 7. Case 2: Bridge prior to cementation, including pink ceramic to replace lost soft tissue.



Figure 8. Case 2: Cementation of bridge.



Figure 9. Case 2: Post-op labial view of all-ceramic resin-bonded bridge *in situ*.



Figure 10. Case 2: Twelve months post-operative smile.

the manufacturer's instructions to cement the bridge (Figures 8, 9). The patient appeared happy with the aesthetic results and no problems have been seen 12 months post-operatively (Figure 10).

Discussion

The use of zirconia products in dentistry is growing; however, its use in children still remains relatively poorly documented. Considerable progress in all-ceramic systems enables the creation of aesthetic and durable resin-bonded bridges that are preservative to the tooth structure. These two case reports demonstrate that Lava appears to be a viable option for the treatment of childhood specific tooth loss. However, further clinical research and case studies are required in order to confirm these findings, in particular with reference to the long-term survival of these prosthesis.

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