Single-Tooth Replacement in the Anterior Arch by Means of a Cantilevered IPS e.max Press Veneer-Retained Fixed Partial Denture: Case Series of 35 Patients

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Purpose: This case series study evaluated the clinical outcomes of cantilevered veneerretained fixed partial dentures (VRFPDs) fabricated with IPS e.max Press for single-tooth replacement in the anterior arch. *Materials and Methods:* A total of 35 patients were treated with VRFPDs, including 17 cases in the maxilla and 18 in the mandible. The patients were evaluated at baseline and annually from October 2005 to July 2011 for the integrity of the VRFPDs, proximal contacts, occulsal relationships, pulp vitality, and tooth mobility. The degree of satisfaction was indicated with a visual analog scale. **Results:** During a mean observation time of 46.57 months, 35 VRFPDs on vital abutment teeth did not exhibit postoperative sensitivity or secondary caries. No fractures or chipping of the restorations occurred within the course of the evaluation. No patient complained of food impaction. One cantilevered pontic needed adjustment on the incisal edge due to premature contacts after the 3-year recall examination. Conclusion: Cantilevered IPS e.max Press VRFPDs should be considered a minimally invasive, single-tooth restorative strategy in the anterior or first premolar area. Longer observation periods are necessary before this type of restorative design can be recommended as a general conservative procedure. Int J Prosthodont 2013;26:181–187. doi: 10.11607/ijp.3102

The rapid development and improvement of adhesive dentistry, as applied to dental ceramic restorations, over the past decade has allowed for more widespread application and variety in the designs of these materials. Many successful reports¹⁻⁵ have been published regarding the use of veneers, inlays, onlays, and fixed partial dentures (FPDs).

Clinicians are constantly presented with the challenge of restoring a single edentulous space due to a congenital missing tooth, trauma, caries, or periodontitis. Currently, multiple restorative treatment options exist. They include implant-supported crowns, FPDs, removable partial dentures (RPDs), and resin-bonded FPDs. Very often, an implant-supported restoration is not the treatment of choice for various reasons, such as compromised deficiencies of the soft and hard tissues during extractions, extra cost from complicated operations involving grafting surgery,^{6–8} poor oral hygiene, and patients' fear of surgery. However, FPDs require crown preparations for the adjacent abutment teeth, resulting in a loss of between 63% to 73% of sound dental structures⁹ and potential future endodontic treatment.¹⁰ Similarly, RPDs seldom satisfy patients' needs for function, esthetics, and comfort. These considerations have led clinicians to seek therapies that offer a less invasive procedure.

The concept of a resin-bonded FPD was first described by Rochette¹¹ as a technique for splinting periodontally compromised mandibular anterior teeth. The clinical technique was modified several times before the currently accepted nonperforated retainer bonded with luting resins. Due to its noninvasiveness, it is currently used as an effective and definitive prosthesis for the restoration of missing teeth in a range of clinical situations.

Most restorations used in previous studies were made of either metal-based, alumina-based, or zirconia-based ceramic.¹²⁻¹⁴ Translucency and strong mechanical properties of the restorative materials are important considerations for an anterior tooth rehabilitation. In recent studies, IPS e.max Press (Ivoclar

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Vivadent) showed a flexural strength of up to 600 Mpa.¹⁵ Waltimo and Könönen¹⁶ reported a mean maximum occlusal force in the anterior region of around 300 N. Based on these findings, the physical properties of IPS e.max Press exceed the measured force that restorations placed in the anterior dentition would face. Additionally, IPS e.max Press has demonstrated greater translucency than the opaque zirconia-containing core materials.^{17,18}

Many clinical factors must be evaluated for the successful use of cantilevered veneer-retained FPDs (VRFPDs). These include occlusion, patient cooperation, periodontal integrity of the abutment teeth, presence of adequate tooth structure, and tooth vitality. The use of cantilevered VRFPDs is still a challenging procedure for the clinician. Until recently, limited studies have been available concerning the clinical performance of cantilevered VRFPDs made from lithium disilicate-based IPS e.max Press. This case series evaluated 35 cantilevered IPS e.max Press VRFPDs to replace a missing single-tooth in the anterior arch observed for a mean duration of 46.57 months.

Materials and Methods

Patients with the indication for cantilevered VRFPDs were treated at the Center of Dental Medicine in China-Japan Friendship Hospital, Beijing, China, from October 2005 to July 2011. All enrolled participants were in good psychologic and physical health. Patients were selected based on the following inclusion criteria: single-tooth loss in the anterior arch with a stable occlusal relationship, no lateral and protrusive interference or premature contacts, normal pulpal vitality, and little or no abrasion in the enamel layer of the abutment teeth. The bone level of the abutment teeth had to be more than two-thirds of the root length, and the maximum accepted tooth mobility was grade 1. The clinical height of the crown had to be at least 4 mm. Slight resorption of hard and soft tissues in the buccolingual aspects of the edentulous site was acceptable if it did not affect the esthetics of the area. For the same reason, there had to be no significant vertical discrepancy.

Exclusion criteria were as follows: bruxism, hard food biting habit, or severe overbite/overjet (in the present study, only one patient characterized with a deep overbite was involved).

Informed consent was obtained from all participants and approved by the Ethical Committee of China-Japan Friendship Hospital. The study enrolled a total of 35 patients (13 men, mean age 40.3 years, range 24 to 57 years; 22 women, mean age 43.2 years, range 25 to 56 years).

Clinical Procedures

The principles for selecting the tooth surface to be used as an abutment for the veneer retainers were as follows: in the maxilla, if the color and shape of the labial surface was generally esthetic and did not require modification, the lingual/palatal surface was the first choice; otherwise the labial/buccal was chosen. In this study, apart from one case where the labial surface of the maxillary canine was prepared, all other veneer retainers were suited on the lingual/palatal surfaces. To ensure that the preparation depth was within the enamel layer, no local anesthesia was administered.

Methodology for veneer tooth preparation adhered to the published studies.¹⁹ The axial surface reduction ranged from 0.5 to 0.8 mm with window preparation without incisal edge involvement. Cervically, a shallow chamfer (0.5 mm) was prepared epigingivally. The proximal reduction was 0.5 to 1 mm. All inner line angles were rounded. All preparation margins were restricted within the enamel layer. The chamfer on the cervical area was required to be at the supragingival margin to avoid exposing the root cingulum area. Guide planes of the adjacent abutment teeth were incorporated within the interproximal surface. Undercuts of the proximal surfaces of the abutment teeth were removed in order to ensure framework passivity.

Impressions were taken with a polyether impression material (3M ESPE). Veneer retainers and cantilevered pontics were made of IPS e.max Press. Restorations were fabricated using the lost-wax procedure, following the manufacturer's instructions. After an ideal wax up of the cantilevered VRFPD, the labial surface was cut back by 0.3 to 0.6 mm to allow for a layer of veneering porcelain. The lingual/palatal veneer retainer was not layered with porcelain. The pontic area was circumferentially veneered with feldspathic porcelain. A U-shaped form was adopted circumferentially around the embrasure of the framework connector, avoiding any sharp angles. The occlusogingival dimension of the connector in the VRFPDs was 3.6 mm (3.3 to 3.8 mm) on average, and the buccal-lingual dimension was 2.8 mm (2.5 to 3.1 mm) on average.

Restorations were evaluated in vivo. VRFPDs were inserted completely along the guide plane using an explorer to examine the fit around the margin. After verification of margin continuity, bonding was performed.

Restorations were bonded using Variolink (Ivoclar Vivadent) according to the manufacturer's instructions. Following cementation, necessary occlusal adjustments were performed with a superfine polishing diamond bur (no. 858UF, Komet) on fully irrigated high-speed handpieces (KaVo). Finally, the occlusal

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surfaces were adjusted with an intraoral porcelain finishing set (Edenta Porcelain Veneer Kit, Edenta). All clinical procedures were performed by the same experienced clinician (QS) for all restorations.

Clinical Evaluation

The patients were initially evaluated at baseline (2 weeks after clinical insertion) and then annually from October 2005 to July 2011 for the integrity of the VRFPDs, proximal contacts, occulsal relationships, pulp status, tooth mobility, fracture or chipping, and bonding integrity. Survival criteria were the integrity of the restoration and the absence of chipping or fracture.

The evaluations were assessed visually and manually by one experienced clinician (BX) using mirrors, probes, articulating paper, and periapical radiographs. The proximal contacts were checked with waxed dental floss. Pulpal vitality was verified with a carbon dioxide test.

At the final follow-up (mean: 46.57 months), patients were asked whether they were satisfied with the esthetic and functional outcomes of their restorations by means of polar questions (yes/no). Patients were asked to indicate their degree of satisfaction with restorations on a visual analog scale (VAS) by making a mark on a 10-cm line labeled "very dissatisfied" at one end and "very satisfied" at the other.²⁰ For the purpose of presenting the data, the scale was subdivided into 100 units with 0 = "very dissatisfied" and 100 = "very satisfied." A score larger than 80 indicated a high degree of satisfaction.

Results

No patients dropped out of the study from baseline to data collection. All VRFPDs had been in situ for a mean duration of 46.57 months (range: 35 to 69 months), representing a survival rate of 100%. Due to premature contacts, one cantilevered pontic in the mandible needed adjustment on the incisal edge after the 3-year recall examination. No fracture or chipping of the restorations was observed at the follow-up recall. Table 1 shows an overview of the distribution of cantilevered VRFPDs.

The proximal contacts between the restoration and the adjacent teeth remained tight and stable. All selected abutment teeth retained normal pulpal vitality, without postoperative sensitivity, food impaction, or secondary caries. All abutment teeth remained within a grade 1 level and exhibited no signs of clinical attachment loss or periapical pathology. The VAS at the final follow-up showed an average score of 87.5

	Site of tooth loss		
	Central incisor	Lateral incisor	First premolar
Maxillary abutment tooth			
Central incisor Canine Lateral incisor Total	- - -	9 6 - 15	- 2 - 2
Mandibular abutment tooth			
Central incisor Canine Lateral incisor Total	2 - 6 8	2 7 - 9	- 1 - 1

Distribution of the VRFPDs

Table 1

(standard deviation, 15.4), representing a high degree of satisfaction. At the final follow-up, all patients reported that they were satisfied with the cantilevered VRFPDs, giving a definite answer of "yes."

Case Presentations

Patient One. A 55-year-old woman presented with decreased space after the extraction of two mandibular central incisors 2 years earlier. The patient was seeking a fixed restoration but refused implant therapy and extra-large volume preparation of the adjacent abutment teeth. After discussing various options, a cantilevered VRFPD treatment design (Figs 1a to 1g) was selected, as it fulfilled the patient's requirements for both a fixed and minimally invasive prosthesis.

Patient Two. A 27-year-old woman with deep overbite presented with the loss of her maxillary left first premolar and a favorable canine protected occlusion. She had excellent oral hygiene and healthy periodontal structures (Figs 2a to 2h). The cantilevered first premolar pontic was free of occlusal contact during mandibular lateral excursion and protrusion.

Discussion

The resin-bonded FPD has several advantages over conventional three-unit FPDs, including conservation of sound tooth structure and reversibility. Reduced chairside time and low laboratory fees have made resin-bonded FPDs a favorable treatment choice for clinicians and have aided in its rapid assimilation into dental practice as an alternative to conventional FPDs.²¹

In the present study, no fractures or chipping of cantilevered VRFPDs were found at the follow-up recalls. These promising results may attest to the reliability of the veneer-related adhesive procedures that, when combined with specific patient parameters,

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VRFPD = veneer-retained fixed partial denture.



Fig 1a Two lost mandibular central incisors with decreased mesiodistal space.



Fig 1b Frontal view of the mandibular dentition pretreatment.



Fig 1d Lingual view of the VRFPD at baseline.



Fig 1e Frontal view of the centric occlusion at baseline.



Fig 1c Frontal view of the VRFPD at baseline.



Fig 1f Frontal view of the VRFPD at 5 years and 9 months after cementation (final follow-up).



Fig 1g Lingual view of the VRFPD at final follow-up.

can reduce torsion stress levels of the bonding interfaces in cantilevered VRFPDs. These parameters include correct abutment preparation methods, location of the missing teeth in the dental arch, adequate restorative space in the edentulous area, favorable occlusal scheme, good oral health, and regular recall examinations.

Compared to the promising bonding result in this study, Guess and Stappert²² reported a loss of retention of 2.3% after 5 years and Fradeani et al²³ a loss of 3.3% after 12 years. In the present study, special attention was given to minimally invasive restorative considerations. The conservative preparation was completely confined to the enamel layer, and the integrity of the dentin was conserved as far as possible; therefore, durable and reliable bonding between the enamel and the veneer was guaranteed, reducing the potential for debonding and the incidence of secondary caries.

Furthermore, in order to reduce mechanical stress levels for bonding interfaces and ceramic materials, a cantilevered VRFPD design is selected instead of a bilateral retainer. During functional movement, especially in protrusion and lateral excursion, a bilateral abutment design will show a significant difference in the scale of the physical movement without coordination.²⁴ However, cantilevered pontics will move harmoniously with the adjacent abutment tooth, resulting in tremendous reduction in shear, tensile, and torsion stresses around all directions for the connector and the bonding interfaces.^{21,24} Single-retainer designs can also facilitate daily oral hygiene care with conventional dental floss, compared to the need to use super floss (eg, Oral-B) for cleaning conventional FPDs.²⁵ Finally, when the retainer design incorporates the palatal/lingual surface, a natural appearance can be achieved with high predictability for patients.

Hussey and Linden²¹reported that the cantilevered FPDs replacing maxillary central incisors and canines were less successful and almost 10 times as likely to debond compared with the FPDs replacing other teeth. Therefore, the present authors excluded such patients in this study.



with decreased mesiodistal and occlusogingival dimension.



Fig 2d Occlusal view of the inserted restoration at baseline.



Fig 2f Frontal view of the centric occlusion at baseline.



Fig 2a A lost maxillary left first premolar Fig 2b The labial surface of the canine was prepared.



Fig 2e Labial view of the inserted restoration at baseline.



Fig 2g Labial view of the inserted restoration at 3 years and 8 months after cementation (final follow-up).



Fig 2c Definitive single-retainer IPS e.max Press ceramic VRFPD.



Fig 2h Periapical radiograph at final follow-up.

One of the main causes for failure of all-ceramic resin-bonded FPDs is fracture of the connector area,26 contingent not only on the dimensions of the connector, but also on the mechanical properties of the materials used. Furthermore, the radius of curvature of the occlusogingival embrasure around the connector area also performs an important role in fracture resistance for the entire restoration. Gingival embrasures with a broad radius of curvature, rather than a sharp contour, have been shown to reduce the stress concentrations under occlusal loading and eventually increase the fracture resistance.²⁷ A circumferential U-shaped wax-up around the occlusogingival embrasure is beneficial for the mechanical resistance of the definitive prosthesis. Additionally, no adjusting should be done prior to insertion to avoid inducing any cracks.

Extensive evaluation should be performed prior to selecting a cantilevered VRFPD. This includes gingival biotype, gingival display, and available space for adequate connector dimension. These factors are closely

related with the final esthetic outcome and the mechanical resistance of cantilevered connectors. Due to the limited connector space, cantilevered VRFPDs designed for patients with a thin and highly scalloped periodontium should be evaluated carefully. Additionally, patients with a high smile line combined with a thin gingival biotype represent a tremendous esthetic challenge when cantilevered VRFPDs are designed. Previous studies using IPS e.max Press confirmed²⁸ that a cross-sectional area of at least 12 mm² would yield sufficient mechanical resistance for the connector between the pontic and the retainer. In the present study, six VRFPDs restoring mandibular central and lateral incisors demonstrated minimal width of the connector measuring less than 3 mm in the buccolingual dimension. In such occasions, the height in the occlusogingival dimension was increased to more than 3 mm to compensate for the strength loss from the width deficiency. Given adequate preoperative evaluation, cantilevered VRFPDs, even in the mandibular central and lateral

incisors with limited dimension, were not found to be compromised during follow-up examination.

As a general principle,²¹ it is agreed that the pontic of the completed FPD should have only light contact in centric occlusion and be protected from loading in lateral and protrusive excursions. Consequently, the pontic should bear only minimal habitual and extrusive forces, if any.²⁵ In the present study, the authors took great care to ensure that minimal loading occurred on the pontic.

Occlusion scheme analysis plays a very important role for cantilevered VRFPDs. Patients demonstrating group function involving multiple posterior teeth or canine protection occlusions are very favorable concerning the success of cantilevered VRFPDs. All the pontics in this case series were designed free of contact during protrusive and lateral movements. Furthermore, by reducing the cusp inclination of the cantilevered pontic, additional stress reduction may be obtained during lateral excursions, thus allowing for a more prolonged and predictable lifespan of the prosthesis.

Finally, adequate oral hygiene and regular maintenance intervals should also be considered important for success. Adequate periodontal support from the abutment can potentially compensate for situations that are biomechanically unfavorable. With regular recall, potential premature contacts of the prosthesis can be inspected and adjusted. In the present study, one cantilevered pontic in the mandibular anterior incisor needed to be adjusted on the incisal edge due to premature contacts after the 3-year recall examination. This circumstance could have resulted from slight abutment tooth movement and/or uniform wear between the ceramic restoration and the opposing teeth.

In the present study, even though a 100% success rate of the cantilevered VRFPDs up to 5 years is certainly encouraging, multiple limitations exist. Regarding the limited number of patients, a study with a larger sample size should be performed before accepting cantilevered VRFPDs made from IPS e.max Press as a generally conservative procedure. Future detailed studies should focus on the long-term evaluation of periodontal response to cantilevered VRFPDs. A new evaluation method for inspecting micromovements of cantilevered abutments should be explored in the future.

Conclusions

The present cases series reflects the 100% success rate of 35 single-tooth replacements in the anterior or first premolar area using cantilevered IPS e.max Press VRFPDs evaluated over a mean observation time of 46.57 months with satisfactory and promising clinical outcomes. The following conclusions can be drawn:

- Cantilevered IPS e.max Press VRFPDs should be considered as a minimally invasive, single-tooth restorative strategy in the anterior or first premolar area.
- Strictly controlled criteria, precise abutment preparation, extensive preprosthetic evaluation, and regular recalls are considered key factors for the long-term success of the cantilevered VRFPDs design.
- Longer observation periods and larger sample sizes, together with long-term periodontal response evaluations, should be provided before this type of design can be recommended as a general conservative procedure.

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Literature Abstract

Changing trends in smoking and alcohol consumption in patients with oral cancer treated at Memorial Sloan-Kettering Cancer Center from 1985 to 2009

This retrospective cohort study aimed to determine the prevalence of tobacco and alcohol use in patients with oral cancer treated at the Memorial Sloan-Kettering Cancer Center. The medical records of 1,617 oral cancer patients from 1985 to 2009 were reviewed. Patient demographics, smoking and alcohol use, and treatment outcomes were recorded. For comparison of trends in alcohol and tobacco use, patients were divided into five cohorts based of the date of initial surgery (cohort 1: 1985 to 1990 [n = 274]; cohort 2: 1990 to 1994 [n = 250]; cohort 3: 1995 to 1999 [n = 315]; cohort 4: 2000 to 2004 [n = 356]; and cohort 5: 2005 to 2009 [n = 422]). No differences were found in sex, age, or stage of disease among cohorts. The tongue was the most common subsite (49%). A small increase in buccal mucosa cancer and a reduction in floor of mouth cancer were observed over time. A decrease in tobacco use was noted, from 80% in cohort 1 to 60% in cohort 5. Alcohol consumption also decreased from 80% in cohort 1 to 67% in cohort 5. In conclusion, there has been a progressive decrease in the prevalence of tobacco use and alcohol consumption in patients with oral cancer so cancers to cancers associated with other factors such as human papillomavirus (HPV) infections. Though this change is similar to that reported for oropharyngeal cancer, further studies on the role of HPV in oral cancer are required.

Montero PH, Patel PD, Palmer FL, et al. Arch Otolaryngol Head Neck Surg 2012;138:817–822. References: 28. Reprints: lan Ganly, Department of Otolaryngology–Head and Neck Surgery, Memorial Sloan-Kettering Cancer Center, 1275 York Ave, New York, NY 10065, USA. Email: ganly@mskcc.org—Teo Juin Wei, Singapore

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