Minimally Invasive Preparation and Design of a Cantilevered, All-Ceramic, Resin-Bonded, Fixed Partial Denture in the Esthetic Zone: A Case Report and Descriptive Review

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ABSTRACT
Resin-bonded, fixed partial dentures have the potential to offer a minimally invasive, fixed-prosthetic approach to tooth replacement in patients who may not be candidates for implant therapy. However, traditional preparation protocols often recommend extensive preparation designs on two abutment teeth, thereby potentially compromising the long-term health of the adjacent abutments and often resulting in unilateral debonding of one of the retainers in the long term. In light of advances in high-strength ceramic systems capable of being reliably bonded to tooth structure and offering improved esthetic outcomes, as well as clinical and case-series research demonstrating improved survivability of cantilevered resin-bonded fixed partial dentures, new preparation designs and methodologies can be advocated. The following case report demonstrates the clinical application of sonoabrasion, coupled with a dental operating microscope, to minimally prepare a single abutment for a cantilevered, all-ceramic resin-bonded fixed partial denture. Relevant historic and contemporary literature regarding double versus single-retainer resin-bonded fixed partial dentures are reviewed, as well as clinical conditions that are most favorable for such restorations to have an optimal long-term prognosis.

CLINICAL SIGNIFICANCE
If appropriate clinical conditions exist, a cantilevered, all-ceramic, resin-bonded, fixed partial denture may be the most conservative means of tooth replacement in a patient who is not a candidate for an endosseous implant. (J Esthet Restor Dent ••:••–••, 2013)

INTRODUCTION
Implant therapy has the potential to offer patients a predictable, minimally invasive, fixed, and potentially esthetic replacement solution to partial edentulism. However, there are many patients for whom a single-tooth implant may not be the first or optimal choice for tooth replacement yet still seek a fixed replacement strategy. These patients include those who have compromised immune status or other uncontrolled systemic diseases that would negatively impact surgical healing, are pregnant, have incomplete skeletal growth, have insufficient apical root spacing to enable placement of an implant, are heavy tobacco users, or have financial limitations. Patients who fulfill specific clinical criteria can potentially benefit from contemporary minimally invasive adhesive approaches that enable a fixed prosthetic replacement via the use of...
a cantilevered, all-ceramic, resin-bonded, fixed partial denture (RBFPD).

RBFPDs were first proposed in the early 1970s and, in the intervening 40 years, have continued to evolve their design and luting protocols based on advancements in prosthetic materials and adhesive systems. Howe and Denehy's initial designs of such prostheses advocated for the incorporation of perforated metallic retainers to optimize retention of the adhesive luting agent. Livaditis and Thompson subsequently developed a method for etching nonperforated, nonprecious metal alloy retainers that improved the longevity of the resin-metal retainer bond by protecting the resin interface from abrasion or leakage. To prevent premature failure or unilateral debonding, designs for RBFPDs often promoted mechanical resistance with design elements such as rest seats, channels and/or slots, struts, and grooves. Such preparation strategies, however, sacrificed additional tooth structure and often moved the preparation into dentin, making such a restoration significantly more invasive and potentially prone to developing caries if a retainer debonded.

Since the early to mid 1990s, all-ceramic RBFPDs were subsequently optimized for the anterior esthetic region, facilitating predictable bonding to tooth structure and enhanced esthetics by eliminating the requirement for metallic retainers that lowered the value of the abutment teeth that supported them. Initial all-ceramic, two-retainer RBFPDs demonstrated a high incidence of unilateral framework failure because of fracture, which left the pontic bonded to a single retainer in a cantilevered fashion, often for a significant amount of time. Rarely were there instances of failure at the ceramic-resin-enamel bond, consistent with in vitro studies that demonstrated that resin bond strengths of such all-ceramic RBFPDs exceeded the fracture strength of the all-ceramic RBFPDs.

Concurrent with investigations into all-ceramic RBFPDs, multiple investigators documented the prolonged survival of two-retainer RBFPDs that had become unilaterally debonded and essentially transformed into cantilevered RBFPDs. These investigators thus proposed a cantilevered design as a de facto approach in minimizing shear and torque stresses placed on RBFPD frameworks that was attributed to differential movement of the abutments during function, ascribable to their respective periodontal ligaments.

Subsequent clinical trials and case-series studies have independently demonstrated the potential for high success rates not only for metal-ceramic cantilevered RBFPDs but additionally for cantilevered all-ceramic RBFPDs of various high-strength ceramic systems. Unfortunately, long-term, randomized, prospective, clinical trial data directly comparing the clinical survival and complications associated with metal-ceramic RBFPDs, as compared with all-ceramic RBFPDs of either design, are absent in the literature. Such data would be valuable to clinicians to offer evidence-based criteria on which to base clinical treatment. With regard to all-ceramic RBFPDs, Kern evaluated the long-term survival of both two-retainer and cantilevered anterior RBFPFs, and reported a 5-year survival rate of 73.9% in the two-retainer group and 92.3% in the single-retainer group. If unilateral fracture of the two-retainer group was accepted as a criterion for failure, the 5-year survival decreased to 67.3%. Emerging data are therefore promising with regard to the potential for cantilevered, all-ceramic RBFPFs to serve as a minimally invasive treatment modality for patients who are not candidates for, capable of, or interested in having a single-tooth implant restoration. Often, a treatment strategy including cantilevering an all-ceramic RBFPD is overlooked by clinicians because of lack of familiarity or comfort with such a treatment approach.

The following case report documents the use of minimally invasive diamond oscillating instrumentation, with the aid of a dental operating microscope, to prepare and restore a congenitally missing maxillary lateral incisor using a cantilevered, all-ceramic RBFPD fabricated from lithium disilicate (IPS e.max Press, Ivoclar Vivadent, Amherst, NY, USA) in a patient who was not a candidate for implant therapy.
Case Report

A 17-year-old healthy male was referred to the authors’ intramural practice at The University of Iowa, College of Dentistry for evaluation and replacement of the maxillary left lateral incisor (#10), which was congenitally missing (Figure 1). The patient had recently completed comprehensive orthodontics that included space preparation of #10 for an eventual single-tooth implant (Figure 2). However, the patient had yet to complete skeletal growth and was nearing departure for post-secondary education, therefore precluding implant therapy. The patient expressed desire for a fixed restoration for the time period leading up to a single-tooth implant; therefore, the established treatment plan called for an RBFPD as a long-term provisional restoration. Such a strategy enabled the patient to complete skeletal growth and to decide upon an optimal time to pursue implant therapy based on the patient’s biological, personal, and financial circumstances. Additionally, the prosthesis provided long-term orthodontic stability of the adjacent abutments that was critical to future implant therapy success. The patient was informed of the alveolar bone and soft-tissue deficiency at site #10 and was offered a subepithelial connective-tissue graft prior to restoration fabrication to aid in esthetic integration of the RBFPD.

FIGURE 1. A, Frontal view of initial clinical presentation demonstrating asymmetry of the maxillary central incisors and the congenitally missing maxillary left lateral incisor. B, Lateral view of initial clinical presentation demonstrating inadequate residual ridge volume and soft-tissue texture apical to site #10.

FIGURE 2. Periapical radiograph at conclusion of comprehensive orthodontic treatment to provide space for a future endosseous implant after completion of skeletal growth.
The patient declined this option and preferred to defer this treatment until implant therapy could commence.

Clinical evaluation of the patient’s maxillary anterior segment revealed asymmetry of the central incisors alignment and length, with #9 presenting 0.7 mm shorter in length and 0.5 mm lingual displacement compared with #8. The patient requested that the central incisors display symmetry of length and prominence, and an additive direct composite restoration for #9 was included in the treatment plan. The teeth adjacent to site #10 revealed intact, noncarious, virgin teeth (Figure 3A). Additionally, occlusal analysis revealed a slight anterior open bite, and an end–end canine relationship on the patient’s left side (Figure 3B). The occlusal scheme, combined with a desire by the patient for a minimally invasive yet durable fixed restoration, resulted in a scenario optimal for a cantilevered RBFPD. The patient was informed that minimal preparation would be necessary and that upon eventual commencement of implant therapy, the connector could be sectioned, and the remaining porcelain wing left bonded to the cingulum of #11.

The preparation of abutment #11 was facilitated by use of a dental operating microscope (OPMI pico, Carl Zeiss Meditec AG, Jena, Germany) and an oscillating handpiece (KaVo SONICflex LUX 2003/L, KaVo Dental, Charlotte, NC, USA) with a hemispherical microtip (microtip no. 33, KaVo SONICflex) and a modified-shoulder sonic tip (SF847KR.000.016, Komet USA, Rock Hill, SC, USA) (Figure 4) under rubber dam isolation. Simultaneously, a direct composite restoration involving the facial and incisal surfaces of #9 was carried out using shades B1B (Filtek Supreme Ultra, 3M ESPE, St. Paul, MN, USA), BL2 and MW (Estelite Omega, Tokoyama Dental America, Encitas, CA, USA) using a layering technique. The final preparation
dimensions on the retainer #11 were 5.2 mm in width, 6.0 mm in height, and 0.5 mm in depth, and were limited to enamel throughout the preparation dimensions (Figure 5).

A mounted master cast of the clinical situation was provided to the ceramist (Figure 6A), and a cantilevered, all-ceramic (IPS e.max Press, Ivoclar Vivadent) RBFPD was fabricated using a BL3 ingot.

FIGURE 5. A, Palatal view of maxillary anterior dentition after preparation completion. B, Direct view of abutment preparation, the dimensions of the preparation were 6.0 mm (height) × 5.2 mm (width) × 0.5 mm (depth) and were limited to enamel throughout.

(Figure 6B). Upon cutback, Opal Effect 3 powder was applied from the incisofacial third to the cervical third of the pontic, and T blue and T clear were layered in the incisal third to adequately mimic incisal effects. The restoration was glazed and subsequently mechanically glazed with rubber wheels and polishing compound to match the luster of the adjacent teeth. The adaptation and fit of the restoration were verified on the master cast (Figure 6C).

The completed cantilevered, all-ceramic RBFPD was seated intraorally before application of the rubber dam to verify proper coronal form, shade, and texture match to the adjacent natural dentition. Proper seating, proximal contact, and marginal adaptation were also assessed at this stage, and no adjustments were required. The anterior sextant was isolated under rubber dam with cervical floss ligatures, and the restoration’s complete seating and marginal adaptation were once again verified. The internal aspect of the retainer was acid-etched with 5% hydrofluoric acid (IPS etching gel, Ivoclar Vivadent) and silanated with silane (Bis-Silane, Bisco, Inc., Schaumburg, IL, USA) according to the manufacturer’s instructions. The preparation was treated with 35% phosphoric acid (Ultra-Etch, Ultradent, South Jordan, UT, USA) for 30 seconds, then rinsed and dried thoroughly. A total-etch adhesive resin (All-Bond 3, Bisco, Inc.) was subsequently applied to both the restoration intaglio and previously etched preparation according to manufacturer instructions, and light-cured for 30 seconds. The RBFPD was luted with a translucent light-curing resin adhesive cement (RelyX Veneer, 3M ESPE) to ensure color stability. Centric and excursive occlusion was verified, and margins were polished with silicone carbide brushes (Jiffy Brushes, Ultradent). A final radiograph (Figure 7) was made to verify cement removal, and proper hygiene around the prosthesis was demonstrated and discussed with the patient. The patient was recalled at 1-year follow-up (Figure 8) and revealed no evidence of chipping, loosening, or rotation of the prosthesis, or any biological complications of the abutment tooth, and was very satisfied with the functional and esthetic integration with the remaining dentition (Figure 9). The patient also felt more socially confident with a fixed restoration as a long-term provisional prosthesis as compared with a removable appliance.

**DISCUSSION**

Cantilevered, all-ceramic RBFPDs represent a progression in the coupling of minimally invasive and adhesive dentistry. Such restorations lead to less morbidity and biological complications of adjacent abutment teeth and superior esthetic outcomes as compared with traditional fixed partial dentures for appropriate patients. Advances in high-strength ceramic systems such as milled zirconium oxide as well as milled or pressed lithium disilicate have enabled the fabrication of robust and esthetic cantilevered, all-ceramic RPFPDs. Such systems enable predictable bonding to tooth substrate and offer the potential for enhanced esthetics when compared with metallic-retainer RBFPDs. Recent clinical studies
FIGURE 8. Clinical views of completed case at 1 year post-insertion (note gingival health apical to the pontic and connector): A, frontal view; B, lateral view; C, palatal view; D, incisal view.

utilizing these ceramic materials for cantilevered RBFPDs have demonstrated promising results in the 3- to 5-year follow-up timeframe.

Sasse and colleagues reported a randomized, clinical trial evaluating 30 patients restored with cantilevered, all-ceramic RBFPDs fabricated with zirconium oxide retainers and frameworks with two adhesive systems.\textsuperscript{27} The study demonstrated a 3-year survival rate of 93.1%, if debonding was considered as a technical failure, and 100% survival if only the final loss of the RBFPD, notwithstanding rebonded RBFPDs, was a criterion for success. The investigators reported two debonding events in this cohort that were attributable to traumatic events (hits/pushes on chin and/or teeth). A second case-series study evaluated the clinical outcomes of cantilevered, all-ceramic RBFPDs fabricated with IPS e.max Press for tooth replacement in the anterior maxilla and mandible.\textsuperscript{25} A total of 35 patients (17 maxillary sites, 18 mandibular sites) were treated and recalled for a mean of 64.57 months (range 35–69 months). The study reported no incidences of prosthesis debonding, no postoperative sensitivity or recurrent caries, or any prosthesis chipping or fracturing. Excellent 3- to 5-year survival outcomes in controlled studies as well as successful documented case reports\textsuperscript{28,29} of cantilevered, all-ceramic RBFPDs are encouraging to practitioners who are presented with patients who may desire a fixed restoration in an anterior, bounded edentulous site either as a long-term provisional restoration or an alternative definitive restoration to a single-tooth implant.

Two factors are of critical importance when evaluating if a patient is a good candidate for a cantilevered, all-ceramic RBFPD. The first contributing factor to evaluate is the patient’s occlusion. It is the authors’ experience that patients who present with mutually protected occlusion including canine or group function tend to have more successful outcomes with cantilevered RBFPDs. Prioritization of minimizing lateral and protrusive forces on the cantilevered pontic is of utmost concern for this restoration design. Patients who possess minimal vertical space because of a deep overbite or supraeruption of opposing teeth make poor candidates for this treatment approach.

Such situations limit the height and width (and hence strength) that can be established for the connector region of the all-ceramic prosthesis,\textsuperscript{30} as well as place the restoration under greater stress in excursive movements because of steeper inclines that must be overcome for the patient to function. The second critical factor to evaluate is the tooth that requires replacement. Hussey and Linden\textsuperscript{16} reported that significant differences exist in the performance of cantilevered RBFPDs based on the teeth that they were replacing. In their study, cantilevered RBFPDs replacing maxillary central incisors and canines had a tenfold higher failure rate, when compared with maxillary lateral incisors and premolars, as well as mandibular incisor and premolar teeth. Therefore, in addition to occlusion, the candidate tooth for replacement must also be taken into account by the clinician when assessing the potential success of a cantilevered, all-ceramic RBFPD. It is of interest to note that Sun and colleagues.\textsuperscript{25} did not include central incisors or canines in their case-series study that reported 100% success.

The clinical case presented here was optimized not only by accounting for factors present clinically, such as an anterior open bite, anterior disclusion, and group function in lateral excursive movements, but also by the micropreparation methodologies employed. Sonobrassion via the use of oscillating diamond-coated tips, as well as enhanced visualization of the field via a dental operating microscope, allowed the authors a high degree of control and accuracy while preparing the canine abutment. Such ssonoabrasive preparation methodologies have been demonstrated to result in less tooth substance loss after preparation as compared with traditional rotary instrumentation\textsuperscript{31} and have traditionally been proposed for Class II cavity lesion preparation\textsuperscript{32,33} or finishing of prosthetic margins prior to prosthetic final impressions.\textsuperscript{34} To the authors’ knowledge, this is the first report of oscillating instrumentation being employed for the preparation of an abutment for a cantilevered, all-ceramic RBFPD.

When appropriate clinical conditions are present, cantilevered, all-ceramic RBFPDs are more conservative in nature, require less time for the clinician to prepare and impress, and are less burdensome to deliver than...
conventional double-retainer, all-ceramic RBFPDs. For patients with limited financial means, laboratory costs will also be less as compared with conventional double-retainer RBFPDs. Additionally, there is significantly less potential for developing recurrent caries on a partially debonded retainer wing for a cantilevered prosthesis, as such an event will immediately lead to loss of the prosthesis, prompting the patient to return to the practitioner for rebonding or repair.

In conclusion, the cantilevered, all-ceramic RBFPD is a uniquely positioned prosthesis that can serve as either a minimally invasive definitive prosthesis for patients who are not candidates for implant therapy, or as a long-term fixed provisional prosthesis for the patient who may desire to pursue implant therapy at a later time, should skeletal growth, health, or finances be of concern. In order to obtain data that could potentially validate the treatment strategy employed in this case report, future case-series, or more ideally, randomized, clinical trial studies including larger populations with longer follow-up periods (greater than 5 years) are warranted. Given that health care is increasingly moving toward minimally invasive approaches when surgical intervention is deemed necessary, it seems natural that such trends are increasingly being seen in private and academic dentistry, where surgical procedures are completed and/or taught routinely.

DISCLOSURE

The authors declare no potential conflicts of interest with respect to the authorship and/or publication of this article.

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